Bridging plans: from Key Stage 3 to Key Stage 4

Science
Bridging plans: from Key Stage 3 to Key Stage 4

Science
## Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Developing independent learners</td>
<td>4</td>
</tr>
<tr>
<td>Science: from Key Stage 3 to Key Stage 4</td>
<td>6</td>
</tr>
<tr>
<td>Science bridging projects</td>
<td>8</td>
</tr>
<tr>
<td>Implementing your bridging plans</td>
<td>9</td>
</tr>
<tr>
<td>Project 1: Investigating scientific questions</td>
<td>11</td>
</tr>
<tr>
<td>Project 2: Self- and peer-assessment</td>
<td>14</td>
</tr>
<tr>
<td>Project 3: Ideas and evidence</td>
<td>18</td>
</tr>
<tr>
<td>Project 4: Key ideas in science</td>
<td>21</td>
</tr>
</tbody>
</table>
Key Stage 3 Strategy publications referred to in this booklet are available at the following website address:

www.standards.dfes.gov.uk/keystage3/publications

Disclaimer

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

In these materials icons, logos, software products and websites are used for contextual and practical reasons. Their use should not be interpreted as an endorsement of particular companies or their products.

The websites referred to in these materials existed at the time of going to print. Tutors should check all website references carefully to see if they have changed and substitute other references where appropriate.
Introduction

Background to the series

This booklet is designed to help science departments plan for effective transition from Key Stage 3 to Key Stage 4 by creating teaching and learning plans that bridge the key stages. In the literal sense, a bridge has two ends. Bridging plans will be effective only if teachers give thought to how the work at the end of Year 9 can be linked with the beginning of Year 10.

From a pupil’s perspective, moving from Key Stage 3 to Key Stage 4 may be less marked than other key stage transitions because it does not usually involve a change of school. However, apart from the completion of the National Curriculum tests, there are other milestones. Perhaps for the first time in their lives, pupils make choices about the subjects they will study and, to some extent, the paths they will follow. They also become aware of how GCSE courses will be different, for example in having an element of assessment by coursework.

Many science departments avoid a sense of anti-climax at the end of Year 9 by offering pupils opportunities that complement or extend the work they have been doing previously. For example, some departments organise participation in ‘Young Scientist’ events with neighbouring schools, while others take the opportunity to carry out extended practical ecological investigations in local habitats or to invite science theatre-groups into school.

The aim of these materials is to suggest additional ways in which you could help pupils make a confident start to Key Stage 4, particularly by making best use of the time in Year 9 after the National Curriculum tests in May. This is not just about starting GCSE courses early: it is about stimulating pupils’ interest and keeping them engaged. It is also about creating a sense of moving on, with an expectation of increasing maturity and independence as a learner. The aim should be to develop bridging plans that can be incorporated into a scheme of work and, with appropriate revision, used from year to year.

How to use this booklet

A suggested sequence of steps is to:

- Read the booklet and reflect on the suggestions it contains – you might want to encourage other colleagues to do so as well.

- At a meeting of the department:
  - highlight some general points from the booklet;
  - review what you currently do during the post-test period in Year 9 and the first few weeks of Year 10;
  - consider possibilities for development, perhaps using the summary of suggestions on page 8 as a starting point;
  - agree on the changes you want to make, possibly delegating detailed development