Key Stage 3
National Strategy

Science

Literacy in science

Notes for tutors
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Overview of the unit

This pack contains the materials, background notes and guidance for the unit on literacy in science. As the Key Stage 3 science consultant or tutor you will use these materials as part of the science strand of the Key Stage 3 National Strategy.

This unit is part of a national literacy in subject series. It is aimed at classroom teachers who have identified literacy in science as one of their needs from the supplementary audit.

The unit is divided into four main sessions. It is designed so that it can be delivered as a whole day, two half-days or four twilight sessions. Each session is designed to last about 1 1/4–1 1/2 hours.

It is advisable that session 1 is done first. The order of the other sessions is largely unimportant.

The unit has a pre-unit task based on the work done in participants’ schools as a result of generic training on Literacy across the curriculum. To date, most schools have opted to look at non-fiction writing as part of their Key Stage 3 strategy training.

Each session has follow-up work that can be dealt with at the end of each session or as a whole at the end of the unit. To help teachers to engage with the ideas, the majority of the follow-up work is provided in classroom-ready form.

It would be advisable for science consultants to deliver this training jointly with English consultants.

Unit objectives

- To raise awareness of the importance of language in teaching science and literacy across the curriculum
- To identify the difficulties encountered when learning scientific words and ways of improving pupils’ skills in dealing with scientific terminology
- To explore the ways and purposes of reading in science to improve pupils’ skills
- To explore the purpose of writing in science, the implications for teaching and ways in which pupils’ writing in science can be improved
- To explore the purpose of speaking and listening in science
- To exemplify techniques that enable pupils to engage fully in discussion

Outline programme

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction and words in science</td>
<td>1 hour 35 minutes</td>
</tr>
<tr>
<td>2</td>
<td>Reading in science</td>
<td>1 hour 20 minutes</td>
</tr>
<tr>
<td>3</td>
<td>Writing in science</td>
<td>1 hour 20 minutes</td>
</tr>
<tr>
<td>4</td>
<td>Talk in science</td>
<td>1 hour 25 minutes</td>
</tr>
</tbody>
</table>
Synopsis

Session 1  Introduction and words in science

The brief introduction makes the point that literacy should be tackled at word, sentence and text level and reminds participants of the support pupils have received to date. The main part of the session addresses the issues about scientific terminology: why some words are difficult, why spelling words accurately may be helpful to the understanding of science and how we can develop pupils’ skills. The session also introduces a taxonomy of words in science that helps teachers to decide which words are ‘key’. A short video clip shows a word loop game in action.

Session 2  Reading in science

This session makes clear the importance of text as a tool for learning science and explores ways in which pupils can be helped to access science texts. It explores types of reading, shared reading and the use of active reading strategies. It also provides pointers to help teachers to assess useful text sources or to create their own.

Session 3  Writing in science

This session builds on the non-fiction writing training in Literacy across the curriculum. It explores some text types important to science and provides examples of how pupils’ writing can be improved. A video sequence shows how writing conclusions can be modelled. The discussion of the post-unit task has two options which may take different lengths of time to deliver.

Session 4  Talk in science

This explores why talk is important in science and how best pupil discussion can be organised, both for the whole class and for small groups.

Preparing for the unit

Writing to schools before this unit

You will need to prepare, and send to schools in advance, a programme based on the outline of the unit, tailoring times of sessions to suit your local circumstances. Send a map of how to get to the venue and include a contact telephone number for the venue that delegates can use.

Include with your letter details of the short pre-unit task, allowing enough time for participants to complete it. Page 9 outlines the task. Notes on the task for the tutor are also on page 9.

You may also want to prepare and send a list of participants’ names and their schools to those who are attending.

You should ask participants to bring with them the following:

• Framework for teaching science: Years 7, 8 and 9.
Tasks for participants before attending this unit

Before this unit all departments represented should have:

• identified the need to improve literacy in Key Stage 3 science as one of the outcomes of the audit;
• carried out the pre-unit task.

Tasks for you to do

You may need to refresh your memory of the notes and guidance provided in the tutor's notes for the launch unit of the science strand under the following sub-headings:

• Some tips on using your tutor's notes
• Preparing for units: practical arrangements

The resources needed for each session are listed below for convenience.

Other preparations consist of making sure you are familiar with:

• Framework for teaching science: Years 7, 8 and 9, particularly the section on scientific enquiry and the relevant yearly objectives including appendix 2;
• Science: a scheme of work for Key Stage 3 (the DfES/QCA exemplar scheme of work for science, henceforth called the ‘QCA scheme of work’);
• these notes (including the tasks for participants), the slide presentation, the video and handouts.

You may also want to refer to Science: the use of language (SCAA, 1997; COM/96/653) and Language for learning in Key Stage 3 (QCA, 2000; QCA/00/595).

Unit evaluation

At the beginning of the unit you should ask participants to retrieve the evaluation form from their packs; a copy appears on page 11. At the end of each session, ask participants to complete the relevant section of the form. Collect the completed sheets at the end of the unit. You will need to read them and to summarise the data. This will be collected as part of the monitoring and evaluation of the Key Stage 3 National Strategy.

As well as an evaluation form for participants, there is one included for you, as the tutor, on pages 13–14. Fill this in after completion of the unit and your analysis of the participant evaluation sheets. Please return to:

Science Team Senior Regional Coordinator
Centre for School Standards
60 Queens Road
Reading RG1 4BS
Resources needed for each session

Session 1  Introduction and words in science

For tutor

- Slides 1.1–1.4, 1.6, 1.8, 1.10, 1.11, 1.14–1.16, 1.19, 1.20
- Video clip 1 Oral starter
- Ofsted secondary subject reports 2000/01: science (HMI 371)
- QCA Key Stage 3 science tests: notes for teachers (e.g. QCA/01/673)
- Flipchart, paper and pens

For participants

- Handouts
  1.5 Possible problems with scientific terminology
  1.7 Some useful word roots
  1.9 Key words
  1.12 Departmental discussion sheet: Introducing new key words
  1.13 Some useful ways to help pupils spell key words correctly
  1.17 Strategies for developing scientific terminology
  1.18 Cell loop cards for follow-up work

- Sufficient copies of the QCA scheme of work for one between four participants
- Evaluation form

Participants should bring:

Framework for teaching science: Years 7, 8 and 9

Session 2  Reading in science

For tutor

- Slides 2.1, 2.2, 2.4, 2.6, 2.10, 2.12
- Copy of handout 2.9 or interactive whiteboard for use with handout 2.9

Handouts in tutors’ pack only
- 2.13 Sequencing activity (restructuring)
- 2.14 Diagrammatic representation (analysis)
- 2.15 Pupil sheet 1: To tell an acid from an alkali
- 2.16 Pupil sheet 2: To tell an acid from an alkali
- 2.17 Teacher guidance sheet: To tell an acid from an alkali
For participants

Handouts
2.3 How fresh is fresh?
2.5 Directed activities related to text (DARTs): a summary
2.7 Text marking (analysis) grid
2.8 Table completion (analysis) grid
2.9 Cells
2.11 Teacher guidance sheet: Cells

Red and blue highlighter pens

Session 3  Writing in science

For tutor

Slides 3.1, 3.2, 3.5, 3.7, 3.9, 3.10, 3.13, 3.16

Handouts in tutors’ pack only
3.17 Index to handouts 3.18 to 3.40
3.18 Pupils’ work: What makes a good conclusion?
3.19 Pupil sheet A
3.20 Pupil sheet B: Examples of conclusions
3.21 Pupil guidance sheet: Writing conclusions
3.22 Teacher guidance sheet: Writing conclusions
3.23 Teacher guidance sheet: Explaining how
3.24 Teacher guidance sheet: Explaining why
3.25 Pupil sheet A: Examples of explanations
3.26 Pupil sheet B: Examples of explanations
3.27 Pupil guidance sheet: Writing explanations
3.28 Teacher guidance sheet: Supporting the writing of explanations
3.29 Teacher guidance sheet: Argument
3.30 Pupil sheet: Argument for seeing because light enters the eyes
3.31 Pupil guidance sheet: Constructing arguments
3.32 Teacher guidance sheet: Supporting the writing of argument
3.33 Teacher guidance sheet: Evaluation
3.34 Pupil sheet: Examples of evaluation
3.35 Pupil guidance sheet: Writing evaluations
3.36 Teacher guidance sheet: Supporting the writing of evaluation
3.37 Teacher guidance sheet: Planning
3.38 Pupil sheet A: Planning
3.39 Pupil sheet B: Writing plans
3.40 Teacher guidance sheet: Supporting planning

Video clip 2 Writing conclusions

For participants

Handouts
3.3 Recording sheet: Writing in science
3.4 Purposes for writing in science
3.6 Departmental discussion sheet: Supporting pupils in writing in science
3.8 Types of writing
Session 4 Talk in science

For tutor

Slides 4.1–4.3, 4.5, 4.7, 4.8, 4.10, 4.12–4.14

Flipchart, paper and pens

For participants

Handouts
4.4 Discussions in science
4.6 Progression in speaking and listening
4.9 Discussing science: Oral starters to science lessons
4.11 Organising group discussions

Sufficient copies of the Key Stage 3 programme of study for science for one copy between two participants

Key messages leaflet

Pre-unit task

Participants should come prepared to discuss what has been done in their school/department concerning literacy across the curriculum. They should be encouraged to bring a brief summary of what has been done and any effects/outcomes in their department. Ideally this should be on a large sheet of paper that can be displayed at the start of the session. This will be briefly referred to in session 1 and can be looked at and discussed over the course of the day.

Post-unit tasks

The following tasks relate to the different sessions within this unit. There are also a relatively large number of additional handouts, only in your tutors’ pack, all of which could be used in follow-up work. These activities could form part of the focus of your follow-up visits to schools.

Towards the end of each session in your tutors’ notes, you will see a section on follow-up work, usually offering several options. This gives you some flexibility in presenting parts of the unit. You will need to decide which approach to take in each case. A further option is to indicate the existence of follow-up work at the end of each session but deal with detail at the end of the unit. You may wish to support different activities in different schools – the choice is yours. It is probably better that the school follows up a little work well rather than a lot poorly.

If you wish to give out any of these additional handouts in session 2 or 3, you will need to photocopy them beforehand. Copies of all handouts are included in these notes.
Task 1 – Words in science

Carry out one or more of the following:

• Review the key words list in terms of the taxonomy provided.

• Integrate one of the techniques for word-level work into a teaching topic.

Consider how you will evaluate the effectiveness of the change in teaching.

Task 2 – Reading in science

Carry out one or more of the following:

• Use materials from tasks F, G, H and I.

• Use handouts 2.13 and 2.14 with a class.

• Use handouts 2.15 to 2.17 to try out some of the techniques learned on the course.

Whatever is used, participants should evaluate the effectiveness of what they have tried.

Task 3 – Writing in science

Carry out one or more of the following:

• Use handouts 3.3 and 3.4 with the department.

• Use the discussion sheets (handouts 3.6 and 3.14) with the department.

• Use the additional handouts (3.18 to 3.40) with a class.

Whatever is used, participants should evaluate the effectiveness of the change.

Task 4 – Talk in science

Carry out one or more of the following:

• Review the departmental scheme of work for planned opportunities for talk and progression in talk.

• Try one of the oral starters in the next topic.

• Organise a small-group discussion in the next lesson.

Whatever is used, participants should evaluate the effectiveness of the change.
Evaluation: Literacy in science

For completion by teachers

What were the most successful aspects of today’s sessions?

What changes would you suggest if today’s sessions were repeated?

Please grade each session on the basis of how well structured and organised it is to meet the objectives identified.

<table>
<thead>
<tr>
<th>Session</th>
<th>Grade: please ring 1 = Very good, 4 = Poor</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Introduction and words in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>2 Reading in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>3 Writing in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>4 Talk in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Overall grade for the unit</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

School __________________________________________

Post held ________________________________________

Please return this form to your tutor before leaving
Summary evaluation: Literacy in science

For completion by consultants or tutors after the unit has taken place

LEA ________________________________

Date of training _____________________

What were the most successful aspects of today’s sessions?

What changes do you suggest might be made to improve this unit?

(a) From the tutor’s point of view

(b) From the participants’ points of view
Please grade the tutor’s material 1 to 4 for clarity of material, pitch of material, ease of use, appropriateness for teachers and so on. Use additional sheets of paper if you wish to provide more detailed comments.

<table>
<thead>
<tr>
<th>Session</th>
<th>Grade: please ring</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Introduction and words in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>2 Reading in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>3 Writing in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>4 Talk in science</td>
<td>1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>Overall grade for the unit</td>
<td>1 2 3 4</td>
<td></td>
</tr>
</tbody>
</table>

Please collate the grades given to each session by the teachers attending. Please provide numbers, not percentages.

Total number of teachers ____________

Please return this form to:

Science Team Senior Regional Coordinator
Centre for School Standards
60 Queens Road
Reading RG1 4BS
Introduction and words in science

Objectives

• To raise awareness of the importance of language in teaching science
• To raise awareness of pupils’ language experiences and literacy across the curriculum
• To raise awareness about the difficulties encountered when learning scientific words
• To identify the importance of word roots to the teaching of science
• To introduce a taxonomy of scientific words and show how to identify key scientific words within a topic
• To introduce a range of techniques for improving pupils’ skills in dealing with scientific terminology

Resources

For tutor

Slides 1.1–1.4, 1.6, 1.8, 1.10, 1.11, 1.14–1.16, 1.19, 1.20
Video clip 1 Oral starter
Ofsted secondary subject reports 2000/01: science (HMI 371)
QCA Key Stage 3 science tests: notes for teachers (e.g. QCA/01/673)
Flipchart, paper and pens

For participants

Handouts
1.5 Possible problems with scientific terminology
1.7 Some useful word roots
1.9 Key words
1.12 Departmental discussion sheet: Introducing new key words
1.13 Some useful ways to help pupils spell key words correctly
1.17 Strategies for developing scientific terminology
1.18 Cell loop cards for follow-up work

Sufficient copies of the QCA scheme of work for one between four participants
Evaluation form

Participants should bring:

Framework for teaching science: Years 7, 8 and 9
### Session outline

<table>
<thead>
<tr>
<th>Introduction</th>
<th>1 hour 35 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Considering this whole unit, sharing the pre-unit task and identifying the importance of language in science</td>
<td>Whole group</td>
</tr>
<tr>
<td><strong>Scientific terminology</strong></td>
<td>Task A, talk</td>
</tr>
<tr>
<td>Raising awareness about the difficulties encountered when learning scientific words</td>
<td>Pairs, whole group</td>
</tr>
<tr>
<td><strong>Science terminology and word roots</strong></td>
<td>Task B, talk</td>
</tr>
<tr>
<td>Identifying the importance of word roots in the teaching of science</td>
<td>Pairs, whole group</td>
</tr>
<tr>
<td><strong>Key words in science at Key Stage 3</strong></td>
<td>Task, task C</td>
</tr>
<tr>
<td>Identifying key scientific words within topics</td>
<td>Individuals, pairs, whole group</td>
</tr>
<tr>
<td><strong>Teaching key scientific words</strong></td>
<td>Task D, task E (video), talk</td>
</tr>
<tr>
<td>Considering ways in which pupils can be helped to spell key words correctly</td>
<td>Pairs, whole group</td>
</tr>
<tr>
<td><strong>Follow-up work</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Looking at how this work can be used back in schools</td>
<td>Whole group</td>
</tr>
<tr>
<td><strong>Plenary</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Reflecting on the main points of the session</td>
<td>Whole group</td>
</tr>
</tbody>
</table>

### Introduction

Before beginning session 1 proper, welcome the participants and deal with any necessary administrative matters including the programme for the day. This would be a good time to check whether they have brought the *Framework for teaching science: Years 7, 8 and 9* (‘Framework’ for short) with them. Also check that participants have displayed their pre-unit task around the room.

Show slide 1.1, the objectives for this introduction.

### Objectives for the introduction

- To raise awareness of the importance of language in teaching science
- To raise awareness of pupils’ language experiences and literacy across the curriculum
Say that:

- While we can regard science in part as a practical subject, language is at its heart. There is a richness of specialised words that often have dual meanings (one in everyday life and another in science) waiting to trip the unwary.

- A glance at the level descriptions shows that in science pupils are often expected to describe, generalise and explain.

- The precise use of scientific language and the ability to explain abstract ideas are important at Key Stage 3.

- The teaching of language has improved in primary schools recently because of the National Literacy Strategy. Many Year 7 pupils will have better-developed language skills than previous cohorts.

- The Key Stage 3 Strategy is supporting pupils' language development further.

- A key feature of the Strategy is that language is tackled at word, sentence and text level.

- All schools will have received some generic training about literacy across the curriculum. This training builds on that and is science specific.

Additional guidance
You may wish to add that the Ofsted secondary subject reports 2000/01: science (HMI 371) identified increasing attention to literacy in science departments. The report includes some useful examples and points out that the most effective development of literacy skills to support teaching and learning in science involves:

- reinforcement of the meaning and use of terminology by pupils in context;

- a reduction in routine written descriptions of practical activity and more writing about pupils’ own understanding and interpretation of information;

- extended writing for other purposes such as ‘ideas and evidence’;

- reading about science issues as well as reading for information.

Show slide 1.2 to indicate the structure of the unit.

<table>
<thead>
<tr>
<th>Session 1</th>
<th>Words in science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 2</td>
<td>Reading in science</td>
</tr>
<tr>
<td>Session 3</td>
<td>Writing in science</td>
</tr>
<tr>
<td>Session 4</td>
<td>Talk in science</td>
</tr>
</tbody>
</table>

Say that:

- Each session stands alone but there are many common threads.

- Each session has materials that you can take away and use either in the classroom or in discussion with your department.

Draw participants’ attention to the display of pre-unit tasks. Suggest they take the opportunity during the day to look at these and exchange experiences.
Say that:

- The work you have done on literacy across the curriculum in school will provide a foundation for the use of the materials provided in these sessions.

Show slide 1.3 that outlines the objectives for session 1 (words in science).

Objectives for session 1

- To raise awareness about the difficulties encountered when learning scientific words
- To identify the importance of word roots to the teaching of science
- To introduce a taxonomy of scientific words and show how to identify key scientific words within a topic
- To introduce a range of techniques for improving pupils’ skills in dealing with scientific terminology

Scientific terminology 10 minutes

Task A 5 minutes

Say that:

- Scientific words can cause pupils problems.
- Improving pupils’ spelling and understanding of the words will improve their understanding of science.

Show participants slide 1.4. Ask them to work in pairs or small groups to consider why some words may cause difficulty and how helping pupils to spell these words correctly might also help them to develop a better understanding of science at Key Stage 3.

Pupils’ use of scientific terminology

Why might these words cause problems?
- energy
- cell
- force

Why might these misspellings cause problems?
- hydraulic acid
- sodiam
- photosinthesus

How could their understanding of science be improved by attending to the difficulties?
After two or three minutes take feedback from pairs or groups.

Participants should quickly identify the problems associated with the difference between everyday use of terms, such as force, and the correct scientific use of the term. They may not recognise the significance of word roots.

Say that:

- Some words have ‘everyday’ meanings and pupils have a range of associations with them, for example force = strength.
- Just because a word is easy to read, such as energy, it does not mean it is easy to understand because it is a concept.
- Misspellings can cause problems because it will be less easy to spot the word roots that can provide pupils with an insight to the science behind the words.

Possible problems with scientific terminology 5 minutes

Ask participants to retrieve handout 1.5 and say that:

- Handout 1.5 provides a summary for future reference.
- In science at Key Stage 3, pupils are expected to use scientific terms precisely.
- Helping pupils to use and spell words correctly aids their scientific understanding because scientific terminology is often developed in systematic ways.
- Having a good grasp of scientific terms helps pupils to communicate observations and scientific ideas.
- This session explores how we can help pupils to develop their scientific vocabulary effectively.

Science terminology and word roots 10 minutes

Say that:

- Spending time introducing new scientific terminology well at Key Stage 3 saves time later.
- During literacy sessions in primary schools, teachers discuss new terminology and word roots with pupils.
- Year 7 pupils are familiar with terms such as prefix and suffix. These help them to talk about and understand the structure of words.
- Many scientific terms have word roots that help us to understand the science behind them.
- At Key Stage 3 you can build on pupils’ improved literacy skills to help them to develop a better understanding of science.
Task B
8 minutes

Show slide 1.6 and ask participants to work in pairs to identify which word roots would be helpful for pupils to know at Key Stage 3 science.

<table>
<thead>
<tr>
<th>Word roots</th>
<th>Slide 1.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look at the example.</td>
<td></td>
</tr>
<tr>
<td><strong>Word root</strong></td>
<td><strong>Meaning</strong></td>
</tr>
<tr>
<td>photo-</td>
<td>light</td>
</tr>
<tr>
<td>Which other word roots would be useful to know at Key Stage 3?</td>
<td></td>
</tr>
</tbody>
</table>

**Additional guidance**
In this session you may like participants to use the QCA scheme of work, pointing them to the ‘Language for learning’ section. You could divide participants into groups so that as many of the units as possible are covered.

After about five minutes ask participants to retrieve handout 1.7 and ask them to compare notes in groups of four.

Ask for any comments or feedback.

**Additional guidance**
The purpose of this session is not to provide a ‘definitive list’, but rather to raise awareness that paying attention to word roots is a useful device to help pupils to understand the science they are learning. Word equations begin to have some meaning when teachers relate these to particles by discussing word roots. Other word roots may be added to the list, such as morph (shaping). Not enough use is made of word roots.

**Key words in science at Key Stage 3**
15 minutes

Say that:

- Many departments help pupils to develop their scientific vocabulary by identifying key words for each topic.
- Many provide pupils with lists, sometimes placing them on the wall, but if these remain there permanently they can be viewed as ‘wallpaper’.
- On their own lists are not effective. Scientific words that are important have to be introduced carefully and then used regularly.
- Often these lists are too long and contain unnecessary words.
- Remember that pupils will have met many scientific terms before in Key Stage 2, so may just need reminding of these.
Show slide 1.8 and ask participants to retrieve handout 1.9.

**Key words**

When identifying key words, focus on the names of objects, processes and concepts within the topic.

A taxonomy of words of science:

- **Category 1: Names**
  - e.g. artery, granite, hydrogen

- **Category 2: Processes**
  - e.g. evaporation, respiration, digestion

- **Category 3: Concepts**
  - e.g. energy, force, atom

Say that:

- We can identify words as ‘key’ if they help pupils to communicate ideas in science clearly and with understanding.

- A useful way of doing this is to identify those words that describe the objects, processes and concepts to do with a topic. Thinking about words in these three categories helps to reduce the length of the list.

- When identifying key words it is important to retain a sense of perspective. Some words are more important than others. Words relating to the equipment used (such as Bunsen burner) should not take dominant positions. Rather you should look for words that help pupils to describe and explain their observations and ideas.

- The words pupils will have met at Key Stage 2 may not need to be included on the list. Therefore, as a teacher, you will need to judge what is needed for your pupils depending on their prior attainment and experiences.

- Scientific terms and technical language found in the QCA schemes of work for science for Key Stage 2 and Key Stage 3 are listed in appendix 3 of the Framework.

Allow participants a few moments to look at appendix 3 of the Framework and ask them how they might use it.

**Additional guidance**

The taxonomy of words is an important idea and will be new for most.

Talk through the key points of slide 1.8 showing how, by thinking about each topic in terms of object, concept and process, we can reduce the list of key words to those that matter.

Jerry Wellington and John Osborne in their book Language and literacy in science education (Open University Press, 2001) state the case for a taxonomy of words and make the point that naming words are easier to deal with because they provide names for observable, real objects. They go on to point out that some process words are less easy to visualise. ‘Whilst a teacher can point to a reaction on a front bench and say “There, that’s combustion” … other processes belong to a higher category, for example evolution (or geological processes at Key Stage 3). You cannot point these out.’
The third category of difficulty is that of concept words (power, fruit, salt, pressure, force, energy). Even though these may be easy to read, they are not easy to understand. Readability scores therefore do not always identify problems with science texts.

Point out that at Key Stage 3 a number of abstract concepts are introduced and that throughout the programme of study there are many processes that are introduced. Stress that dividing words into the three categories above can be a very helpful way of identifying key words.

**Task C**

Show slide 1.10 to introduce task C. Give out the QCA units and invite participants to explore the two questions on slide 1.10.

**Identifying key words for a topic**

Briefly read the section ‘Language for learning’ on two or three different QCA units. Questions for discussion:

- How do the instructions bring attention to the points so far discussed?
- How might your final key word list differ for an upper ability group and a lower ability group?

After about five to six minutes review quickly how the ‘Language for learning’ section tackles the words to be taught within a topic.

Next quickly discuss how teachers would adapt key word lists for different groups or abilities.

Say that:

- ‘Language for learning’ is a useful section for each topic, but it does not give a complete list of words.
- You will need to adapt your key word list for different groups of pupils.

**Additional guidance**

You could summarise the first part of the discussion by making these points:

- Names for many objects or structures are identified.
- Words which may cause problems, such as those having everyday meanings, are identified.
- Patterns in words (such as word roots) and ways of teaching the language are not provided.

You could summarise the second part by making these points:

- When identifying key words for different abilities you should be careful not to fall into the trap of making a longer list for pupils of lower ability.
Neither should you avoid seemingly difficult words. It would be better to focus your attention on a select group of words that would be most useful. For example, for lower ability groups working on the topic ‘cells’ it would be appropriate to focus on the words that are to do with structure, including ‘difficult’ areas such as membrane and nucleus and the plural nuclei, but pay less attention to the names of some specialised cells such as ciliated epithelial cells.

As teachers you will know the abilities of your pupils and be able to use your judgement, but always try to focus on a short list rather than a long list.

Appendix 3 of the Framework for teaching science: Years 7, 8 and 9 contains a list of scientific vocabulary arranged by year and attainment target. (You should specifically refer participants to this which was looked at earlier.)

QCA Key Stage 3 science tests: notes for teachers contains a list of words that must not be simplified or explained to pupils, since they form part of the scientific understanding tested by the question.

Teaching key scientific words

Say that:

- To help pupils to do their best you will need to spend time introducing new key words. Pupils need time to practise using them.
- They need opportunities to pronounce the new words, to explore how they are spelt and used. Do not be afraid to use terms such as noun, adjective or verb. Pupils will know these.
- The handouts and slides that we are about to look at provide a strategy for introducing new words that has proved effective.

Show slide 1.11 and ask participants to retrieve handouts 1.12 and 1.13. Guide participants through the two handouts, highlighting the key points. Point out that these can also be used back in school.

Introducing new key words

- Introduce the word.
- Write it on the board.
- Say the word.
- Ask pupils to say the word out loud.
- Break the word down into syllables.
- Ask pupils to read the word.
- Ask pupils to use the word in a description or explanation.
**Additional guidance**

When describing the technique for introducing key words, stress the importance of saying the words aloud. Pupils welcome this because they recognise it helps them to spell the word correctly and understand it. You may like to prepare other examples to illustrate the approach.

**Task D**

Show slide 1.14 to introduce the next task, which asks participants to apply the ideas that have just been discussed. Allow only two or three minutes and then take quick feedback.

**Task D**

How would you introduce the following key words and help pupils to spell and remember them correctly?

- aorta
- photosynthesis
- respiration
- vacuum
- calcium carbonate
- electromagnet
- chlorophyll
- parallel

**Practising using key words**

Say that:

- There are many ways in which pupils’ use of scientific terminology can be developed throughout a topic.
- During oral work you can insist on correct pronunciation and increase the opportunities for pupils to say words aloud.
- Lesson starters could focus on the key words for the topic, for example using a loop game or a card activity matching words to definitions, or even a quick 10-question test. (These will be covered in more detail later in the session.)
- Rather than putting a key word list for the topic on the wall, select out the key words that will be used during the lesson. These can be attached to a Velcro® pad and held up to display them.
- A homework activity could focus on word-level work, using activities such as word webs and word completion exercises.

**Task E**

Introduce the task by saying that in this part of the session participants will explore a range of activities for developing pupils’ scientific terminology. As an example participants watch a short video on an oral starter which shows a word loop game on cells.

Show slide 1.15 to focus discussion.
Then show the video clip. Ask participants to discuss it briefly in pairs then draw out the main points.

Additional guidance
All pupils were involved because they had to listen for the answer. Interest was maintained because there was an element of competition.

You need to stress that the game will be played on more than one occasion at the start of lessons. The object is for the class to increase the speed at which they complete it. Heading for a time target over the week can be very motivating.

If you wish, the group could play the game and then move quickly on to the last part of the session.

Show slide 1.16 and ask participants to retrieve handout 1.17.

Show slide 1.15 and ask participants:

**Task E**

For the loop game, consider:
- How does the activity support scientific understanding?
- How does the teacher ensure that all pupils are involved?

**Strategies for developing scientific terminology**

Read handout 1.17 which provides some examples of strategies to tackle word-level work in science.

What other strategies do you use that are effective?

Together with a partner choose a technique neither of you has used and discuss how you would use it in a future topic.

How would you know it was a successful technique?

Say that:
- Handout 1.17 provides a number of examples of how word-level work can be incorporated into science lessons, some of which you will be familiar with.
- Paying attention to terminology can help to raise standards in science; the end-of-key-stage tests require pupils to use precise language.
- In the final task in this session you will have an opportunity to discuss these ideas and some of your own. The important point to remember is that this work is effective if it is little and often and involves the class in oral work.

Allow participants 20 minutes for discussion and then take quick feedback recording other ideas on the flipchart.

Additional guidance
There are some helpful comments on cloze procedures (handout 1.17 part 3) in an article on reading in science, School Science Review, 83 (304), March 2002, pp. 51–62, to which you might like to refer.
Follow-up work 5 minutes

Say that:

• This session has explored the importance of word-level work in science.

• The main points to remember are:
  – identify key words with care, match your list to the needs of the pupils;
  – explore new words together, consider their structure, word roots and correct meaning;
  – provide opportunities for pupils to say words aloud;
  – use strategies to review words regularly (little and often).

Refer participants to handout 1.18 which contains the master for a loop card game.

Show slide 1.19 to introduce the follow-up work.

Follow-up work – science words Slide 1.19

Consider a future topic.

• Review the key word list in light of the taxonomy provided (names, processes, concepts).
• Select one of the suggested techniques and integrate it into your teaching of that topic.
• How will you evaluate the effectiveness of the change in teaching?

Allow participants two minutes to consider their actions and take brief feedback from one or two about how they might evaluate the effectiveness of their work.

Plenary 5 minutes

Use slide 1.3 to remind participants of the objectives of the session. Then show slide 1.20 to identify some anticipated outcomes. Ask participants to consider how far the objectives have been met.

Plenary for session 1 Slide 1.20

By the end of the session participants should:

• be aware of the difficulties encountered when learning scientific words;
• recognise the importance of word roots to the teaching of science;
• be able to identify a taxonomy of scientific words and identify key scientific words within a topic;
• recognise a range of techniques for improving pupils’ skills in dealing with scientific terminology.
Invite any further questions and points participants might like to make and encourage them to complete the evaluation form for session 1. Tell them that now is a good time to note any points from the session which they may want to follow up in school. These in turn can be linked to action points in their action planning. After all, their attendance on the unit should have been based on needs identified from the audit.

Remind them that the outcomes from the pre-unit task are on display for viewing and discussion.
Possible problems with scientific terminology

Some scientific words have everyday meanings as well as scientific meanings. It is important to make pupils aware of these differences. Constant reinforcement is needed to encourage correct usage. Scientific definitions of words should be made clear and distinctions made from everyday meanings.

Words with everyday meanings include:

**Force**  
often used interchangeably with energy and power; will probably have everyday associations rather than the scientific concept.

**Energy**  
often used interchangeably with force; linked to the everyday notion of energy being used up or running out which will lead to misconceptions.

**Material**  
although introduced with a scientific meaning in Key Stage 2, the everyday meaning often persists at Key Stage 3.

**Dissolve**  
sometimes used interchangeably with melt even though introduced correctly in Key Stage 2.

**Tissue**  
has a distinct scientific meaning but also has everyday meaning.

Many scientific words have been developed systematically. Knowing this can help pupils spot patterns and so develop their scientific understanding – for example, knowing that the word root *chlor* means green, and that within the name of a compound this could indicate the presence of a chlorine atom. This will aid understanding. Misspelling of words can lead to these patterns being missed.

Commonly misspelled words where patterns could be missed include:

**Hydraulic acid**  
A fairly common mistake; pupils miss the point about the chlorine atom being present.

**Sodium**  
It is not always easy for pupils to accept sodium as a metal. Knowing that the suffix *-ium* has been taken to mean ‘metal’ provides pupils with a powerful tool for recognising metals from names.

**Photosinthesus**  
Misspelling the word misses the word root, *syn*-, so pupils are unable to connect the word with the notion of building or putting together.
Some useful word roots

<table>
<thead>
<tr>
<th>Root</th>
<th>meaning</th>
<th>Root</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>aer</td>
<td>oxygen</td>
<td>iso-</td>
<td>the same</td>
</tr>
<tr>
<td>all</td>
<td>different</td>
<td>lign</td>
<td>wood</td>
</tr>
<tr>
<td>amphi-</td>
<td>both</td>
<td>lys</td>
<td>breakdown</td>
</tr>
<tr>
<td>ante-</td>
<td>before</td>
<td>macro-</td>
<td>large</td>
</tr>
<tr>
<td>anti-</td>
<td>against</td>
<td>micro-</td>
<td>small</td>
</tr>
<tr>
<td>arthr</td>
<td>joint</td>
<td>myc</td>
<td>fungus</td>
</tr>
<tr>
<td>bi</td>
<td>life</td>
<td>-oid</td>
<td>resembling</td>
</tr>
<tr>
<td>-ium</td>
<td>two</td>
<td>-on</td>
<td>a unit</td>
</tr>
<tr>
<td>bi-</td>
<td>heart</td>
<td>-ose</td>
<td>a carbohydrate</td>
</tr>
<tr>
<td>cardi</td>
<td>green</td>
<td>peri-</td>
<td>around</td>
</tr>
<tr>
<td>chlor</td>
<td>cell</td>
<td>phot</td>
<td>light</td>
</tr>
<tr>
<td>cyt</td>
<td>skin</td>
<td>sapr</td>
<td>decay</td>
</tr>
<tr>
<td>derm</td>
<td>two</td>
<td>spir</td>
<td>breathe</td>
</tr>
<tr>
<td>di-</td>
<td>across</td>
<td>stoma</td>
<td>mouth</td>
</tr>
<tr>
<td>dia-</td>
<td>outside</td>
<td>sym-, sym-</td>
<td>together with</td>
</tr>
<tr>
<td>ecto-</td>
<td>inside</td>
<td>therm</td>
<td>heat</td>
</tr>
<tr>
<td>endo-</td>
<td>mating</td>
<td>trans-</td>
<td>across</td>
</tr>
<tr>
<td>gam</td>
<td>earth</td>
<td>troph</td>
<td>feeding</td>
</tr>
<tr>
<td>ge</td>
<td>write</td>
<td>vas</td>
<td>vessel</td>
</tr>
<tr>
<td>graph</td>
<td>female</td>
<td>vor</td>
<td>feeding</td>
</tr>
<tr>
<td>gyn</td>
<td>blood</td>
<td>xyl</td>
<td>wood</td>
</tr>
<tr>
<td>haem</td>
<td>water</td>
<td>zoo</td>
<td>animal</td>
</tr>
</tbody>
</table>

These word roots are extracts from Signs and symbols in primary science, compiled by Neil Burton and Lynne Wright (ASE, 1998). A similar list appears in Signs, symbols and systematics: ASE companion to 5–16 science.

Pupils’ understanding of the naming of elements and compounds is not well developed during Key Stage 3. The following information about word roots will help:

- In the 18th century, Antoine Lavoisier was credited with the development of the modern view of elements and compounds and is sometimes dubbed the ‘father of modern chemistry’. The systematic naming of compounds saw a major revolution from this time onwards.

- New metals that were discovered were to end in -ium.

- Acids ending in -ic lead to the formation of salts with names ending in -ate (or sometimes -ide).

- Acids ending in -ous lead to the formation of salts with names ending in -ite.

- In simple terms, -ide, -ite and -ate can be related to the amounts of oxygen in a group of atoms in the salt.
Key words

When identifying key words focus on the names of objects or structures, processes and the concepts within the topic. You will also want to note those words that may cause difficulty because they have different everyday meanings and therefore require special attention.

The trick is not to make the list too long but to concentrate on what matters. You can regard this as forming a taxonomy of words. Names are the simplest words to understand. Some processes cannot be easily seen so cause problems in understanding what they mean. Concepts are largely abstract, and words such as force, even though easy to read, are nevertheless difficult to understand.

Category 1: Names
- e.g. artery, granite, hydrogen

Category 2: Processes
- e.g. evaporation, respiration, digestion

Category 3: Concepts
- e.g. energy, force, atom

Example for a topic on cells (e.g. QCA scheme of work unit 7A)

Key words

Names:
- cell
- cell wall
- red blood cell
- spermatozoon
- ovule
- neurone
- cytoplasm
- nucleus
- vacuole
- organ
- membrane

Processes:
- fertilisation
- respiration
- photosynthesis
- absorption

Concepts:
- adaptation
Introducing new key words

- Introduce the word (is it a name, concept or process?).
- Write it on the board.
- Say the word.
- Ask pupils to say the word out loud.
- Break the word down into syllables; point out similarities with other words, use mnemonics to remember spellings if necessary.
- Ask pupils to read the word as it is used.
- Ask pupils to use the word in a description or explanation.

Example

The word **hydrochloric** (acid) can be pronounced and written.

- Break the word into syllables to help pronunciation and spelling, such as **hydro-chlor-ic** (acid).
- Point out patterns with other words, such as acids ending in -ic (or -ous) and any word roots, for example **chlor** meaning green as in chlorine, chloroplast, chlorophyll. Relate the **chlor** to a chlorine particle and **hydro-** as in hydrogen.
- Establish the meaning of the word with pupils; for example, hydrochloric acid contains hydrogen and chlorine atoms.

Pupils can be asked to write a sentence using the word to show how it is used, such as ‘Hydrochloric acid will neutralise an alkali’.

Discussion

- How do you introduce new words?
- Would a ‘word root’ list help?
- How could this be used within the department?
Some useful ways to help pupils spell key words correctly

1 Syllabification
Help pupils by breaking down the word into syllables – get them to say it, write it and read it:
e.g. ox-y-gen, di-ges-tion, re-spir-a-tion, en-er-gy, el-e-ment

2 Grouping words
Talk to pupils about words with similar patterns:
e.g. -tion endings for processes – nutri-tion, fil-tra-tion, distilla-tion
    -ic endings for acids – sulphur-ic, nitr-ic, hydrochlor-ic

3 Making links
Talk to pupils about new words by making links with those they already know:
e.g. electrode from electron, filtration from filter

4 Spelling rules
Remind pupils of spelling rules (check with the English department):
(a) the split vowel digraph (formerly known as magic ‘e’):
    e.g. bitÆbite, ratÆrate
(b) y changes to i when adding a suffix:
    e.g. geologyÆgeological, classifyÆclassification
(c) the ‘i’ before ‘e’ except after ‘c’, when the sound is ee
    e.g. believe and receive

5 Personal dictionaries
Ask pupils to make up their own dictionaries based on key words. Encourage them to write definitions.

6 Cued spelling
Ask pupils to use mnemonics, or memory hooks, to remember troublesome words:
e.g. diarrhoeaÆDown In Africa Red Riding Hood Only Eats Apples
    laboratoryÆLab or a Tory (humour)
Some people remember the shapes of words and these can be exaggerated.

On some occasions saying a word differently can help:
e.g. Wed - Nes - Day or Elec-trol-Y-sis
7 Look, say, cover, write, check

This is a common, well-practised technique used in English departments and for pupils with special educational needs.

8 Calligrams

Sometimes exaggerating part of the word to help illustrate its meaning is helpful, for example making the double ‘ll’ in parallel much longer when writing it on the board helps pupils remember the spelling.

*These ideas about spelling have been adapted from Developing literacy – a course for teachers of Key Stage 3 and Key Stage 4, reproduced by permission of the Basic Skills Agency. There is a similar list in the spelling section of Literacy across the curriculum.*
Strategies for developing scientific terminology

1 Words and definitions (card games and flash cards)

These activities are card based and can be quite varied. Loop cards (see handout 1.18) are similar.

Word and definition cards

Two boxes of cards are used for a topic: one contains the words, the other contains the definitions. Pupils are asked to match the words with their definitions. Alternatively, the words and their definitions could be stored on computer and pupils could cut and paste the correct pairs.

Flash cards

In this variation a whole class is given a set of ‘flash cards’, for example key words to do with cells (perhaps seven each). The teacher then reads out a definition. Pupils, facing the teacher, hold up the word that they think the teacher is describing. Because all pupils are facing the front, the teacher can easily see which are correct and which are wrong.

Definition dominoes

In this game each card contains two ends (like dominoes). The idea is that pupils can play the game of dominoes using key words and definitions. Cards can be placed next to each other provided the definition matches the key word. Cards can be combinations of ‘definition–definition’ or ‘key word–definition’ or ‘key word–key word’.

2 ‘Quickie’ quiz

In this activity pupils take a ‘five-minute’ quiz read out by the teacher. Pupils respond with one-word answers. They exchange papers and check answers. Importantly, the questions that the majority of the class answered incorrectly are repeated in the next test, so that pupils have the chance of success. There will need to be a number of alternative tests, to be used as pupils move through a topic. One test per week seems to work well.

Example for cells

1. What is the name given to the fluid found inside a cell?
2. What is the name of the film surrounding cells, which controls what gets in and out?
3. What is the name of the stiff outer coat of a plant cell?
4. What is the oval body that controls cells and contains instructions to make more cells?
5 What is the name of the space found within cells?
6 What is the name of a group of the same type of cells?
7 What is the green body in plant cells that absorbs sunlight?
8 What is the name of the green chemical in plant cells?
9 This type of cell found in plants is long and thin with a large surface area to absorb water and minerals.
10 This type of cell makes antibodies to fight disease.

3 Word completion exercises

There are a number of word completion exercises that are often used such as cloze procedure, word searches and key word crosswords. When using these, care should be taken to make sure they are sufficiently challenging to pupils and do not merely become a way of occupying them. The examples below show how the level of challenge can be increased by requiring pupils to explore word roots.

Word webs

The purpose of this activity would be to point out the patterns in words through attention to word roots and so aid spelling and understanding. Pupils can use rhyming dictionaries to help find suffixes, and dictionaries to help with prefixes. You could provide sheets with starters, for example the words shown in bold in the example below. Pupils would have to add words they found, such as those in italics. This could be used as a homework activity.

Example

Cellar  
Cellophane  
Cellule  
Celluloid  
...  
So what does cell mean?

CELLULOSE

Glucose  
Sucrose  
Fructose  
Dextrose  
...  
So what does -ose mean?

Glyc  
Glycerine  
...  
So what does glyc- mean?
Word cluster posters

Here words with a common root are displayed together. The common root, often Latin or Greek, is pointed out, and the teacher explains how this makes spelling and remembering the meanings of the words easier. Pupils create their own cluster posters for their science laboratory, for example photosynthesis, photograph, photosensitive, photoreceptor, phototropism.

4 A loop card game

This is very effective at helping pupils learn and remember the key words.

Thirty playing cards are prepared with questions on one side and key word answers on the other side. The key word answer on one card relates to a question on a different card. Each pupil is given a card. (More able pupils might be given two depending on numbers.) One pupil will start the game by asking the question on their card. The rest of the class look at their cards and the correct answer is read out. That pupil then reads out the question on the other side of their card. The game continues until all questions are answered. The game is timed (say four minutes). This can then be repeated over a week until the class can answer in a shorter time, e.g. 90 seconds. This is motivating and generates enthusiasm.

Questions and answers can be printed on labels and stuck onto blank playing cards, which are available from a number of suppliers.

A three-card loop for cells

<table>
<thead>
<tr>
<th>Front</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>This type of cell contains no nucleus.</td>
<td>TISSUE</td>
</tr>
<tr>
<td>What is the name of the fluid inside the cell?</td>
<td>RED BLOOD CELL</td>
</tr>
<tr>
<td>Lots of cells grouped together are called …</td>
<td>CYTOPLASM</td>
</tr>
</tbody>
</table>
5 Concept maps

In this activity pupils can be provided with key words on cards and asked to link them together, in a way similar to mind maps. Pupils need to think about organisation (i.e. grouping) and how key words are connected. They place the cards on an A3 sheet, draw the connections and then write on the connections.

For example, part of an outcome might look like:
Cell loop cards for follow-up work

Lots of cells of the same type grouped together are called ….

<table>
<thead>
<tr>
<th>TISSUE</th>
<th>What do groups of tissues make up?</th>
<th>ORGANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>What film surrounding cells controls what goes in and out?</td>
<td>CELL MEMBRANE</td>
<td>What is the name of the fluid inside a cell?</td>
</tr>
<tr>
<td>CYTOPLASM</td>
<td>This part of the cell carries all the information about the organism.</td>
<td>NUCLEUS</td>
</tr>
<tr>
<td>This type of cell contains no nucleus.</td>
<td>RED BLOOD CELL</td>
<td>This type of cell can be found in the upper part of a leaf.</td>
</tr>
<tr>
<td>PALISADE CELL</td>
<td>Cells in air passages move mucus with hairs called ….</td>
<td>CILIA</td>
</tr>
<tr>
<td>This type of plant cell is long and thin to absorb water and minerals from the soil.</td>
<td>ROOT HAIR CELL</td>
<td>This type of cell has a tail to help it to swim.</td>
</tr>
<tr>
<td><strong>SPERM</strong></td>
<td>Leaf cells are green because they contain bodies called ....</td>
<td><strong>CHLOROPLASTS</strong></td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Chloroplasts are green because they contain the chemical ....</td>
<td><strong>CHLOROPHYLL</strong></td>
<td>Plant cells have a rigid outside called a ....</td>
</tr>
<tr>
<td><strong>CELL WALL</strong></td>
<td>The female sex cell is called an ....</td>
<td><strong>EGG</strong></td>
</tr>
<tr>
<td>To fight diseases your white blood cells make chemicals called ....</td>
<td><strong>ANTIBODIES</strong></td>
<td>These medicines fight bacteria.</td>
</tr>
<tr>
<td><strong>ANTIBIOTICS</strong></td>
<td>Many plant cells have a space inside called a ....</td>
<td><strong>VACUOLE</strong></td>
</tr>
<tr>
<td>This can cause disease.</td>
<td><strong>VIRUS</strong></td>
<td>This is found in the nucleus.</td>
</tr>
<tr>
<td><strong>DNA</strong></td>
<td>A red blood cell carries what around the body?</td>
<td><strong>OXYGEN</strong></td>
</tr>
<tr>
<td>What happens in the cytoplasm?</td>
<td>CHEMICAL REACTIONS</td>
<td>Root cells are long and thin so they can absorb ...</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>WATER and MINERALS</td>
<td></td>
<td>Which type of cell does not have a cell wall? ANIMAL CELL</td>
</tr>
<tr>
<td>The nucleus contains instructions to make ...</td>
<td></td>
<td>MORE CELLS Bacteria in foods can be ...</td>
</tr>
<tr>
<td>HARMFUL</td>
<td></td>
<td>This happens when a sperm cell meets an egg cell. FERTILISATION</td>
</tr>
<tr>
<td>What do antibodies in the bloodstream provide?</td>
<td>IMMUNITY</td>
<td>The thick cell walls in plants provide ...</td>
</tr>
<tr>
<td>SUPPORT</td>
<td></td>
<td>The process by which plants make their own food is called ... PHOTOSYNTHESIS</td>
</tr>
<tr>
<td>Every living thing is made of ...</td>
<td></td>
<td>CELLS</td>
</tr>
</tbody>
</table>

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Reading in science

Objectives

• To explore the ways and purposes of reading in science
• To provide teaching strategies to support active reading in science
• To explain how to support reading through shared reading

Resources

For tutor

Slides 2.1, 2.2, 2.4, 2.6, 2.10, 2.12
  copy of handout 2.9 or interactive whiteboard for use with handout 2.9

Handouts in tutors’ pack only
2.13 Sequencing activity (restructuring)
2.14 Diagrammatic representation (analysis)
2.15 Pupil sheet 1: To tell an acid from an alkali
2.16 Pupil sheet 2: To tell an acid from an alkali
2.17 Teacher guidance sheet: To tell an acid from an alkali

For participants

Handouts
2.3 How fresh is fresh?
2.5 Directed activities related to text (DARTs): a summary
2.7 Text marking (analysis) grid
2.8 Table completion (analysis) grid
2.9 Cells
2.11 Teacher guidance sheet: Cells

Red and blue highlighter pens

Session outline

<table>
<thead>
<tr>
<th>Session outline</th>
<th>1 hour 20 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Talk 5 minutes</td>
</tr>
<tr>
<td>Overview of the session</td>
<td>Whole group</td>
</tr>
<tr>
<td><strong>Reading and science texts</strong></td>
<td>Tasks F and G, talk</td>
</tr>
<tr>
<td>Considering ways and purposes of reading in science – continuous reading, close reading, skimming and scanning</td>
<td>Individuals, whole group 15 minutes</td>
</tr>
<tr>
<td><strong>Active reading in science</strong></td>
<td>Tasks H and I, talk</td>
</tr>
<tr>
<td>Looking at strategies to support active reading in science</td>
<td>Pairs, whole group 30 minutes</td>
</tr>
<tr>
<td><strong>Shared reading</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Looking at a strategy to support reading through shared reading</td>
<td>Whole group 15 minutes</td>
</tr>
</tbody>
</table>
Follow-up work
Considering further activities to try back in school

Plenary
Reflecting on the main points of the session

Introduction

Objectives for session 2
- To explore the ways and purposes of reading in science
- To provide teaching strategies to support active reading in science
- To explain how to support reading through shared reading

Say that:
- Reading in science should be a demanding activity.
- Often the vocabulary is highly specialised and science texts can be dense.
- Textbooks often break text down into small chunks to make it more accessible.
- The double-page spread can bring its own problems in navigating the text.
- Chunking can result in insufficient text to carry much meaning or information.
  Textbooks are now starting to carry more text and pupils need to be shown how to read them.
- Supporting pupils in reading and offering them ways to access text is better than reducing the amount and quality of their reading.

Reading and science texts

Ways of reading
Continuous reading: uninterrupted reading of continuous text
Close reading: careful reading and study
Skimming: glancing quickly through a passage to get the gist of it
Scanning: searching for a particular piece of information
Say that:

- Pupils are taught these terms and what they mean in English:
  - continuous reading, such as a novel or magazine article for pleasure;
  - close reading, which usually involves pausing to think, and referring backwards and forwards;
  - skimming, for example to see if an article is worth reading, or looking at sub-headings to gain an overview;
  - scanning, such as looking up a phone number or words in a text.

- It is important that teachers tell pupils which strategies to select and why, especially early on in Key Stage 3, so that they can select the appropriate strategy independently as soon as possible.

**Task F 5 minutes**

**Ways of reading in science**

Leave slide 2.2 on show and invite participants to think about when these ways of reading might be used in science and why. Explain that frequently one approach may be used as a way into another. For example, skimming is frequently followed by a close read of the relevant section(s) located through the skimming process.

Ask participants to give you examples of where each strategy is or might be used.

Possible responses may include:

- Continuous read: background reading on a topic of interest.
- Close read: developing understanding of a concept such as energy or a process such as digestion; considering the pros and cons of an argument.
- Skim: to find out if a chapter is worth reading; does the text, for example, provide sufficient and appropriate depth of information on cells to be worth reading?
- Scan: to find a topic in, for example, an index or to locate words to do with forces.

Briefly summarise key points from the feedback, then say that:

- It can be difficult to find texts at Key Stage 3 that contain sufficient scientific information to be useful to pupils.
- Textbooks are often, of necessity, brief and can become outdated quickly.
- Even when science readers are available, they are not always written so that pupils can engage with them actively (that is, lend themselves to DARTs activities – directed activities related to text – these will be discussed in more detail later).
- If specific texts are needed, it might be useful for departments to construct their own round a given topic. This can be helpful because:
  - They can be differentiated easily.
  - They can ensure both a good scientific experience for the pupils and a good read.
They will provide a richer teaching and learning experience than a traditional worksheet.

They can be stored in the department for future use and easily updated using IT. There is no need to rewrite, just amend.

Pictures, graphs and other support material can be imported easily to enhance the learning.

**Task G**

5 minutes

Say that:

- The texts you will use later in this session have been created with specific science purposes in mind.
- They are also written in such a way that pupils can actively engage with the text.
- They provide a model for you to write your own.

Ask participants to retrieve handout 2.3.

Say that:

- This is an example of a text created for specific science purposes.

Ask participants to read the text and consider why it is useful.

**Additional guidance**

*You could suggest that participants first skim read to get the gist and then close read the text.*

Participants should think about the topic; where it could be used; the kind of information it contains and why this would be useful at Key Stage 3.

Take feedback and make the following points:

- The article helps pupils realise that respiration takes place in the cell. Most would not regard a picked apple as living, or that the flesh of an apple is made of cells.
- The article brings some relevance to the science they are learning and makes connections with everyday life. This can be motivating to many.

Now show slide 2.4.

**Writing science texts for pupils**

Science texts that pupils can explore are better than traditional worksheets. To be effective they should:

- stimulate interest
- use the active voice
- use paragraphs
- help pupils make connections (e.g. with everyday life)
- use key scientific terms in context.
Say that:

- The article *How fresh is fresh?* is written with pupils in mind.
  - It has an engaging title.
  - It is written in the active voice so is easier to understand than if written in the passive voice.
  - Paragraphs break up the text.
  - The text is relevant to everyday life yet well matched to Key Stage 3 science, containing key scientific terms in new contexts.

- You could use this checklist to judge the worth of commercially produced texts.

Conclude by saying that we could use this text with pupils as it stands, asking them to skim read to get an overview and then close read each paragraph. The style in which it is written, however, allows us to use it in ways to encourage pupils to engage actively with reading. This is what we will look at next.

**Active reading in science**

30 minutes

Say that:

- Directed activities related to text (or DARTs), which some may remember from the 1970s, are good ways to ensure that pupils engage with text in a way that promotes understanding.

- They are *directed* because pupils are told why they are reading and what they should gain from the experience before they start.

- The activities are *active* because they make pupils think and take decisions. A good rule of thumb is ‘if an activity does not require pupils to make a decision, don't do it’.

Ask participants to retrieve handout 2.5 which summarises these types of activity.

Briefly talk through the sheet and point out that there are broadly two types of directed activity related to text:

- The first column (restructuring) shows those activities you can use with modified text, that is segments for sequencing or text where parts have been removed.

- The second column (analysing) is potentially more useful and shows the sorts of activity that you can use to help pupils engage purposefully with blocks of extended text.

Before moving on, draw participants’ attention to the cloze procedure (filling in the gaps).

Say that:

- Although used a lot, cloze procedure is often unsuccessful as an active reading strategy because pupils can often complete it from their general knowledge; they pick words out too easily from a passage or use grammatical cues to select words from a passage or a list, such as nouns, verbs, adjectives. They recognise they can only go in one place so guessing is often easy.
• Guessing in this way does not help pupils to develop a better understanding of science.

• If you want pupils to use key words or subject-specific terms, it might be better to use alternative means such as those suggested in the last session, for example matching words with definitions.

**Additional guidance**

You may find it useful to refer to the article on reading in science in the School Science Review, 83 (304), March 2002, pp. 51–62. In the pilot several consultants found interesting examples of cloze exercises in published texts to use with colleagues.

Tell participants they will now consider ways of using DARTs in their lessons that challenge pupils to engage with scientific texts.

**Task H**

10 minutes

**Example 1 Text marking (analysis)**

Ask participants to refer back to handout 2.3 *How fresh is fresh?*

Show slide 2.6 and ask participants to retrieve **handout 2.7**.

---

**Example 1 Text marking (analysis)**

The article in handout 2.3 tells you about how you can extend the shelf life of apples.

Skim read the article, then, working in pairs:

• highlight in red those things that happen as the apple ripens;
• highlight in blue ways of preventing ripening;
• once you have completed the highlighting, complete the grid on handout 2.7 by answering the questions.

Say that:

• The article tells you about how you can extend the shelf life of apples.
• You would first expect pupils to skim read the entire text.
• Then you would ask them to work in pairs to highlight in red those things that happen as the apple ripens and then highlight in blue ways of preventing ripening.

In pairs, ask participants to discuss how the exercise helps pupils to engage with the text and encourages understanding of respiration.

Take feedback and ensure the following points are made:

• Pupils know what they are looking for and have a clear purpose for reading.
• They have to engage with the text, they cannot copy passages.
- The skimming exercise ensures that pupils have an overview of the text before they close read.
- They have to think about the information and understand it in order to complete the columns.
- Working in pairs supports learning and develops discussion towards common understanding.
- Pupils are not isolated and do not have to commit themselves to an answer immediately.
- The teacher has a record in the grid to monitor understanding.
- The pupils have an aide-mémoire for future reference or revision.

**Task 1**

**Example 2 Table completion (analysis)**

Ask participants to retrieve **handout 2.8**. Ask them to work in pairs to:

- re-read the text on handout 2.3;
- find reasons for the statements in the left-hand column of handout 2.8;
- write the explanation in the right-hand column.

After three minutes, ask participants to consider how the task supports reading and understanding. Is anything different from the first exercise?

Ensure the following points are added to the comments on task H:

- Encouraging pupils to link cause and effect and provide explanations is essential in science at Key Stage 3. This type of table works well.
- Using ‘because’ encourages pupils to use connectives appropriately when they talk and/or write.
- Pupils could be encouraged to construct sentences from the table as a follow-up activity if there is a need to develop pupils’ ability to write explanations.

Briefly summarise the points and indicate that there is a range of activities, including sequencing, with which participants will be familiar.

End this section by saying that:

- DARTs can be used to help pupils understand text better.
- Be wary of using the cloze procedure as the only technique.
- Analysis techniques operate on ‘whole text’ and are ultimately more useful.
- It may be better to invest your time in finding or creating good examples of scientific text that pupils can explore rather than providing more standard worksheets – remember: **think active!**
Shared reading 15 minutes

Say that:

• Shared reading is a good way to introduce new or more difficult texts, especially those that contain a lot of new, specialised vocabulary.

• Pupils can then go on to an independent, active reading task.

• Whilst many are working in pairs, small groups or independently, the teacher can support one group who may need additional help, or the more able pupils who could be given a more difficult text on the same subject.

Ask participants to retrieve handout 2.9.

Say that:

• This is a sample text that might be used as a shared reading exercise.

• It could be difficult because there are many scientific terms; however, it has been constructed with a scientific purpose in mind.

• The text is designed to help pupils to gain a better understanding of the link between form and function in cells.

Show slide 2.10 and allow participants time to read it.

A strategy for shared reading

• The class can share the reading.
• The teacher copies the text onto an OHT.
• The pupils are then looking at the teacher and the text.
• The teacher gives the class an overview of the text.
• Specialist vocabulary can be taught before the reading.
• The teacher reads the text aloud to the end, encouraging pupils to follow.
• The teacher can then explain meanings and difficulties.

Explain to participants that with their help you are going to model the strategy.

Now model the strategy using handout 2.9, either as an OHT (or slide) or on an interactive whiteboard, following through the points below:

• Project the text onto a screen.

• Check participants are looking at the text on the screen and at you, which helps engagement and helps the teacher to monitor attention.

• Give the group an overview of the text, that is explain what it is about.

• Teach any specialist vocabulary before the reading. This should explain any word roots that are unfamiliar, such as cyto- or -plasm.

• Read the text aloud to the end, encouraging participants to follow.

• Explain meanings and difficulties: explanations can be written on OHT (or slide) and linked to the text by an arrow.
**Additional guidance**

Point out that you would not be asking pupils to read aloud round the class where they might feel threatened and stumble over new words.

Shared reading clearly includes using comprehension-type questions with pupils to clarify meaning. Pupils could then either work on the existing text or be given another similar text to develop their skills.

Say that:

- Once the pupils have an overview of the text and understand the vocabulary, they can be set tasks to do independently which develop their understanding.

Ask participants to retrieve **handout 2.11**. Allow them time to read briefly through the handout and explain that participants could try out the suggestions in handout 2.11 using the text in handout 2.9 with their pupils.

Encourage participants to think about the notion of shared reading. Ask them how it differs from what they already do.

Say that:

- Once again, this use of the text has a specific scientific outcome in mind.
- Notice again the use of pupils working together, supporting each other.
- Also notice that the text on cells is demanding and that technical words have not been avoided. However, the text is carefully constructed to lend itself to DARTs activities.

Conclude this part of the session by saying:

- All the activities ensure information processing and selecting rather than just copying or the more usual form of note taking.

**Follow-up work**

There are five additional handouts in your tutors’ pack from which you may wish to choose one or more as follow-up work for participants.

**Option 1**

They already have some materials that they can use back in school from tasks F, G, H and I. You can suggest that they use these as a follow-up to the unit.

**Option 2**

If you decide to use any of the additional handouts you will need to say something along the following lines:

- **Handouts 2.13 and 2.14** are other tasks, which could be set on the same text in handout 2.3. Participants could try them out with their own pupils.
- Handout 2.13 involves cutting up the text and giving it out as cards so that pupils have to sequence and restructure it.
• Handout 2.14 involves analysing the text and selecting key sentences about good storage for apples.

And/or:

• The following pupil (handouts 2.15 and 2.16) and teacher (handout 2.17) sheets provide you with a further opportunity to try out some of the techniques outlined earlier.

• The purpose of this reading is to help pupils to make links between what they are learning about acids and alkalis.

Say that:

• In doing any of these activities back in school you will need to decide:
  – which group you will use it with;
  – what type of writing you want to promote and why;
  – if you need to produce any different resources;
  – how you will evaluate its effectiveness.

Conclude this session by saying:

• Active reading strategies ensure pupils access text and make sense of it.
• They involve all the pupils so there is less off-task activity.
• They ensure a variety of learning styles: sort activities are good for kinaesthetic learners; mind mapping and diagrammatic responses help the visual learner; aural learners are helped by the talk.
• Groups can be organised carefully for purpose, such as mixed ability, gender groupings, less-able pupils with more able.

Plenary 5 minutes

Use slide 2.1 to remind participants of the objectives of the session. Then show slide 2.12 to identify some anticipated outcomes. Ask participants to consider how far the objectives have been met.

Plenary for session 2

By the end of the session participants should:
• have a greater understanding of the ways and purposes of reading in science;
• be able to use teaching strategies to support active reading in science;
• realise how to support reading through shared reading.

Invite any further questions and points participants might like to make and encourage them to complete the evaluation form for session 2. Tell them that now is a good time to note any points from the session which they may want to follow up in school. These in turn can be linked to action points in their action planning. After all, their attendance on the course should have been based on needs identified from the audit.
How fresh is fresh?

You may have noticed that the supermarkets sell apples and other fruits all the year round. Apples ripen in England in the autumn. Once ripe, they last up to a week or two. Apples are imported from other countries such as New Zealand to extend the season, but this alone will not make sure that you can have an apple at any time of the year. Many apples are picked just before they are ripe and then stored in a controlled environment. When stored carefully, some varieties of apple can last up to 12 months. So the apple you buy could be a year old.

How can you store an apple so that it will stay fresh? As apples ripen, the minerals and other chemicals in the cells that make up the apple tissue change. Starches in the cells change to sugars and the cell walls begin to break down, so when you bite into the apple it tastes sweet and juicy. If you want to keep an apple for longer you need to make sure it does not ripen too soon. You do this by picking the apple at the right time and then by storing it so that it ages slowly.

You can check how close apples in an orchard are to being ripe by testing one or two to see how much of minerals such as phosphorus, magnesium and potassium they contain. Cell walls need some of these minerals to maintain their rigidity. As the apple ripens, so the amount of each mineral in the fleshy part changes. By tracking the changes you can tell how ripe an apple is. Picking the apple at just the right time makes sure it will last longer.

Once picked the apple will continue to ripen, so this process needs slowing down. An apple is living and each of its cells continues to respire. This means that they continue to absorb oxygen from the air and give off carbon dioxide. As each cell respires, some of the stored food is converted to energy. The apple also gives off a gas called ethylene that helps to ripen the fruit. Controlling the atmosphere in the store can slow down the respiration rate in the apple cells. A slow-turning fan can keep the air circulating and blow away the ethylene as it is formed. If you decrease the level of oxygen and increase the level of carbon dioxide then cell respiration slows. Some varieties of apple will tolerate high levels of carbon dioxide in the atmosphere. For instance, Cox apples will tolerate 9% of carbon dioxide. These varieties can be stored for longer. Apples such as the Worcester will tolerate less, so cannot be stored for long periods.

The apple store is also cooled. This makes sure that any chemical reactions, such as respiration, will take place at a slower rate than normal.

Fruit such as apples cannot be frozen without becoming softer and mushy. This is because, as the water in the cytoplasm freezes, sharp crystals of ice form that burst the cell membranes and cell walls. As water freezes to form ice it expands, and this will also cause the cell walls and cell membranes to burst.

Growing and selling apples and other fruits is big business, so it is in the interests of many to extend the shelf life of these products as long as possible. But do they taste the same as freshly picked apples? The industry claims they do. If you are lucky enough to live in an apple-growing area you could try your own experiment, but you may have to wait until next autumn.
## Directed activities related to text (DARTs): a summary

<table>
<thead>
<tr>
<th>Reconstruction activities</th>
<th>Analysis activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>use modified text.</td>
<td>use straight text.</td>
</tr>
<tr>
<td>Pupil tasks: completion-type activities with deleted or segmented text.</td>
<td>Pupil tasks: text marking and labelling or recording.</td>
</tr>
</tbody>
</table>

### 1 Text completion
Pupils predict deleted words (cloze), sentences or phrases.

### 2 Diagram completion
Pupils predict deleted labels on diagrams using text and other diagrams as sources.

### 3 Table completion
Pupils complete deleted parts of a table using table categories and text as sources of reference.

### 4 Completion activities with disordered text
- Predicting a logical order for a sequence.
- Classifying segments according to categories given by the teacher.

### 5 Prediction
Pupils predict next part(s) of text with segments presented in sequence.

### 1 Underlining
Pupils search for specific target words or phrases that relate to one aspect of content, e.g. key words.

### 2 Labelling
Pupils label segments of text which deal with different aspects, e.g. labelling a scientific account with labels provided by the teacher such as prediction, evidence, conclusion.

### 3 Segmenting
Segmenting of paragraphs or text into information units.
Labelling of segments of text.

### 4 Diagrammatic representation
Constructing diagrams from text, e.g. using flow diagrams, concepts maps, mind maps, labelled models.

### 5 Tabular representation
Pupils construct and represent information in tabular form, extracting it from a written text.

This summary is adapted from Reading for learning in the sciences, by Davies and Green (Pearson Education Limited, 1984).
### Text marking (analysis) grid

<table>
<thead>
<tr>
<th>How can ripening be slowed?</th>
<th>What process does it stop?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Table completion (analysis)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples are imported from other countries such as New Zealand</td>
<td>because</td>
</tr>
<tr>
<td>When you bite into a ripe apple it tastes sweet and juicy</td>
<td>because</td>
</tr>
<tr>
<td>The apple store is cooled</td>
<td>because</td>
</tr>
<tr>
<td>Levels of oxygen are decreased</td>
<td>because</td>
</tr>
<tr>
<td>You cannot use freezing as a method to store apples</td>
<td>because</td>
</tr>
<tr>
<td>An unripe apple contains phosphorus, magnesium and potassium</td>
<td>because</td>
</tr>
</tbody>
</table>
Cells

Almost all cells have a nucleus which is suspended in a jelly-like fluid called cytoplasm. This cytoplasm is contained within a membrane that lets some substances in and out.

Cells can be different in shape, size and colour. This is because they do different jobs. Sperm cells have a small head and a long, lashing tail. Their job is to fertilise an egg cell. They have to swim to the egg; the head carries the genetic material. A palisade cell is found in the upper parts of a leaf and is green. The green colour is due to chlorophyll, a chemical that helps plants to photosynthesise. The job of a leaf cell is to produce glucose from carbon dioxide and water using energy from the Sun. A root hair cell is long and thin and so has a large surface area. Its job is to absorb water and minerals from the soil. Nerve cells have a small region which contains the nucleus and most of the cytoplasm. Other parts of the nerve cell can be very long and thin and even be shaped like the branches and twigs of trees. Their job is to pass on messages, in the form of electrical signals, to different parts of the body. For example, if your hand is burned in a flame, nerve cells would transmit messages from your hand to the central nervous system in your spine and then back to your arm muscles to pull your hand away from the flame.

So whilst all cells have the same features, such as cell membrane, nucleus and cytoplasm, what they look like can be very different. Their form and what extra they contain, such as chlorophyll or haemoglobin, helps them to perform different functions.
Teacher guidance sheet: Cells

Suggested activities

1 Text analysis (DARTs)

(a) Pupils can be asked to consider the text. For instance, they could be asked to:
   - underline in BLUE all words that identify different types of cells;
   - underline in RED all phrases that identify their function;
   - underline in GREEN all phrases that identify the structure of the cell.

(b) As a follow-up activity, pupils can be shown how to WRITE sentences which EXPLAIN the link between structure and function using connectives which indicate cause and effect (see connectives handout in Literacy across the curriculum, section 3).

You could provide a sentence structure indicating connectives, such as the structure of BLUE have GREEN because/as RED:

   e.g. Sperm cells have small heads and long, lashing tails because they have to swim to the egg to fertilise it.

2 Group reading leading to a writing activity

Pupils are asked to read a piece of text. In groups they then discuss the text. They might ‘mark’ it, for example use highlighting to identify features such as key words to do with names of parts of a cell. Pupils then, individually or as a class, write about an aspect of cells using the key words and information from the text.
Sequencing activity
(restructuring)

**Slowing down respiration**

Pupils are provided with a fragmented paragraph on cards and are asked to sequence the text to re-form the paragraph. Doing this will not only help pupils to develop a better understanding of respiration but also help them to formulate ideas about how to construct a logical argument.

<table>
<thead>
<tr>
<th>Once picked the apple will continue to ripen, so this process needs slowing down.</th>
<th>An apple is living and each of its cells continues to respire.</th>
</tr>
</thead>
<tbody>
<tr>
<td>This means that they continue to absorb oxygen from the air and give off carbon dioxide.</td>
<td>As each cell respires some of the stored food is converted to energy.</td>
</tr>
<tr>
<td>The apple also gives off a gas called ethylene that helps to ripen the fruit.</td>
<td>Controlling the atmosphere in the store can slow down the respiration rate in the apple cells.</td>
</tr>
<tr>
<td>A slow-turning fan can keep the air circulating and blow away the ethylene as it is formed.</td>
<td>If you decrease the level of oxygen and increase the level of carbon dioxide then the cell respiration slows.</td>
</tr>
<tr>
<td>Some varieties of apple will tolerate high levels of carbon dioxide in the atmosphere.</td>
<td>For instance, Cox apples will tolerate 9% of carbon dioxide.</td>
</tr>
<tr>
<td>These varieties can be stored for longer.</td>
<td>Apples such as the Worcester will tolerate less so cannot be stored for long periods.</td>
</tr>
<tr>
<td>The apple store is also cooled.</td>
<td>This makes sure that any chemical reactions such as respiration will take place at a slower rate than normal.</td>
</tr>
</tbody>
</table>

Pupils can be asked to think of a title for their reconstructed paragraph.
Diagrammatic representation (analysis)

Apple store

In this example of locating information, pupils are asked to convert text to labels.

Draw a box to represent the apple store. Label it with the features that make it a good store to keep apples.
To tell an acid from an alkali

You can group substances according to whether they are acidic, neutral or alkaline. But what does that mean? We all have an idea about what acids are and perhaps even what alkalis are. If you stopped someone in the street and said, ‘What is an acid?’, the chances are they would say it is something that burns you. Lemon juice contains an acid, so does vinegar. These substances do not burn, so this cannot be the whole story. We need a better way to tell what an acid is as well as ways of describing alkalis.

Acids and alkalis only really behave as acids or alkalis when they are in water. In the laboratory you use them diluted in water. Have you ever looked at them closely? They often look the same – colourless transparent liquids. So what are they and how can we tell them apart?

As it said before, lemon juice and vinegar both contain acids, so too do sour milk, limes, oranges and apples. Sour apples contain more acid. Does this give you your first clue? All these examples have something in common that is true of all acids. They all taste sour; they have a sharp taste. You would not want to taste acids such as sulphuric acid or nitric acid because these are harmful, even when diluted. When they are concentrated (more acid to less water) they are corrosive. What does this mean?

Corrosive means that the acids react with substances such as metal or skin cells. When this happens you can often see fizzing and things can get quite hot. This heat is a result of the chemical reaction. If concentrated acid is spilt on skin it can cause a burning sensation. So perhaps this is where the idea of ‘burning’ comes from. It is quite wrong, however, to say that acids burn. Burning happens in fires; it is a reaction between things such as fuels and oxygen.

Another property of acids is their ability to react with metals. Diluted acids react with many metals to form solutions and release bubbles of hydrogen gas. Acids also react with some rocks such as limestone. This is because rocks such as limestone contain calcium carbonate. You can see the reaction taking place as a ‘fizz’. The fizz is carbon dioxide gas being released.

Did you know that normal rain water is slightly acidic because it contains dissolved carbon dioxide? Carbon dioxide in water is called carbonic acid, and of course acids attack limestone rocks .... So the cycle continues.
Pupil sheet 2

To tell an acid from an alkali

Alkalis are quite different from acids but they can also be corrosive. Sodium hydroxide and ammonium hydroxide are two common alkalis. If you spill alkali on your skin it would feel soapy, because the alkali sets about dissolving the fat on and in the skin (another chemical reaction). This makes alkalis quite useful as cleaners. Oven cleaner sprays often contain sodium hydroxide. Alkalis are also used in the manufacture of soaps. Another useful alkali is potassium hydroxide which is sometimes used in the production of fertilisers.

Alkalis are therefore also corrosive. Like acids, they can react with metals and skin but they react in different ways. Alkalis can be just as harmful as acids, and they are even more harmful to eyes than acids. Indeed, our bodies are designed to cope with acids better than with alkalis. Did you know that the sweat from our skin is slightly acidic and that our stomachs contain hydrochloric acid to help with the digestion of food?

So how can we tell the difference between acids and alkalis? It would not be sensible to rely on taste or on a soapy feel to the skin. Luckily there is a better way. Extracts from some plants can be used to make indicators. These indicators often go red or yellow in acidic solutions and blue or violet in alkaline solutions. Litmus is an example which is made from a lichen. It turns red in acidic solutions and blue in alkaline solutions. You can also make your own indicator from red cabbage. Universal indicator is commonly used in the science laboratory. It is made from a mixture of compounds and will turn red, orange or yellow according to the strength of the acidic solution, red indicating the strongest acidic solution.

Even though acids and alkalis are both harmful, when you mix them together in the right proportions you can end up with a neutral substance that is no longer corrosive and is less harmful. The chemical reaction that occurs between acids and alkalis is called neutralisation. The resulting neutral solution will turn a universal indicator green. So we have a way to tell an acidic solution from an alkaline one, and from a neutral one, using indicators.

A final thought – have you noticed anything about the naming of acids and alkalis? Look at the names above. Can you spot a pattern? Can you tell an acid from an alkali by the way it is spelt?
Teacher guidance sheet

To tell an acid from an alkali

Suggested activity

Ask pupils to work in pairs and read either the article on handout 2.15 or the one on 2.16. They should then use an A3 sheet of paper to summarise what the article says about acids and alkalis. They should start by putting the words ‘acid’ and ‘alkali’ in the middle of the paper. Ask pupils to then produce either a concept map or a mind map with information from the article.

Display the cognitive maps and discuss similarities and differences with the pupils. Match this information to the text.

This is likely to be an effective learning activity because:

• pupils have shared the work so have refined and clarified ideas as they work;
• they have supported each other in the activity, hence they are not exposed;
• they have begun to make links between concepts;
• the exercise permits the teacher to assess the level of understanding;
• the final A3 sheets can be displayed to support further learning through the topic;
• the map can readily be used as a process for the start of another text type, such as a talk;
• the concept mapping ensures a variety of learning styles other than straightforward note-taking.

Next step

Use the same text with a different group and try one of the other suggested activities from the active reading and shared reading sessions.
Writing in science

Objectives

• To explore the purpose of writing in science and the implications for teaching
• To exemplify the structures and types of writing that are important in science
• To consider ways in which pupils’ writing in science can be improved

Resources

For tutor

- Slides  3.1, 3.2, 3.5, 3.7, 3.9, 3.10, 3.13, 3.16
- Handouts in tutors’ pack only
- 3.17 Index to handouts 3.18 to 3.40
- 3.18 Pupils’ work: What makes a good conclusion?
- 3.19 Pupil sheet A
- 3.20 Pupil sheet B: Examples of conclusions
- 3.21 Pupil guidance sheet: Writing conclusions
- 3.22 Teacher guidance sheet: Writing conclusions
- 3.23 Teacher guidance sheet: Explaining how
- 3.24 Teacher guidance sheet: Explaining why
- 3.25 Pupil sheet A: Examples of explanations
- 3.26 Pupil sheet B: Examples of explanations
- 3.27 Pupil guidance sheet: Writing explanations
- 3.28 Teacher guidance sheet: Supporting the writing of explanations
- 3.29 Teacher guidance sheet: Argument
- 3.30 Pupil sheet: Argument for seeing because light enters the eyes
- 3.31 Pupil guidance sheet: Constructing arguments
- 3.32 Teacher guidance sheet: Supporting the writing of argument
- 3.33 Teacher guidance sheet: Evaluation
- 3.34 Pupil sheet: Examples of evaluations
- 3.35 Pupil guidance sheet: Writing evaluations
- 3.36 Teacher guidance sheet: Supporting the writing of evaluation
- 3.37 Teacher guidance sheet: Planning
- 3.38 Pupil sheet A: Planning
- 3.39 Pupil sheet B: Writing plans
- 3.40 Teacher guidance sheet: Supporting planning

Video clip 2 Writing conclusions

For participants

- Handouts
  - 3.3 Recording sheet: Writing in science
  - 3.4 Purposes for writing in science
  - 3.6 Departmental discussion sheet: Supporting pupils in writing in science
  - 3.8 Types of writing
### Session outline 1 hour 20 minutes

<table>
<thead>
<tr>
<th>Introduction</th>
<th>1 hour 20 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Overview of the session</td>
<td>Whole group</td>
</tr>
<tr>
<td><strong>Why write in science?</strong></td>
<td>Tasks J and K, talk</td>
</tr>
<tr>
<td>Considering the purpose of writing in science and the implications for teaching</td>
<td>Pairs, whole group</td>
</tr>
<tr>
<td><strong>Developing a strategy to support pupils’ writing in science</strong></td>
<td>Task L (video), talk</td>
</tr>
<tr>
<td>Exemplifying the structures and types of writing that are important in science</td>
<td>Pairs, whole group</td>
</tr>
<tr>
<td><strong>Putting the strategy into practice</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Considering ways in which pupils’ writing in science can be improved</td>
<td>Pairs, whole group</td>
</tr>
<tr>
<td><strong>Follow-up work</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Considering further activities to try back in school</td>
<td>Whole group</td>
</tr>
<tr>
<td><strong>Plenary</strong></td>
<td>Talk</td>
</tr>
<tr>
<td>Reflecting on the main points of the session</td>
<td>Whole group</td>
</tr>
</tbody>
</table>

### Introduction 5 minutes

Say that:

- Pupils’ writing skills at Key Stage 2 are steadily improving although at a slower rate than reading.
- Many science teachers have been paying more attention to writing in science recently because they recognise that Key Stage 3 science requires pupils to use language precisely.
- This session will explore the purposes of writing in science, what you should expect of pupils and how you can best support them.
Show slide 3.1, the objectives of the session.

**Objectives for session 3**

- To explore the purpose of writing in science and the implications for teaching
- To exemplify the structures and types of writing that are important in science
- To consider ways in which pupils’ writing in science can be improved

Briefly invite participants to think about how often they ask pupils to write in science at Key Stage 3. Ask them to think about the lessons for a Year 7, Year 8 or Year 9 group over the last week. What proportion of time was devoted to writing? Were all homeworks written tasks? Take brief feedback then move on.

**Why write in science?**  **15 minutes**

**Task J**  **5 minutes**

Introduce task J by showing participants slide 3.2 and ask them to retrieve handout 3.3.

**Writing in science**

- Think about what you have asked pupils to write in science at Key Stage 3 and the reasons for this.
- Record as many ideas as you can on the recording sheet on handout 3.3.

Say that:

- Research shows that on average pupils spend about a third of their time writing in science lessons. This is a considerable investment.
- It is therefore important to make sure that what we ask pupils to write helps them to learn science.
- In pairs, complete the recording sheet. After about two minutes share your ideas with others.

*T Additional guidance*

*Newton, Driver and Osborne conducted the research mentioned above in 1999. Davies and Greene quoted similar findings in their book Reading for learning in the sciences, published in 1984.*

After about two minutes ask pairs to share their ideas with another pair.

Ask participants to retrieve handout 3.4 and quickly review the main points in the handout.

Ask participants for any other examples they wish to add.
Additional guidance

The list is presented with no judgements being made. However, slide 3.5 and handout 3.6 which follow make some types and purposes of writing more valuable than others. If discussion points this out you may wish to begin to discuss the issues here. You may acknowledge that some writing tasks are used to keep order and maintain control.

Show slide 3.5 to introduce task K and ask participants to retrieve handout 3.6.

---

Writing to support learning in science

<table>
<thead>
<tr>
<th>Writing will support learning in science when:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• the purpose is clear;</td>
</tr>
<tr>
<td>• the writing helps pupils to organise their thinking;</td>
</tr>
<tr>
<td>• pupils are challenged to think and make decisions about their writing;</td>
</tr>
<tr>
<td>• pupils are asked to write for a variety of purposes and audiences;</td>
</tr>
<tr>
<td>• the writing is well chosen and supports the point of the lesson;</td>
</tr>
<tr>
<td>• pupils are clear about the characteristics of the writing expected.</td>
</tr>
</tbody>
</table>

---

Task K

10 minutes

Briefly talk through slide 3.5. Ask participants to read handout 3.6. Then ask them to discuss the points in pairs and judge how well their departments measure up.

Take brief feedback. Point out that handout 3.6 could also be used back in school to promote a discussion about writing in science.

Additional guidance

You should use the opportunity to encourage discussion about the way we use writing in science. Some important seeds to sow are:

• The write-up of complete experiments is not obligatory and there is no ‘correct way’ such as using the third person and the past tense. Stress the point that the type of writing should support the learning objective.

• At Key Stage 3 there is no requirement to write about or do investigations in the manner required by an awarding body for GCSE. Key Stage 3 is far more flexible and you should use this opportunity to continue to teach investigative skills explicitly. The type of writing you use should support this.

• Pupils have been writing up their investigative work for six years in primary schools so have many skills in this area already.

• Copying notes for ‘revision’ is not a very effective use of time; copying does not promote learning. If the information is important you can provide it in a different way. Some schools provide pupils with a cheap revision book at the start of Year 8 or Year 9 as their ‘home’ textbook and encourage them to personalise it and annotate it. This reserves the exercise book for learning tasks.
Some types of writing are more effective in aiding learning. This type of writing should be encouraged.

You may find it useful to refer to the article on writing in science by R. Staples and R. Hesledon in School Science Review, 83 (303), December 2001, pp. 35–46.

Developing a strategy to support pupils’ writing in science

Additional guidance
This section develops further the issues covered in Literacy across the curriculum section 2. You may wish to establish who has studied this unit.

Show slide 3.7 and ask participants to retrieve handout 3.8.

Say that:

- There are many types of non-fiction writing that the curriculum demands of pupils.
- Literacy across the curriculum identifies the main types of non-fiction writing. These are shown in the middle column of handout 3.8.
- Slide 3.7 and handout 3.8 show how these match the main types of writing in science.

Main text types important in science at Key Stage 3

- Explanation – how
- Explanation – why
- Argument
- Conclusion
- Evaluation
- Plan

Review the handout briefly. Say that:

- Each of these categories (types of writing) has its own conventions at word, sentence and text level.
- Whichever text type you are dealing with, there is one common strategy that you can use to teach pupils.
Show slide 3.9 from Literacy across the curriculum which outlines a strategy for supporting writing.

**A strategy for supporting writing in science**

1. Establish clear aims
2. Provide example(s)
3. Explore the features of the text
4. Define the conventions
5. Demonstrate how it is written
6. Compose together
7. Scaffold the first attempts
8. Develop independent writing
9. Draw out the key learning
10. Review

*From Literacy across the curriculum, Key Stage 3 National Strategy.*

Say that:

- As science teachers you will have used writing frames (prompt sheets) to scaffold pupils’ attempts to plan their investigations or to write up an investigation. You may have used other writing frames.

- Writing frames can provide good support but they should not be seen as the solution. You should aim to help pupils to write independently.

- Pupils will make more rapid progress if you use all the strategies suggested here.

- The video you are about to watch will illustrate part of this sequence in helping pupils to develop better skills when drawing conclusions.

**Task L**

15 minutes

Show slide 3.10 to introduce the video clip *Writing conclusions.*

**Writing conclusions**

The video you are about to watch will illustrate parts of this sequence applied to teaching the writing of conclusions.

As you watch:

- make a note of the strategies the teacher uses to help pupils to produce a good written conclusion.

After you have watched:

- discuss in pairs what you have noted and consider what else you might do.

Then show the *video clip.*
Additional guidance

The video shows a teacher with a Year 9 class. They are of mixed ability. He is helping them to improve their writing of conclusions. The final conclusions written by each group are contained in the tutors’ pack for this session (handout 3.18). Use these only if teachers are keen to see them, but be careful about the timing of the session.

After the video finishes, allow pairs to comment on the strategies and add others of their own. Point out the main features of the video and match them to slide 3.9.

Ask participants to retrieve handouts 3.11 and 3.12 and say that:

- Good conclusions often have a three-part structure. Handout 3.11 shows this.
- Handout 3.12 shows the main features of the text in the form of a teacher guidance sheet.
- The ‘language features’ column will help you to identify those points that need to be made to pupils.

Essential points to make clear

Talk participants through the ‘language features’ column and help them to recognise the structure of the guidance sheet. Point out the text-level, sentence-level and word-level comments. Pupils make good progress when language is promoted at these three levels. Refer participants to the introductory session and the word-level work in session 1. They may need to be reminded of naming, process and concept words.

It is important that participants understand the terms used, such as connectives, because they will be referring to these shortly in other guidance sheets.

Additional guidance

You might like to remind participants at this point of word-level work where key words were identified at three categories of difficulty: names, processes and concepts. Some process words are more difficult to understand because the process cannot easily be seen or there is an insufficient grasp of the ‘big picture’, such as photosynthesis or digestion. Asking pupils to write an explanation of how these take place aids their understanding because they will have to use their imagination to explain something they cannot see and put all the pieces together for themselves in a logical sequence. Explaining why will bring into sharp relief the category of words we call conceptual. These concept words are abstract and often have dual meanings.

Handout 3.1 (Connectives as signposts) from Literacy across the curriculum may be useful here if participants are unclear about connectives.

In your tutors’ pack of extra materials you have copies of handouts 3.19–3.22. You could either photocopy these and give them to participants to take away and use in school as part of the follow-up task or keep them to use with participants in your follow-up/support work (see page 71 for details under follow-up work).
Putting the strategy into practice  

15 minutes

Show slide 3.13 to remind participants of the text types that are important in science at Key Stage 3.

### Important text types

- Explanation – how
- Explanation – why
- Argument
- Conclusion
- Evaluation
- Plan

Say that:

- We will now apply the strategy for supporting writing.
- Some types of non-fiction writing help pupils to organise their scientific thinking.

Ask participants to retrieve handout 3.14. Say that:

- These types of writing are important at Key Stage 3 because:
  - **constructing explanations** (of how and why) helps pupils to describe and explain processes and link ideas together using concepts;
  - **constructing arguments** is a skill pupils need for exploring ideas and evidence;
  - **drawing conclusions**, **writing evaluations** and **constructing plans** are skills needed for scientific enquiry.

- These types of writing have conventions that pupils need to be taught explicitly.
- You can also use handout 3.14 to instigate a departmental discussion back in school about what types of writing are used to develop pupils’ understanding of science at Key Stage 3.

Allow participants to read through handout 3.14 and discuss with a colleague. Invite any comments.

Depending on any time available, you could use some of the handouts 3.23 to 3.40 in your tutors’ pack to discuss and model the strategy for one of the types of science text. This would reinforce the approach seen on the video for writing conclusions.

### Additional guidance

You may wish to make the point that there are other types of writing that can be used to help pupils to understand science, such as story telling (for example the story of an oxygen molecule passing through the body) or poetry. Such creative writing has its place, but we must make sure that the expected ways of communicating science are fully developed. You may wish to explore the questions at the bottom of handout 3.14 with the participants by asking them to reflect on the work of one group over the last four weeks.
Say that:

- You should expect pupils to make progress in each category across Key Stage 3.

Ask participants to retrieve **handout 3.15** which shows what that progress should look like. Allow participants time to read and discuss the handout. Invite any comments.

**Follow-up work**

There are a large number of additional handouts (3.18 to 3.40) that can be used for follow-up work. The risk is that they will be taken but not used. For this reason they are only in your tutors’ pack and not in the participants’ materials. You need to decide, given local circumstances and the feel of the training, whether to keep these for later support work in schools or to give out some or all of them now. If you do give them to participants now (option 2 below), explain the detail and use of the handouts as you distribute them.

**Option 1 (5 minutes)**

If you decide not to give them out then say that:

- A good starting point to use what you have discussed today back in school is to check out with your department the purposes of writing in science (handouts 3.3 and 3.4).
- Similarly the departmental discussion sheets (handouts 3.6 and 3.14) could be used to promote discussion.
- Whatever you decide to do, you should link your action points into your action planning.

You may wish to allow participants an opportunity to discuss how they might use these handouts.

Now go to the plenary session.

**Option 2 (10 minutes)**

If you decide to distribute all or some of the additional handouts say that:

- The extra handout(s) provide guidance on text types with examples, writing frames and teachers’ notes on how to use these in the classroom.

**Handout 3.17** outlines the additional handouts related to this session.

Say that:

- When back in school, skim through the materials and then select those you would like to try in your classroom. The purpose is to try out the approach suggested.
- What you need to decide now is:
  - Which group will you be working with?
  - What type of writing do you want to promote and why?
- Will you need to produce any different resources?
- How will you evaluate its effectiveness?

• In using them with your own pupils, you may have to modify the materials to suit their age and abilities.

Give participants some time to discuss these issues. If there is time, you may wish participants to look through the materials.

As part of the follow-up work, when you visit each school, find out which of the materials are being used in the classroom and what the impact is. You may wish to start some of these negotiations now.

**Plenary**

<table>
<thead>
<tr>
<th>Plenary for session 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>By the end of the session participants should:</td>
</tr>
<tr>
<td>• recognise the purpose of writing in science and the implications for teaching;</td>
</tr>
<tr>
<td>• appreciate the structures and types of writing that are important in science;</td>
</tr>
<tr>
<td>• know ways in which pupils’ writing in science can be improved.</td>
</tr>
</tbody>
</table>

Plenary for session 3 Slide 3.16

Use slide 3.1 to remind participants of the objectives of the session. Then use slide 3.16 to identify some anticipated outcomes. Ask participants to consider how far the objectives have been met.

Invite any further questions and points participants might like to make and encourage them to complete the **evaluation form** for session 3. Tell them that now is a good time to note any points from the session that they may want to follow up in school. These in turn can be linked to action points in their action planning. After all, their attendance on the course should be based on needs identified in the audit.
# Recording sheet: Writing in science

<table>
<thead>
<tr>
<th>Type of writing</th>
<th>Purposes</th>
</tr>
</thead>
<tbody>
<tr>
<td>e.g. answer to questions</td>
<td>e.g. to check understanding</td>
</tr>
</tbody>
</table>
### Purposes for writing in science

<table>
<thead>
<tr>
<th>Examples of types of writing</th>
<th>Possible purposes</th>
</tr>
</thead>
</table>
| Answers to questions                              | • To check understanding  
• To provide a task for homework                                                        |
| Plan for an investigation                        | • To learn how to make decisions about how to collect evidence that is valid and reliable  
• To learn how to set out a procedure  
• To assess planning skills                                                               |
| Record of observations or measurements           | • To learn how to assemble evidence in such a way that it can be interpreted easily  
• To assess recording skills                                                              |
| Conclusion to an experiment                      | • To learn how to analyse evidence, construct arguments and develop reasoning skills  
• To assess understanding                                                                  |
| Evaluation of an experiment                      | • To learn how to evaluate procedures  
• To check procedural understanding, e.g. of the need for a fair test or the reliability of measurements |
| Note taking                                       | • Aid for revision                                                                |
| Explanation                                       | • To help pupils to make links between ideas and apply their understanding  
• To probe understanding and reveal misconceptions  
• To help pupils to explain their thinking                                                  |
| Argument                                          | • To analyse and present conflicting views  
• To develop the skills for considering evidence  
• To engage pupils  
• To allow pupils to demonstrate achievement  
• To capture creative thought                                                            |
| Experimental write-up                             | • To show how scientists report findings  
• To make sure pupils have completed the work                                              |
| Worksheet completion                              | • To check understanding  
• To provide a task for homework                                                            |
# Departmental discussion sheet: Supporting pupils in writing in science

<table>
<thead>
<tr>
<th>Writing will support pupils’ learning in science when:</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>• the purpose is clear</td>
<td>Pupils can find writing in science a chore because they do not see the point. You should be clear about why setting a writing task will help pupils to develop their understanding of science further.</td>
</tr>
<tr>
<td>• the writing helps pupils organise their scientific thinking</td>
<td>Some types of writing help pupils to learn by organising their thinking (e.g. writing an explanation on how digestion takes place, or constructing an argument about what the evidence is for a spherical Earth). Currently these happen infrequently. More opportunities should be provided to do this.</td>
</tr>
<tr>
<td>• pupils are challenged to think and make decisions about their writing</td>
<td>Some types of writing do little to challenge and merely let pupils mark time (e.g. copying notes). Research has shown that learning does not take place if pupils merely copy. The rule of thumb is: • if the writing task does not require pupils to make decisions – don’t do it.</td>
</tr>
<tr>
<td>• pupils are asked to write for a variety of purposes and audiences</td>
<td>Giving pupils little variety in their writing can be demotivating (e.g. answering the questions in the textbook or writing up the experiment).</td>
</tr>
<tr>
<td>• the writing is well chosen to support the point of the lesson</td>
<td>Think carefully how writing can help pupils to learn the science. If you are teaching pupils how to record observations in a particular format, don’t waste time asking them to write up the whole experiment. This distracts pupils from the point. This is a case where less means more.</td>
</tr>
<tr>
<td>• pupils are clear about the characteristics of the writing expected</td>
<td>To write well, pupils need to understand the characteristics of different text types. For example, they need to be taught how to structure a conclusion, how to frame an argument when considering ideas and evidence, and how to construct an explanation. There are differences between explaining how and explaining why. Pupils need models for their writing. Just as a picture paints a thousand words, so examples achieve the same.</td>
</tr>
</tbody>
</table>

## Reflection
- What are the implications?
- How well do your writing tasks support pupils’ learning in science?
## Types of writing

<table>
<thead>
<tr>
<th>Science writing</th>
<th>Type of non-fiction writing</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explaining how</td>
<td>Explanation</td>
<td>How digestion takes place</td>
</tr>
<tr>
<td>Explaining why</td>
<td></td>
<td>Why some metals rust</td>
</tr>
<tr>
<td>Experimental report</td>
<td>Recount (report)</td>
<td>The refraction of light through a prism</td>
</tr>
<tr>
<td>Observational account</td>
<td></td>
<td>What happens as a candle burns?</td>
</tr>
<tr>
<td>Description</td>
<td>Information</td>
<td>A description of different types of rocks or soils</td>
</tr>
<tr>
<td>Persuasion</td>
<td>Persuasion</td>
<td>Using facts to persuade someone to give up smoking</td>
</tr>
<tr>
<td>Argument</td>
<td>Analysis</td>
<td>Considering evidence – the possible causes of global warming</td>
</tr>
<tr>
<td>Planning an experiment</td>
<td>Analysis</td>
<td>Consider the factors affecting the rate of dissolving</td>
</tr>
<tr>
<td>Drawing a conclusion</td>
<td>Analysis</td>
<td>Analysis of results of an experiment on the factors affecting the strength of an electromagnet</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Evaluation</td>
<td>Considering improvements to an experiment</td>
</tr>
<tr>
<td>Description</td>
<td>Discursive</td>
<td>The possible effects of burning fossil fuels and how to minimise these</td>
</tr>
</tbody>
</table>
Teacher guidance sheet 1: Writing conclusions

The structure of a conclusion will vary slightly depending on the context, but will follow the main stages as illustrated with three different skills.

**Considering evidence**

- **Skill 1**
  - **Describing relationships** by looking at tables, graphs, series of observations and measurements and writing generalisations; identifying anomalous results.

- **Skill 2**
  - **Drawing concluding remarks** that are consistent with the evidence and answer the original enquiry. Conclusions may be drawn from patterns or directly from observations and measurements.

- **Skill 3**
  - **Relating conclusions to scientific knowledge and understanding** either by explaining conclusions in the light of pupils’ developing scientific ideas or using the findings to suggest a hypothesis for testing.

- Pupils need to be taught to describe relationships, using comparative adjectives, when appropriate, to make generalisations.

- Pupils need to be taught to draw concluding remarks that relate back to the enquiry question and are consistent with the evidence. They may need to relate their conclusion to a prediction made.

- Pupils need to be taught how to use their scientific knowledge and understanding to support their conclusions or suggest further ideas to test.
## Teacher guidance sheet 2: Writing conclusions

<table>
<thead>
<tr>
<th>Text type</th>
<th>Purpose</th>
<th>Language features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conclusion</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| **Examples** | • What affects the strength of an electromagnet?  
• How are plants adapted to suit their environment? | • To present an analysis and interpretation that is consistent with the evidence. |
| **Text** | Generally has three parts: | |
| | • One section describes any patterns in the results as generalisations, e.g. *the larger the number of coils the stronger the electromagnet. Also the larger the current...* |
| | • Another summarises these as a concluding remark which relates directly back to the enquiry question, e.g. *the factors that affect the strength of an electromagnet are...* |
| | • In the third section, attempts are made to explain the remark in terms of scientific understanding or relate back to any prediction made, e.g. *the reasons for this are that when electricity flows through a wire it produces a magnetic field... I predicted that...* |
| | It may suggest further ideas to test. |
| **Sentence** | | |
| | • Active voice, often first person. |
| | • Connectives help to describe patterns using comparative adjectives, e.g. *longer, hotter, heavier.* |
| | • Connectives used to establish cause and effect, e.g. *because, since, therefore, as a result...* Also relate to evidence, e.g. *this shows that, I know this because...* |
| **Word** | | |
| | • Process words and concept words dominate. |
Departmental discussion sheet: Non-fiction writing in science

<table>
<thead>
<tr>
<th>Text type</th>
<th>Purpose in science</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanation</strong></td>
<td><em>Explanation</em> helps pupils to develop their scientific knowledge and understanding and reveals misconceptions across all attainment targets.</td>
</tr>
<tr>
<td>(of how and why)</td>
<td><em>Explaining how</em> helps pupils to understand processes better by describing them, e.g. how digestion takes place, how light travels through materials.</td>
</tr>
<tr>
<td></td>
<td><em>Explaining why</em> helps pupils to link ideas together. They use concepts, abstract scientific ideas and models to explain phenomena, e.g. explain why diffusion occurs using the particle model; or why enzymes are needed for digestion.</td>
</tr>
<tr>
<td><strong>Argument</strong></td>
<td><em>Constructing arguments</em> is a skill pupils need in order to explore ideas and evidence. It helps pupils to explore and see the significance of evidence. Questions relating to ideas and evidence are new to the Key Stage 3 tests.</td>
</tr>
<tr>
<td><strong>Conclusion</strong></td>
<td><em>Drawing conclusions</em>, <em>writing evaluations</em> and <em>constructing plans</em> are skills needed for scientific enquiry. Drawing conclusions helps pupils to describe patterns, generalise and use scientific understanding to explain observations.</td>
</tr>
<tr>
<td><strong>Evaluation</strong></td>
<td><em>Writing evaluations</em> helps pupils to consider the reliability and validity of the evidence collected and suggest improvements.</td>
</tr>
<tr>
<td><strong>Plan</strong></td>
<td><em>Constructing plans</em> helps pupils to apply their developing understanding. Pupils use their scientific ideas to make predictions, decide what evidence should be collected and how. Constructing plans helps pupils to organise their thinking by describing safe procedures for collecting the evidence.</td>
</tr>
<tr>
<td><strong>Reflection</strong></td>
<td>• What balance do you give to these types of writing across each year group?</td>
</tr>
<tr>
<td></td>
<td>• Are there sufficient opportunities for pupils to develop their understanding of science through writing?</td>
</tr>
</tbody>
</table>
### Teacher guidance sheet: Progress in writing in science across Key Stage 3

<table>
<thead>
<tr>
<th>From dependent</th>
<th>To independent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explanations of how:</strong></td>
<td><strong>Explanations of why:</strong></td>
</tr>
<tr>
<td>• lack organisation and sequence</td>
<td>• have good links made through the use of suitable connectives, e.g. because, so and therefore</td>
</tr>
<tr>
<td>• use naming words occasionally or incorrectly</td>
<td>• use the key ideas in science at Key Stage 3 well to explain phenomena</td>
</tr>
<tr>
<td><strong>Explanations of why:</strong></td>
<td>• use process and concept words effectively</td>
</tr>
<tr>
<td>• do not link cause and effect</td>
<td><strong>Arguments:</strong></td>
</tr>
<tr>
<td>• demonstrate no clear understanding of how the key ideas at Key Stage 3 can be used to explain phenomena</td>
<td>• have a clear structure</td>
</tr>
<tr>
<td>• use naming words and process words correctly or incorrectly</td>
<td>• present a reasoned approach</td>
</tr>
<tr>
<td><strong>Arguments:</strong></td>
<td>• state clearly what evidence there is and how it supports a point of view</td>
</tr>
<tr>
<td>• lack structure</td>
<td>• state where there is evidence to the contrary</td>
</tr>
<tr>
<td>• express opinion</td>
<td><strong>Conclusions:</strong></td>
</tr>
<tr>
<td>• pay little attention to the evidence</td>
<td>• have a clear structure</td>
</tr>
<tr>
<td><strong>Conclusions:</strong></td>
<td>• describe patterns</td>
</tr>
<tr>
<td>• restate the results</td>
<td>• make generalisations using connectives, e.g. as… so…</td>
</tr>
<tr>
<td>• do not make generalisations</td>
<td>• relate directly to the enquiry question</td>
</tr>
<tr>
<td>• do not answer the original enquiry questions</td>
<td>• make attempts to explain observations using scientific knowledge</td>
</tr>
<tr>
<td>• do not attempt to explain observations using scientific ideas</td>
<td>• show how the evidence supports any prediction being made</td>
</tr>
<tr>
<td><strong>Evaluations:</strong></td>
<td><strong>Evaluations:</strong></td>
</tr>
<tr>
<td>• have no logical structure</td>
<td>• are well structured</td>
</tr>
<tr>
<td>• do not explore ideas of reliability or validity</td>
<td>• justify improvements in procedures by explaining how these will improve the validity or reliability of the evidence collected</td>
</tr>
<tr>
<td>• state how to improve an experiment without explaining how this will improve the validity or reliability of the evidence</td>
<td><strong>Plans:</strong></td>
</tr>
<tr>
<td><strong>Plans:</strong></td>
<td>• state clearly what is to be investigated, what evidence needs to be collected and a clear procedure for doing this</td>
</tr>
<tr>
<td>• are disorganised</td>
<td>• may state a prediction, and if so, will provide justification for this</td>
</tr>
<tr>
<td>• lack purpose and do not set out adequate procedures</td>
<td><strong>Placy</strong></td>
</tr>
<tr>
<td>• make predictions without justification</td>
<td><strong>Plans</strong></td>
</tr>
</tbody>
</table>

From dependent to independent.
Index to handouts
3.18 to 3.40

3.18 Pupils’ work: What makes a good conclusion?
3.19 Pupil sheet A
3.20 Pupil sheet B: Examples of conclusions
3.21 Pupil guidance sheet: Writing conclusions
3.22 Teacher guidance sheet: Writing conclusions
3.23 Teacher guidance sheet: Explaining how
3.24 Teacher guidance sheet: Explaining why
3.25 Pupil sheet A: Examples of explanations
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3.27 Pupil guidance sheet: Writing explanations
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3.31 Pupil guidance sheet: Constructing arguments
3.32 Teacher guidance sheet: Supporting the writing of argument
3.33 Teacher guidance sheet: Evaluation
3.34 Pupil sheet: Examples of evaluations
3.35 Pupil guidance sheet: Writing evaluations
3.36 Teacher guidance sheet: Supporting the writing of evaluation
3.37 Teacher guidance sheet: Planning
3.38 Pupil sheet A: Planning
3.39 Pupil sheet B: Writing plans
3.40 Teacher guidance sheet: Supporting planning
Pupils’ work: What makes a good conclusion?

Commentary

This handout contains the written conclusions provided by each group on flipcharts in the Year 9 video clip Writing conclusions. They have been typed, but contain original spellings, phrases and paragraphing.

Group 1

The cooler the water the longer the salt takes to dissolve. The hotter the water the faster the salt dissolves.

We conclude that the greater the temperature, the faster the salt dissolves.

When the water heats up the water particles move faster. This enables the salt to dissolve quicker. So this means that the cooler the temperature of the water the slower the water particles move around so they don’t collide as much. The warmer the water the faster the water particles move so they collide into the salt particles more often dissolving the salt faster.

Group 2

How does the temperature effect solubility of SALT?

We found out the hotter the water, the quicker the salt dissolved and the cooler the water, the longer it took the salt to dissolve.

The cooler the water particles, the slower the salt particles move. The hotter the water particles, the faster the salt particles move.

The heat of the water effects how fast or slow the salt particles collide and dissolve.

Group 3

How does temperature effect the solubility of salt

The graph shows that the cooler the temperature the longer it takes for the salt to dissolve. The higher the temperature the shorter amount of time is taken.

From this we conclude that the higher the temperature the less time it takes to dissolve.

When the water is hotter the particles move faster so the salt dissolves quicker. When the water is cooler the particles move slower so the salt dissolves slower.

Group 4

HOW DOES THE TEMPERATURE AFFECT THE SPEED OF WHICH SALT DISSOLVED?

In this experiment we found out that the cooler the water the more time it took the salt to dissolve, the warmer the water the less time it took the salt to dissolve.

We conclude that the warmer the water the quicker the salt dissolves.

When the water is cool the particles move slowly and when the water is warm the water particles move faster and when they bump into the salt, the salt dissolves making a solution.
**Pupil sheet A**

**Experiment: What happens when acid is put on rock?**

When pupils were investigating rocks they were asked to find out what happened when dilute acids were placed on the minerals that made up the rocks. Here is a set of their results.

**Results**

<table>
<thead>
<tr>
<th>Mineral salt</th>
<th>Acid added</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium sulphate</td>
<td>Hydrochloric acid</td>
<td>No reaction seen</td>
</tr>
<tr>
<td>Sodium silicate</td>
<td>Sulphuric acid</td>
<td>No reaction seen</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>Hydrochloric acid</td>
<td>Fizzes a lot, bubbles and gas</td>
</tr>
<tr>
<td>Iron chloride</td>
<td>Nitric acid</td>
<td>No reaction seen</td>
</tr>
<tr>
<td>Sodium carbonate</td>
<td>Sulphuric acid</td>
<td>Fizzing, bubbles</td>
</tr>
<tr>
<td>Aluminium sulphate</td>
<td>Hydrochloric acid</td>
<td>No apparent reaction</td>
</tr>
<tr>
<td>Copper sulphide</td>
<td>Hydrochloric acid</td>
<td>No reaction seen</td>
</tr>
<tr>
<td>Sodium sulphate</td>
<td>Sulphuric acid</td>
<td>No reaction seen</td>
</tr>
<tr>
<td>Copper carbonate</td>
<td>Sulphuric acid</td>
<td>Fizzing, bubbles, blue colour seen</td>
</tr>
<tr>
<td>Iron sulphate</td>
<td>Nitric acid</td>
<td>No reaction seen</td>
</tr>
<tr>
<td>Zinc carbonate</td>
<td>Nitric acid</td>
<td>Fizzing, bubbles seen</td>
</tr>
<tr>
<td>Iron carbonate</td>
<td>Hydrochloric acid</td>
<td>Fizzing, bubbles seen</td>
</tr>
</tbody>
</table>
Pupil sheet B: Examples of conclusions

Example 1
My results show me that some rocks fizz and some do not when acid is added. Hydrochloric acid made calcium carbonate fizz, sulphuric acid made sodium carbonate fizz and copper carbonate made hydrochloric acid fizz. Fizzing also happened between zinc carbonate and nitric acid and iron carbonate and hydrochloric acid. None of the other rocks fizzed. The reason for this is that there is a reaction between some types of minerals that might be in rocks and acids. You could use this as a test for some minerals, but you could not tell which is which. The bubbles mean that a gas is made in the reaction. The gases I know about are hydrogen, oxygen and carbon dioxide, it could be one of these, but I would need to test them.

Example 2
My results show me that fizzing only occurs with those minerals that contain carbonate. The results also show that it doesn’t matter what type of acid you use.

I conclude that carbonates react with acids to produce a fizz. You could use acids to test whether rocks contain carbonates or not.

The fizz means that a gas is given off. This gas is probably carbon dioxide, because it comes from a carbonate and the names are similar. I could test and be sure by seeing if the gas turns limewater milky.
Pupil guidance sheet:
Writing conclusions

Step 1: Describe the patterns

- Describe patterns or trends in graphs or data.
- Phrases to use:
  - comparative adjectives such as longer, heavier, hotter
    e.g. The brighter the light the faster the plant photosynthesises.
  - as the… so the…
    e.g. As the number of batteries increases so the current increases.
- You may need to comment on how good the pattern is, e.g.
  This is a good pattern because… or The pattern is not very strong.

Step 2: Make a concluding remark

- Answer the original enquiry question.
- Phrases to use:
  - To conclude…, I conclude that… (relate to original question or question and prediction)
  - The experiment shows that…, In general…, This means that…

Step 3: Explain the conclusion

- Use the science you know or can find out to explain your conclusion. Say if this leads to another experiment.
- Phrases to use:
  - This can be explained by…, As I predicted…, This is because…, The reason for this is…, To be sure I will need to test…
- Aim to:
  - use paragraphs;
  - use the present tense;
  - use scientific words accurately.
Teacher guidance sheet:
Writing conclusions

Pupils need to see examples of conclusions and discuss the merits of each.

They need to build a picture of what the structure of a conclusion looks like and how paragraphs help to organise the text.

They need to know how to describe patterns, draw concluding remarks and explain their observations in the light of scientific knowledge and understanding.

Pupil sheet B provides two examples of conclusions. You can use these to discuss how to write conclusions with pupils.

A suggested approach

• Ask pupils to work in pairs.
• Provide each pair with a set of results (pupil sheet A).
• Ask them to think about what conclusions they might draw from the results.
• Provide each pair with the two conclusions (pupil sheet B).
• Ask pupils to annotate each (using different colours) to show what is good about each and what is bad.
• Invite discussion about the merits of each.

Some points to make

Example 1 has a better conclusion than example 2.

Example 1 strengths:
• starts by stating what the results show;
• uses scientific terms correctly;
• attempts to summarise with The reason for this is... .

Example 1 weaknesses:
• no description of a pattern, merely repeats results although is partially selective (separates carbonates from others);
• no paragraphs, so difficult to follow sequence;
• no clear generalisation or concluding remark;
• because no pattern was identified (i.e. carbonates produce fizz), it was difficult to explain using scientific understanding.

Example 2 strengths:
• clear structure demarcated with paragraphs;
• clearly identifies pattern in results, generalises by referring to carbonates;
• makes a concluding remark and identifies significance (You could use acids to…);
• explanation uses appropriate scientific understanding, good speculation about name of gas.
# Teacher guidance sheet: Explaining how

<table>
<thead>
<tr>
<th>Text type</th>
<th>Purpose</th>
<th>Language features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explain how</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>• How digestion occurs.</td>
<td>• Text usually starts with general statement, e.g. <em>Digestion is a process…</em></td>
</tr>
<tr>
<td></td>
<td>• How weathering of rocks occurs.</td>
<td>• A series of steps follows in sequence.</td>
</tr>
<tr>
<td></td>
<td>• How energy is transferred in conduction.</td>
<td>• Diagrams, illustrations or bullet points may be included to aid clarity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To explain processes involved in natural phenomena.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To explain how something works.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Text</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sentences contain connectives that indicate sequence, e.g. <em>first, next, then, gradually, meanwhile, finally.</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Active voice or sometimes passive.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Present tense or past tense.</td>
<td></td>
</tr>
<tr>
<td><strong>Word</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Key naming words are important.</td>
<td></td>
</tr>
</tbody>
</table>
## Teacher guidance sheet: Explaining why

<table>
<thead>
<tr>
<th>Text type</th>
<th>Purpose</th>
<th>Language features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Explain why</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>To develop conceptual understanding by linking ideas together.</td>
<td></td>
</tr>
<tr>
<td>• Why air exerts a pressure on things.</td>
<td>To provide explanations for phenomena using the key ideas in science at Key Stage 3.</td>
<td>Text usually starts with a description of the phenomenon, e.g. <em>Air exerts a pressure on things, or in an electrical circuit the current is not used up when...</em></td>
</tr>
<tr>
<td>• Why current is not ‘used up’ by components in an electrical circuit.</td>
<td></td>
<td>This is followed by an explanation using the conceptual ideas in science. At Key Stage 3 this will often be <em>particles, energy, force, interdependence or cells.</em></td>
</tr>
<tr>
<td>• Why we need to breathe air in and out.</td>
<td></td>
<td>Diagrams, illustrations or bullet points may be included to aid clarity.</td>
</tr>
</tbody>
</table>

**Sentence**

- Sentences contain connectives that indicate causal links, e.g. *because, the reason for this is, consequently, a further reason, so, therefore.*

- Active voice.
- Present tense.

**Word**

- Process words and concept words are important here.
Example 1: Explaining how digestion occurs

I want to explain how a piece of bread is digested.

First you place the bread in your mouth and your teeth start to chew the bread, breaking it down into smaller pieces whilst saliva mixes with it. Next, the saliva, which is an enzyme, starts to break up starch, which is a big molecule, into sugars.

You then swallow the sticky bread pieces. These are forced into your stomach by muscles squeezing it down your oesophagus. The food then enters the stomach where it is mixed with acids and enzymes. These help break the food down a little more.

Next the food mixture passes into the small intestine where more enzymes break the large molecules of fats and proteins into smaller ones. This allows the smaller molecules to pass through the intestine wall into the bloodstream. The intestine acts a bit like a sieve and only lets small molecules through.

What is left passes into the large intestine where water and mineral salts are absorbed. Finally what is left passes out of the body through the anus as faeces.

Example 2: Explaining how digestion occurs

This is an explanation of how digestion occurs.

After digestion you end up with faeces and food that has gone into the bloodstream. This happens because the food in your stomach and intestines has been broken down into smaller pieces by enzymes. Acid in your stomach helps break down food as well. In your mouth, there is an enzyme that changes starch, which is a big molecule, into smaller ones. You swallow your food when the muscles in your neck contract and force it down. They can only do this if there is a ball of food. You make this by chewing it with your teeth. Water passes through the large intestine into the body.

Digestion happens in stages, with different parts being absorbed in different places. This happens in the mouth, the stomach, the small intestine and the large intestine. Teeth chew on the food and mix it with water. This helps you swallow it. The stomach mixes things with the food and when the food ends up in the large intestine most of it has been absorbed into the blood stream and you are left with faeces.
Pupil sheet B: Examples of explanations

Example 1: Explaining air pressure
Air hitting the surface of things as it moves around causes air pressure. The density of the air can change and this makes the air pressure change. The higher the density of the air, the higher the air pressure. This is because there is more air to hit the surface because the air is thicker in denser air. In lower density air, the air is thinner. This means that the air pressure is lower. There is a lot of air around us but we do not feel the pressure because we are used to it.

Example 2: Explaining air pressure
Air causes pressure. Sometimes the air pressure is high and sometimes it is low. You can explain this using the idea that air is made up of particles.

The particles are very small and move very quickly in all directions so they sometimes hit the ground, or you, or anything else in their way. Each time a particle strikes a surface it pushes against it so the air particle exerts a force on the surface.

Many millions of these collisions are happening every second. Consequently, this causes air pressure. If the air is not very dense, then there are fewer particles present and this causes low air pressure. Dense air causes high air pressure because there are more particles hitting the surface at any one time.
Pupil guidance sheet: Writing explanations

Explaining how
You might want to explain how something happens or how something works. Start by stating what you want to explain and then use connecting words like those below.

• I want to explain how…
• First…
• Next…
• Then…
• Finally…

Explaining why
If you are trying to explain why something happens, you will need to start by stating what you are trying to explain. Follow this using connecting words and phrases like those below.

• I want to explain why…
• This is because…
• So when…
• A further reason is…
• Consequently…
Teacher guidance sheet: Supporting the writing of explanations

When supporting pupils’ writing of explanations you will need to make the distinction between explaining how and explaining why.

Structure

In each case, encourage pupils to write an opening sentence that describes what they are attempting to explain. This should be followed by either a sequence of steps (how) or reasons that link a phenomenon to a scientific idea (why).

Connectives

You will need to show pupils which connectives they should use.

Typical connectives to use when:

<table>
<thead>
<tr>
<th>Explaining how</th>
<th>Explaining why</th>
</tr>
</thead>
<tbody>
<tr>
<td>First…</td>
<td>Because…</td>
</tr>
<tr>
<td>Next…</td>
<td>So…</td>
</tr>
<tr>
<td>Then…</td>
<td>Consequently…</td>
</tr>
<tr>
<td>Finally…</td>
<td>It causes…</td>
</tr>
</tbody>
</table>

Pupils need to see examples of explanations and discuss the merits of each. They need to build a picture of what the structure of an explanation looks like and how paragraphs help to organise the text.

Handouts 3.25–3.27 provide pupil materials to use with a class. Pupil sheets A and B (handouts 3.25 and 3.26) provide examples of explanations. You can use these to discuss how to write conclusions with pupils. The pupil guidance sheet (handout 3.27) can act as a prompt.

A suggested approach

- Ask pupils to work in pairs.
- Provide each pair with two explanations (either pupil sheet A or B).
- Ask pupils to read each and then to identify which they think is the better and why.
- Ask pairs to team up and compare their answers. Can they agree?
- Invite discussion on each, then provide handout 3.27 and ask pupils to write their own.
Some points to make

Explaining how

The first explanation is better because:

- it follows a logical sequence;
- it correctly uses the scientific terms (e.g. oesophagus);
- it also separates the ideas into paragraphs so is easier to follow;
- it could, however, benefit from a diagram.

The second example is muddled.

Explaining why

The second explanation is better because:

- it attempts to provide a reason based on a key scientific idea.

The first does not really provide an explanation although it does contain some useful connectives such as *This is because*… .
## Teacher guidance sheet: Argument

<table>
<thead>
<tr>
<th>Text type</th>
<th>Purpose</th>
<th>Language features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Argument</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| • Provide the evidence to support the view that we see because light enters our eyes. | To analyse evidence and present a view that is consistent with it. | **Text**
| • Provide the evidence for a spinning Earth. | To analyse conflicting views on the basis of evidence. | • Text usually starts with a statement of an idea or a particular point of view, e.g. *We see because light enters the eye or Seeing because light enters the eye makes more sense, or The spinning Earth causes day and night.*
| • What causes day? | To develop the skills of considering evidence. | • Presenting a case, which sets out the evidence, follows this. It may include diagrams to aid clarity.
| • What are the possible causes of global warming? | | **Sentence**
| | | • Sentences contain connectives that show formal logic, e.g. *this shows..., my reasons are..., because..., therefore..., the evidence for this is...*
| | | • There may be reference to a model or analogy, e.g. *it is like...*
| | | • Counter-arguments may be set up to be demolished. *Some people think that... another point of view is... but the evidence shows...*
| | | • Active voice, often first person.
| | | • Present tense.
| | | **Word**
| | | • Process words and concept words are important here.
Pupil sheet: Arguments for seeing because light enters the eyes

We need light to see things. Some people believe we see because light bounces off things and enters our eyes, others because light leaves our eyes, striking an object, so helping us see.

Argument 1

We must see because light enters the eye. We need light to see by, otherwise we would be able to see in the dark because light could come out of your eyes.

Argument 2

Seeing because light enters the eye makes more sense. We can’t see when there is no light at all. If something was coming out of our eyes, we should always be able to see even in the pitch black. Another reason for believing this is that if you are standing outside looking into a dark room you cannot easily see things. If, however, light is let into the room from a window you can see things in it. This is because the light bounces off objects into your eye.
Pupil guidance sheet:
Constructing arguments

My argument
• My idea is…
• My reasons are that…
• Arguments against my idea might be that…
• I would convince somebody that does not believe me by…
• The evidence I would use to convince them is that…

Teacher guidance sheet: Supporting the writing of argument

Constructing arguments helps pupils to explore ideas and evidence and make a case based on evidence. Arguments may also analyse conflicting points of view. It is important to avoid opinion and to encourage pupils to support their views with evidence.

Structure

Constructing a good argument is not a simple task.

Start by writing an opening statement about an idea or point of view, e.g. *My idea is… , I believe that… , There are different views about… .* Follow this by presenting the evidence that supports this view or the conflicting views. In the case of conflicting views, make a judgement about the balance of the evidence and then summarise.

A suggested approach

- Ask pupils to work in pairs.
- Ask them to draw a picture to show how we see. Quickly review the drawings to see if there are any standard misconceptions present (there probably will be). If there are, discuss them before moving on.
- Provide each pupil pair with the pair of arguments on handout 3.30.
- Ask them to identify the evidence for the view in each argument.
- Ask them to decide which is better and why.
- Carry out a ‘modelled write’ that would improve the argument.
- Give each pupil a copy of handout 3.31. Ask them to make the links with the ‘modelled write’.

Some points to make

Neither argument presented on handout 3.30 is very good, but the second is better because it provides some evidence to support the idea.

Start writing the argument on the board together with pupils. Help them to understand the structure by agreeing the opening and then starting the next paragraph with ‘The evidence for this is…’.

At this point it may well help to break the class into small groups so that pupils can suggest pieces of evidence to be included in the argument.

Once this has happened, discuss with pupils what evidence there is and then together finish the argument.
# Teacher guidance sheet: Evaluation

<table>
<thead>
<tr>
<th>Text type</th>
<th>Purpose</th>
<th>Language features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evaluation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>• An evaluation of an investigation into the factors affecting the rate of photosynthesis.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• An evaluation of the methods for determining the speed of an object.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To suggest improvements to methods.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To consider whether evidence is sufficient to support a conclusion.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To explain anomalous results.</td>
<td></td>
</tr>
<tr>
<td><strong>Text</strong></td>
<td>• An opening statement about the evidence, e.g. its <strong>reliability</strong> (accuracy, error, sample size) or its <strong>validity</strong> (control of variables, appropriateness of model, such as a beaker to represent a washing machine when testing washing powders).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Suggested improvements; demonstrate how the collection of the evidence could be improved and why this is important.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Text will differ depending on the context. Explaining anomalous results is regarded as a much higher-order skill (L8+).</td>
<td></td>
</tr>
<tr>
<td><strong>Sentence</strong></td>
<td>• Opening statement refers to evidence collected. <em>The measurements show...</em>, <em>The sample size was...</em>, <em>My results show wide variation...</em>, <em>This means that...</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Improvement statements start with to improve..., <em>next time I could...</em>, and contain connectives that indicate causal links, e.g. <em>this is because...</em>.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Active voice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Present tense and future tense in the main (but may be past tense).</td>
<td></td>
</tr>
<tr>
<td><strong>Word</strong></td>
<td>• Critical vocabulary includes evidence, reliable, valid, accuracy and error, variation, agreement.</td>
<td></td>
</tr>
</tbody>
</table>

---

**Handout 3.33**
Pupil sheet: Examples of evaluations

Experiment
Comparing the porosity of different soil types (clay, sand, garden etc.). Water was poured onto soil and the time for it to trickle through was measured. Each soil was tested twice.

Evaluation 1
If I did this experiment again I would change the following things:
• I would use very fine soil rather than soil with small granules.
• I could try and sieve the sand to get rid of anything in it that isn’t needed in the experiment (i.e. plants, stalks, humus).

Evaluation 2
The results show that for most soils there is good agreement between the first and second test. However, the garden and school soils show wide variation in the time taken for water to pass through between the first and second samples. This is probably due to the size of lumps in different samples. This means that measurements for these soils are not reliable.

To improve the experiment, I would sieve the soil first to get rid of the lumps. This would mean that each sample had an even texture and this should lead to closer results so more reliability.
Pupil guidance sheet: Writing evaluations

Step 1
Make an opening statement about how good you think your evidence is.
• How reliable do you think your results are?
• Do you think the evidence you have collected is valid (e.g. was it a fair test)?

Things to consider
• Are there enough results to spot a pattern?
• If you repeated your measurements, is there wide variation or are they similar?
• How accurate are your measuring instruments?
• How accurate are your observations?
• What possible errors could have crept in?
• How confident are you about your results?

Step 2
Make some suggestions about how to improve your experiment.

Step 3
Explain why these suggestions would provide better evidence.
Teacher guidance sheet: Supporting the writing of evaluation

At Key Stage 3, pupils are expected to consider anomalies in observations or measurements, to consider whether the evidence is sufficient and to suggest improvements to methods.

Structure

Evaluations should start with an analysis of the evidence, and then make suggestions for improvement, giving reasons.

A suggested approach

- Ask pupils to work in pairs.
- Ask them to read the pupil guidance sheet Writing evaluations (handout 3.35).
- Ask pupils to read the two examples on handout 3.34 and identify the main features that are present (e.g. opening statement).
- Invite discussion about what a good evaluation looks like – reinforce the main features.
- Ask pupils in pairs to review some evaluations that they have previously written. Each member of the pair should suggest some improvements that the other could make (peer review).
- Ask each pupil to rewrite his or her own evaluations in the light of the suggested improvements.

Some points to make

The first example on handout 3.34 only provides suggestions without considering the evidence. The second example has an opening statement about the evidence collected. It analyses the results and suggests reasons for differences. There are reasons given for the improvements suggested.
# Teacher guidance sheet: Planning

<table>
<thead>
<tr>
<th>Text type</th>
<th>Purpose</th>
<th>Language features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plan</strong></td>
<td>• To identify the evidence that should be collected to answer an enquiry question.</td>
<td>• An opening statement about the purpose of the enquiry and what evidence should be collected. It may include a hypothesis or prediction.</td>
</tr>
<tr>
<td>Examples</td>
<td>• To outline a procedure for gathering the evidence so that it is valid and reliable.</td>
<td>• A justification of the procedure to make sure the evidence is reliable and valid, and a statement of any predictions, e.g. <em>If heating substances causes their particles to vibrate more and gain energy, I would expect substances to dissolve faster in hot water. This is because...</em></td>
</tr>
<tr>
<td></td>
<td>• To make a prediction if appropriate.</td>
<td>• This is followed by an outline procedure to collect the evidence.</td>
</tr>
</tbody>
</table>

**Text**

- Procedure can be bulleted or numbered lists.
- Connectives used to justify procedure often link cause and effect. *I will make sure..., this is because..., I will need to make sure that..., so that the results are reliable I will need to...*.
- Active voice.
- Future and present tense.

**Sentence**

- Critical vocabulary includes evidence, reliable, valid, and names of apparatus.
Investigation To See Whether The Length And Cross Area Section Of A Wire Affects The Current In The Wire.

Introduction

This is an investigation to see whether the length and cross area section of a wire affects the current in the wire.

Hypothesis

I think that as the length increases the current will decrease. I think this because if the length of a wire is increased there is more length for the current to go through. This therefore makes it harder for the current to go through the wire so the current decreases. I think that the current will decrease when the cross area section of the wire is increased. I think this because there is more space for the current to push through the wire.

TEACHER: Does the current increase or decrease when the cross-section of the wire increases?
RACHEL: It increases. More electrons can get through at once.

This example is taken from the National Curriculum in Action website created by QCA © Qualifications and Curriculum Authority 2001. It is regularly updated and examples of pupils’ work with commentary: www.ncaction.org.uk.
Pupil sheet B: Writing plans

How does changing the number of masses on a piece of wood affect how much force is needed to pull it along?

Introduction:
For wood to be pulled along a surface, the amount of force needed to get it moving must be greater than the total force of the forces that are stopping the object from moving, e.g. friction, and then equal to those forces to sustain a steady speed. I will test what force is needed to pull the block along at a steady speed and what effect changing the mass of the object will have. The force will be measured in newtons (N).

Hypothesis and predictions:
I think that the larger the mass of the wood and the weights combined the more force will be needed to move them at a steady speed.

Everything on Earth has a mass and in result, a downward force. This downward force is caused by gravity acting upon this mass.

Another effect which may change the force needed to pull the block and masses along is friction. Friction is caused by microscopic ‘bumps’ on the surfaces of the two objects. These ‘bumps’ run into each other when the two surfaces rub along each other. These collisions prevent the objects moving past each other smoothly, which means more force is required to keep the object moving at a steady speed. Also, the less smooth the surfaces, the more friction will be caused, meaning even more force will be needed to keep the object moving at a steady speed.

Diagram:
**Apparatus list**
- wood and string (41 g)
- newton meter
- 2000 g of 100 g weights (20 weights)
- metre ruler
- table
- scales

**Plan**
To find the effect of changing the mass of a block of wood has on the force needed to pull it along the desk, I will need to follow this plan closely to ensure the test is fair and achieves the correct results. Firstly I will select the equipment I need (listed in the apparatus list above), then I will weigh it and make a note of this weight. I will next select the surface on which the experiment will take place. Then I shall place one 100g weight on to the block and pull it along for a distance of one metre at a steady speed and measure the amount of Newtons (N) it takes to pull the block and weight. I will then repeat the process, adding one weight (100g) each time.

**Fair testing**
To ensure the results I get are as fair as possible, I should follow the following rules as closely as I can.

I must use the same block of wood and piece of surface for my experiment otherwise, different amounts of forces, either friction or gravity, may be placed upon the block and wood. This may cause an increase in the force required to pull the block along.

I must plan carefully the direction on which the surface that I pull the block as I will need to keep pulling the block in that direction as the grain in the wood will cause additional resistance, meaning more friction. Pulling the block across the wood grain will cause more friction and pulling the block in the same direction as the wood grain will mean there is less resistance, meaning less friction and less force needed to pull the block.

---

This example has been taken from Sci-Journal, edited and published by the Research and Graduate School of Education, University of Southampton. It is a web-based collection of pupils’ scientific enquiries, available at www.sci-journal.org. Comments are invited about the submissions.

**Disclaimer**
The Department for Education and Skills wishes to make it clear that the Department, and its agents, accept no responsibility for the actual content of any of the materials suggested as information sources within this document, whether these are in the form of printed publications or on a website.
Teacher guidance sheet:
Supporting planning

Structure
Plans should set out what evidence is to be collected and why. Often a prediction is made, although this may not need to be the case.

At Key Stage 3, pupils should collect evidence from first-hand experience or secondary sources. Secondary sources of evidence are currently underused.

Criticising plans that others have made can help pupils structure their own in more purposeful ways.

The unit on scientific enquiry provided a ‘thinking frame’ strategy for making decisions about what to investigate. It was provided on a large poster for class use.

A suggested approach
• Ask pupils to work in pairs.
• Ask pupils to read pupil sheet A (handout 3.38).
• Ask them to consider what evidence they would need to collect to test this hypothesis.
• Ask them to consider how much evidence they would need to make sure the results would be reliable.
• Ask each pair to write this in no more than two sentences.
• Ask each pair now to team up as a group of four and compare results – who has the most succinct statements?

Provide pupils with pupil sheet B (handout 3.39).
• Ask them to skim read the plan.
• Explain that this is rather long and we would like to make it shorter.
• Display the planning poster and ask them to use the prompts to help them restructure the plan.
• Alternatively, you could use the same poster to select from the plan those sentences that are useful and start pupils off by collaboratively writing the first few sentences.
Talk in science

Objectives

• To explore the purpose of speaking and listening in science and the implications for teaching

• To exemplify the techniques that enable pupils to engage fully in discussion:
  – how to organise whole-class discussions
  – how to organise small-group discussions

Resources

For tutor

Slides 4.1–4.3, 4.5, 4.7, 4.8, 4.10, 4.12–4.14

Flipchart, paper and pens

For participants

Handouts
  4.4 Discussions in science
  4.6 Progression in speaking and listening
  4.9 Discussing science: Oral starters to science lessons
  4.11 Organising group discussions

Sufficient copies of the Key Stage 3 programme of study for science for one copy between two participants

Key messages leaflet

Session outline

<table>
<thead>
<tr>
<th>Session outline</th>
<th>1 hour 25 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>Talk</td>
</tr>
<tr>
<td>Overview of the session</td>
<td>Whole group</td>
</tr>
</tbody>
</table>

The purpose of speaking and listening

Considering why talk is important in science and exploring the implications for teaching

Task M, talk

Pairs, whole group

15 minutes

Organising whole-class discussions

How to make discussions effective and the use of oral starters

Tasks N and O, talk

Pairs, whole group

35 minutes

Organising small-group discussions

Considering a variety of strategies for effective discussion

Task P, talk

Pairs, whole group

20 minutes

Follow-up work

Activities to do back in school

Talk

Whole group

5 minutes

Plenary

Reflecting on the main points of the session and reviewing the unit as a whole

Talk

Whole group

5 minutes
Introduction

Show slide 4.1 to share objectives with the participants.

Objectives for session 4

- To explore the purpose of speaking and listening in science and the implications for teaching
- To exemplify the techniques that enable pupils to engage fully in discussion:
  - how to organise whole-class discussions
  - how to organise small-group discussions

Say that:

- Research shows that pupils spend about a third of their time listening in science lessons but very little of their time in discussion with each other or with their teacher.
- Pupils need opportunities to describe, explain and justify their understanding of scientific ideas and to use precise scientific vocabulary.
- Speaking scientific terms aloud helps pupils to spell correctly.
- Pupils need opportunities to ‘think aloud’, to discuss and explore ideas with each other.
- Where talk is modelled well, it helps pupil to write – it gives them a voice into their writing.

The purpose of speaking and listening

Show slide 4.2.

Why talk?

Talk can be an efficient way:

- to make sense of the world;
- to find out what others know and share our knowledge.

Say that:

- We talk to make sense of the world and try to exert some control over it.
- We talk in order to find out what others know, and to share what we know.
- We talk in order to develop our thinking.
- We use talk to entertain, to tell stories, to create imaginative worlds.
• We use talk to evaluate our work, achievements and learning.
• We use talk to demonstrate and to describe what we know or have found out.

*From* Teaching talking and learning in Key Stage 3 (*National Oracy Project, 1991*).

**Task M**

**Slide 4.3**

Show *slide 4.3* to introduce the next task. Give out copies (one between two) of the Key Stage 3 programme of study for science. Allow about five to seven minutes for participants to consider their thoughts.

**Discussion in science**

Look at the programme of study for science at Key Stage 3.

• Where will discussion particularly aid the development of understanding in science and why?

**Handout 4.4**

Then ask participants to retrieve *handout 4.4* and ask them to compare their thoughts with the areas raised in the handout. Point out that the programme of study for science states that pupils should be taught to communicate scientific ideas using scientific language, and to provide scientific explanations based on evidence (see Breadth of study section).

Take any feedback from participants about the opportunities for and benefits of discussions in science.

Say that:

• There are many opportunities to use talk in science.
• Discussing ideas does help pupils to develop their understanding of science.
• Discussion does, however, need to be organised to be effective. This will be considered later in this session.

**Slide 4.5**

Show *slide 4.5* and ask participants to retrieve *handout 4.6*.

**Handout 4.6**

**Departmental discussion focus**

**Progression in speaking and listening**

<table>
<thead>
<tr>
<th>From:</th>
<th>To:</th>
</tr>
</thead>
<tbody>
<tr>
<td>simple answers to closed questions</td>
<td>complex answers to open questions in which pupils explain their thinking</td>
</tr>
<tr>
<td>discussion in pairs or small groups</td>
<td>speaking to a larger audience</td>
</tr>
<tr>
<td>listening to or giving a narrative account</td>
<td>listening to or giving an analytical account</td>
</tr>
<tr>
<td>listening to or using simple vocabulary</td>
<td>using specialised vocabulary</td>
</tr>
</tbody>
</table>

*Adapted from SCAA 1997; cited in Language and literacy in science education, by Wellington and Osborne (Open University Press, 2001)*
Say that:

- Slide 4.5 shows how we should expect pupils to make progress in talk. You may like to consider the discussion points on handout 4.6 in your department when you return to school.

Ask participants to reflect for a moment on the two questions posed on handout 4.6. Deal with any comments or questions that arise.

**Organising whole-class discussions**

35 minutes

Say that:

- To be effective whole-class talk needs to be organised.
- Slide 4.7 gives some pointers for effective discussion.

Show slide 4.7.

**Whole-class discussions**

To be effective, whole-class discussions need to:

- be planned;
- have clear, explicit and useful outcomes;
- have precise time limits;
- engage all pupils;
- have a clear concrete focus (i.e. a model or analogy) when abstract concepts are involved;
- lead to some other task such as writing or practical work.

Prepare pupils beforehand with specific language.

Talk through slide 4.7 and be prepared to provide examples to illustrate the points.

Say that:

- Class discussions do not work well when one or more of these features is not present.
- Talk sessions should be well timed. Whole-class discussions that are too long will cause many pupils to lose interest. Aim for no more than 10–15 minutes.
- There should be an appropriate balance between speaking and listening.
- Pupils should not be expected to talk about abstract ideas without reference to a model or an analogy.
- Pupils should be prepared by giving them the vocabulary they need beforehand.
You may wish to invite further suggestions from participants.

Say that:

- Discussion is often used at the beginnings and ends of science lessons.
- Oral starters to lessons can engage and motivate pupils and develop their scientific language very effectively.
- Recall the video you watched in session 1 where pupils were encouraged to develop their scientific understanding through talk at the start of a lesson, using a card loop game.

**Task N**

15 minutes

Ask participants to reflect on how they manage whole-class discussions in their own classrooms. After about one minute, get participants to share their thoughts with a colleague and then share in a group of four.

Use slide 4.8 to focus feedback.

**Additional guidance**

An example of a successful whole-class discussion involved an oral starter on elements. The teacher asked the class if they knew the names of any chemical elements ('no – don’t tell me!') and encouraged pupils first to think for themselves (noting the names of elements on a piece of paper), then to discuss ideas in a pair, then to discuss ideas further in a small group (about four). The teacher then took feedback from each group in turn to build up a list of elements that the group knew. This was brought to a conclusion by summarising what the group had found and offering pupils the opportunity for brief further comment and discussion. It was successful because the teacher:

- provided clear time limits: ‘On your own you have 30 seconds to think of as many elements as possible’;
- made sure that as a pair or small group pupils had to make a decision, e.g. ‘As a pair come up with an agreed list of elements. Those you are doubtful about leave to one side’;
- made sure that pupils moved deliberately from one to two to four and even to eight before giving feedback;
- organised the furniture so that pupils faced each other when discussing ideas, could move easily to fours and then to eights.
At the end of the discussion say that:

• These are just one or two or more [if these have come out of discussion] ways in which you can organise purposeful talk at the start of science lessons.

• Careful thought needs to be given to the arrangement of furniture so that it promotes group discussion – pupils in a line is not helpful.

• When using teacher questioning to initiate pupil talk, pupils need to be given ‘think time’ or ‘wait time’ before they are asked to respond. This can be achieved in a variety of ways, e.g. thinking on their own or discussing in pairs before feeding back.

• Whatever the purpose of the discussion, some visual focus helps stimulate debate, e.g. a rock when discussing its features.

• We will now look at some further examples of oral lesson starters.

**Task O**

15 minutes

Ask participants to retrieve handout 4.9 and show slide 4.10.

**Handout 4.9**

**Slide 4.10**

**Oral starters for science lessons**

Consider each of the suggestions in handout 4.9 with a partner.

• Select one strategy you have not used before and would like to try out.

• Discuss how you would manage the discussion for your class.

Take feedback from one or two pairs whom you have identified during the discussions as having some good ideas.

**Additional guidance**

You may wish to check out example B3 in handout 4.9 for yourself, using a glass rod.

**Organising small-group discussions**

20 minutes

**Additional guidance**

It may be worth making the following point:

• Although we are focusing on starters during this session, plenaries also provide an opportunity for purposeful talk in science. The DfES publication Making good use of the plenary (DfES 0192/2002) gives useful guidance on how they can be developed. Materials to support starters and plenaries in science will also be considered in the unit on effective lessons in science.
Say that:

- Discussion is particularly important for exploring ideas and evidence in science and for developing an understanding of scientific concepts.
- Sustained discussion is often better developed at Key Stage 3 through organised small-group discussions, such as snowballs.
- Predetermined outcomes and time limits for each stage of the discussion help pupils to move on effectively.
- Encouraging pupils to work together, in other than only friendship groups, will widen their learning experience and can develop confidence.
- The furniture needs to be organised so that pupils can face each other and move easily if required.
- There is a wide variety of ways of organising small-group discussion. These are shown on handout 4.11.

**Task P**

Ask participants to retrieve handout 4.11 and show slide 4.12 to introduce the task.

Ask participants to work in pairs on a joint activity that both can try.

**Task P**

- Choose an area of Key Stage 3 science that you are about to teach.
- Choose one of the strategies on handout 4.11 to try.
- Plan your approach. Think about:
  - What will the outcome be?
  - How will you start the discussion (question, stimulus etc.)?
  - What will be the time targets for each stage?
  - What extra resources will you need?

**Additional guidance**

You may wish to prepare some examples of each strategy in the context of science if you feel that participants are unfamiliar with these. They will have met this handout before in the Literacy across the curriculum training materials.

Some examples you could use include:

**Pair talk:** To identify three key points from the previous lesson’s work on acids, alkalis and indicators. Each pair has two minutes to agree the three key points before feeding back.

**Envoys:** Following an investigation into the factors affecting the size of current in a series circuit, envoys are sent to share their initial conclusions together with the supporting evidence with another group. The pupils had explored the effect of different aspects, e.g. number of batteries, length of wire, and number of components in the circuit. They worked in pairs and compiled the final results as a team of four. One of the four acts as an envoy.
**Snowball:** To compile a list of evidence to support the idea that light travels in straight lines. As an individual, pupils have one minute to set down their ideas; as a pair, pupils have two minutes to compile an agreed list; as a four, pupils have five minutes to sort their evidence in order of priority (strongest evidence at the top) and finally, as an eight, they have five minutes to agree their priority list before feeding back.

At the end of 15 minutes, briefly draw participants together and review progress in their planning.

Say that:

- Discussion is important and we need to make time for it in science.
- The plan you are developing can be developed as your follow-up work.

**Follow-up work**

As follow-up work you could:

**In the department:**
- Organise a review of the scheme of work for science:
  - Are there planned opportunities for talk?
  - If so, do they allow for the progression in talk as suggested (see handout 4.6)?

**In your teaching:**
- For your next topic:
  - try one of the oral starters;
  - organise a small-group discussion.

Consider how you will evaluate the effectiveness of the change in teaching style.

Say that:

- We have considered the importance of talk in science and how best to organise discussion, both whole class and small group.
- The follow-up work invites you to try out some of the ideas suggested.
- If you feel less confident about managing small-group work, try the snowball first. It works very well.
- Exploring understanding of concepts and understanding of evidence provides fertile ground for discussion.
Plenary 5 minutes

Use slide 4.1 to remind participants of the objectives of the session. Then use slide 4.14 to identify some anticipated outcomes. Ask participants to consider how far the objectives have been met.

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**Plenary for session 4**

By the end of the session participants should:

- recognise the purpose of speaking and listening in science and the implications for teaching;
- be able to use the techniques that enable pupils to engage fully in discussion:
  - be able to organise whole-class discussions;
  - be able to organise small-group discussions.

---

Invite any further questions and points participants might like to make and encourage them to complete the **evaluation form** for session 4 and to grade the unit overall. Tell them that now is a good time to note any points from the session which they may want to follow up in school. These in turn can be linked to action points in their action planning. After all, their attendance on the course should have been based on needs identified from the audit.

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**Additional guidance**

Ensure you collect in all the completed evaluation forms and that you have a complete register of participants who attended. You will use the register to follow up development work in school.

Stress again how you are available to support participants in school. If you have already identified individuals whom you believe will need support, make sure that you book a date and time with them before they leave or as soon as possible after the unit. This is particularly important with those departments that are going to be supported by you during the coming year. Booking follow-up visits at the end of a CPD unit can save you time chasing people at a later stage.
Discussions in science

There are many occasions when talk can help to raise pupils’ attainment in science at Key Stage 3. This list is not exhaustive but identifies some important areas.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Ideas and evidence</strong></td>
<td>Talking about ideas enables pupils to ‘think aloud’ and explore issues with each other. Discussing the evidence to support a particular idea helps pupils to develop an understanding of evidence, e.g. talking about health provides pupils with opportunities to express views and separate fact from opinion.</td>
</tr>
<tr>
<td><strong>2 Investigative skills</strong></td>
<td>Talking about what evidence should be collected and how it should be collected helps pupils to improve their planning skills. Practising with others how to describe patterns in graphs, and discussing how results provide evidence for an idea, helps pupils to draw conclusions.</td>
</tr>
<tr>
<td><strong>3 Concepts</strong></td>
<td>Discussion about key ideas in science helps pupils to link ideas together. Pupils need opportunities to talk about concepts, to explore their own understanding through talk with others and to attempt explanations using these concepts.</td>
</tr>
<tr>
<td>e.g. particles</td>
<td>Talking about how a particle model can explain how substances dissolve or why mass is conserved in chemical reactions can help to develop pupils’ understanding and reveal misconceptions.</td>
</tr>
<tr>
<td>e.g. energy</td>
<td>Talking about energy can help to develop science-specific language and pupils’ understanding of how ideas about energy can be used to explain a range of phenomena and reveal misconceptions.</td>
</tr>
</tbody>
</table>
Progression in speaking and listening

From:
- simple answers to closed questions
- discussion in pairs or small groups
- listening to or giving a narrative account
- listening to or using simple vocabulary

To:
- complex answers to open questions in which pupils explain their thinking
- speaking to a larger audience
- listening to or giving an analytical account
- using specialised vocabulary

*Adapted from SCAA 1997; cited in Language and literacy in science education, by Wellington and Osborne (Open University Press, 2001)*

Discussion

- How does the way talk is organised change across Years 7 to 9 to make sure pupils make progress?
- How does the teaching make sure that pupils recall and use the scientific language they developed in their primary schools?
Discussing science: Oral starters to science lessons

A: Language-building activities

Example 1 Talking explanations

Within a topic on electricity the teacher starts the lesson with a five-minute starter activity designed to help pupils to focus on cause–effect relationships. This will be followed by some practical problem-solving activities.

The teacher asks the class to think about some possible reasons why a bulb might not light in a circuit. He tells pupils that each of them must provide a reason in a sentence they say aloud. They must use one of the connective words because, so, the reason or consequently (written on the board).

The teacher starts: ‘In a circuit… the bulb doesn’t light because there might be a flat battery.’

Pupils then have to change the sentence by giving a different reason or changing the connective:

e.g. ‘The circuit has a flat battery, consequently the bulb will not light.’ or ‘In a circuit… the bulb doesn’t light because there might be a broken wire.’

This continues round the class.

Example 2 Describing relationships

Pupils are told to use the construct … as… then… to describe the relationship between two variables on a graph, filling in with the names of the variables and using comparative adjectives. This could be carried out with the whole class using a range of slides as overlays. Positioning the different overlays, pupils are asked to describe the pattern.

Reproduced from AKSIS investigations: getting to grips with graphs (published by ASE).
B: Providing stimulating phenomena

Example 1

When introducing a lesson on adaptation and competition you could start with a wild oat seed. Explain that wild oats are very successful and difficult to get rid of. Demonstrate or ask pupils to hold a seed in their hands and drop water on it. Ask them to observe what happens and then in pairs ask them to hypothesise about why this action might help the plant. Get them to think about as many reasons as possible, then join with another pair and compare notes.

Example 2

Place a plastic rod near a stream of water from the tap. Ask pupils to say what they expect to happen. Show pupils that the water bends. In pairs ask them to come up with an explanation. Pairs form fours to share their ideas and agree on one. Take feedback from the fours. Use this as an introduction to a lesson on static electricity.

Example 3 Whole-class session – Introduction to refraction

Ask pupils to write the word CARBON DIOXIDE in capitals. Provide them with a glass rod, and ask them to place it over the words. What do they see?

What pupils should see is shown below. Both words are inverted, but DIOXIDE is symmetrical and so appears not to have been changed.

![CARBON DIOXIDE]

Get pupils to work in pairs. Ask them how many possible explanations with reasons they can come up with for what they see. Have them feed back to the class; then start the lesson on refraction.

C: Explore a challenging statement

This is an alternative to questioning. Provide pupils with a statement to explore rather than questions.

Example 1

When introducing a lesson on solutions in Year 7, the teacher says, ‘Substances are likely to dissolve more quickly in hot water because particles are moving faster.’

The teacher asks pupils to work in pairs and attempt to explain what the statement means. Can they identify the particles in question? Can they tell the story of a dissolving ‘particle’ of potassium nitrate?

Example 2

When teaching Year 9 pupils about the role of the root in photosynthesis, the teacher starts with the statement ‘Plants that are watered too frequently may die’. She invites them to discuss this idea with their neighbour, and on their white boards jot down as many reasons why this might be so using the word ‘cell’. After about five minutes she asks them to show their white boards and then quickly collects suggestions, asking pairs to add any other ideas to their own boards.
D: Encouraging pupils to raise their own questions

Following work on acids and alkalis in Year 7, this Year 8 group are briefly reminded of their work and then are asked what more they would like to find out about acids. The teacher asks, 'What else would you like to find out about acids? Discuss this with your partner and come up with three good questions.'

Some responses may be:

- Which is the strongest acid?
- Are there acids that can dissolve glass?
- Are all acids colourless?
- Are there any solid acids?
- What does acid do to skin?
- What does acid do to metals?
- What is acid rain?
- Are there any acids in the body?
- What can you use acids for?
- How many types are there?

With these questions, plus a few raised by the teacher, the class then goes on to plan what they would do in the next topic and how they would find answers.

E: Using questions to stimulate thinking

The teacher quickly reminds the Year 7 class of the work they have completed on forces in their primary schools (e.g. push–pull, gravity, friction, air resistance and upthrust).

She then prepares the pupils for a question by saying:
‘I’m going to ask you a question about forces which I want you to think about. I want you to think about it by yourselves for a minute [providing wait time] and then, when I tell you, discuss your ideas with your neighbour. See if you agree. I will then ask each pair to give me one of your ideas.’

She then asks the question:
‘What connections are there between forces and movement?’

F: Using a stimulus for discussion

Example 1 Exploring opposing views

Use a concept cartoon to stimulate debate and make learners’ views explicit.

The example on the next page is taken from the ConCISE project.

Pupils can first be asked to consider the ideas by themselves, then to discuss their ideas in small groups and try to reach a consensus. At the end of this discussion time, the teacher manages the feedback by asking each group to share their views about what will happen and why.

Full details of how concept cartoons can be used may be found in Concept cartoons in science education, by S. Naylor and B. Keogh (Millgate House Publishers, 2000).
Will the lemonade get lighter now that you have left the top off the bottle?

I think it will stay the same weight.

I think it will get heavier.

8.5 Lemonade

What do YOU think?

© S. Naylor and B. Keogh
Example 2 Constructing an argument

At the start of the lesson pupils are provided with the following:

Pupil sheet Argument

Which of the following arguments is the best piece of evidence that matter is made up of particles and why?

(a) Air in a syringe can be squeezed
(b) All the crystals of any pure substance have the same shape
(c) Water in a puddle disappears
(d) Paper can be torn into very small pieces

From Language and literacy in science education, by Wellington and Osborne

In groups of four, pupils are asked to consider the statements for three minutes. The teacher then takes initial feedback from each group about which they feel provides the best evidence and briefly why. No further comment is made. Pupils are then given two minutes to reconsider their ideas. The teacher then manages the discussion, inviting views from different camps. Once ideas have been explored, the teacher then explains that pupils will now turn these discussions into a written argument.

Example 3 Constructing a concept map

At the start of the lesson pupils are organised into groups of four seated around a table. They are told they are to construct a concept map to show how all the cards in an envelope they have been given link together. In order to make decisions pupils must discuss their ideas with each other.

The teacher makes the outcome clear: ‘What I am looking for is that you as a group summarise what you know about plants. A good concept map will use all the cards and be linked using the right scientific words and ideas. The cards will be set out so that they show logical connections. In 10 minutes be prepared to show your map to others.’

The words on the cards are:

<table>
<thead>
<tr>
<th>Plant</th>
<th>Root</th>
<th>Stem</th>
<th>Flower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stigma</td>
<td>Stamen</td>
<td>Carpels</td>
<td>Water</td>
</tr>
<tr>
<td>Minerals</td>
<td>Sugars</td>
<td>Reproduction</td>
<td>Seed</td>
</tr>
<tr>
<td>Cell</td>
<td>Transport</td>
<td>Day</td>
<td>Night</td>
</tr>
<tr>
<td>Growth</td>
<td>Ovary</td>
<td>Respiration</td>
<td>Cells</td>
</tr>
<tr>
<td>Palisade</td>
<td>Leaf</td>
<td>Style</td>
<td>Photosynthesis</td>
</tr>
</tbody>
</table>
Organising group discussion

Pair talk
This is easy to organise even in cramped classrooms. It is also ideal to promote high levels of participation and to ensure that the discussions are highly focused, especially if allied to tight deadlines. It can be used in the early stages of learning for pupils to recall work from a previous lesson, generate questions, work together to plan a piece of writing or take turns to tell a story.

Pairs can also be used to promote ‘response partners’ during the drafting process, and to work as reading partners with an unfamiliar text. It is also ideal for quick-fire reflection and review, and for rehearsal of ideas before presenting them to the whole class.

Pairs to fours
Pupils work together in pairs – possibly friendship, possibly boy/girl, etc. Each pair then joins up with another pair to explain and compare ideas.

Listening triads
Pupils work in groups of three. Each pupil takes on the role of either talker, questioner or recorder. The talker explains something, or comments on an issue, or expresses opinions. The questioner prompts and seeks clarification. The recorder makes notes and gives a report at the end of the conversation. Another time roles are changed.

Envoys
Once groups have carried out a task, one person from each group is selected as an ‘envoy’ and moves to a new group to explain and summarise, and to find out what the new group thought, decided or achieved. The envoy then returns to the original group and feeds back. This is an effective way of avoiding tedious and repetitive ‘reporting back’ sessions. It also puts a ‘press’ on the envoy’s use of language and creates groups of active listeners.

Snowball
Individuals explore an issue briefly; then pairs discuss the issue or suggest ideas quickly; then double up to fours and continue the process into groups of eight. This allows for comparison of ideas, or to sort out the best, or to agree on a course of action. Finally, the whole class is drawn together and a spokesperson for each group of eight feeds back ideas. This is a useful strategy to promote more public discussion and debate and works well in science.
**Rainbow groups**

This is a way of ensuring that pupils are regrouped and learn to work with a range of others. After small groups have discussed together, pupils are given a number or colour. Pupils with the same number or colour join up, making groups comprising representatives of each original group. In their new group pupils take turns to report back on their group’s work and perhaps begin to work on a new, combined task.

**Jigsaw**

A topic is divided into sections. In ‘home’ groups of four or five, pupils allocate a section each, and then regroup into ‘expert’ groups. In these groups experts work together on their chosen area, then return to original ‘home’ groups to report back on their area of expertise. The ‘home’ group is then set a task that requires the pupils to use the different areas of ‘expertise’ for a joint outcome.

This strategy requires advance planning, but is a very effective speaking and listening strategy because it ensures the participation of all pupils.

**Spokesperson**

Each group appoints a spokesperson. The risks of repetition can be avoided if:

- one group gives a full feedback, and others offer additional points only if they have not been covered;
- each group is asked in turn to offer one new point until every group ‘passes’;
- groups are asked to summarise their findings on A3 sheets which are then displayed – the class is invited to compare and comment on them.
Literacy in science

Main messages from the unit

There are four important aspects to literacy in science – words, reading, writing and talk.

Words in science

Science is rich in specialised words, many of which have an everyday meaning as well as a scientific meaning. Improving pupils’ spelling and understanding of these words will improve their understanding of science.

The use of ‘word roots’ helps to develop an understanding of the scientific meaning of the word.

The taxonomy of words (words that describe objects, processes and concepts) can be used to identify those words which are ‘key’ to the communication of ideas and understanding.

Identify key words with care, matching your list to the needs of your pupils.

Explore new words together, consider their structure, word roots and correct meaning.

Provide opportunities for pupils to practise using key words during class discussion or during question-and-answer sessions.

Review words regularly (little and often).

Reading in science

Reading in science should be a demanding activity.

Supporting pupils in reading and offering them ways to access text is better than reducing the amount and quality of their reading.

Tell pupils how to read (continuous reading; close reading; skimming; scanning) and why.

Make use of a range of DARTs (directed activities related to text) where pupils are actively engaged with the text and are clear about why they are reading and what they should gain from the experience.

Develop the use of a range of texts related to particular topics and purposes.

Shared reading is a good way to introduce new or more difficult texts, especially those that contain a lot of new, specialised vocabulary.
Writing in science

Research shows that, on average, pupils spend about a third of their time writing in science lessons. It is important to ensure that what we ask pupils to write helps them to learn science.

Writing supports learning in science when:

• the purpose is clear;
• pupils are challenged to think and make decisions about their writing;
• the writing helps pupils to organise their thinking;
• pupils are asked to write for a variety of purposes and audiences;
• the writing is well chosen and supports the objective of the lesson.

Copying notes for ‘revision’ is not a very effective use of time; copying does not promote learning and understanding.

There are six main types of writing (text types) which are important in science. These can all be taught using the strategy for teaching writing outlined in section 2 of the *Literacy across the curriculum* folder.

Talk in science

Pupils need opportunities to describe, explain and justify their understanding in science lessons. They need opportunities to ‘think aloud’, discussing and exploring ideas with each other.

Where talk is modelled well, it helps pupils to write – it gives them a voice into their writing.

Discussion needs to be organised to be effective. It should be planned and have clear, explicit and useful outcomes. It should engage all pupils and lead to some other task, such as writing or practical work.

Discussion is often used at the beginnings and ends of lessons. Oral starters can engage and motivate pupils and develop their scientific language very effectively.

We should expect pupils to make progress with their science talk.

Small-group discussion can take many forms and encourages pupils to work together in different groups to reach predetermined outcomes. This widens their learning experience and helps to develop their confidence.
Implications for the department

The priority the department has given to developing literacy in science will be reflected in the action points identified in the departmental action plan. A number of actions which could be taken by individual teachers, or the department as a whole, are listed below.

For the department

- Review the scheme of work for science to ensure appropriate opportunities are provided for reading, writing, talk and the introduction and use of key words.
- Check whether these opportunities allow for progression as suggested in the unit.
- Use the discussion sheets to promote debate about the purposes of writing in science.

Consider how you will evaluate the effectiveness of any changes you make.

For individual teachers

Consider a future topic:

- Review the key word list in the light of the taxonomy provided (names, processes, concepts).
- Select one of the suggested techniques (from words, reading, writing and/or talk) and integrate it into your teaching of that topic.
- How will you evaluate how effective the change in teaching has been?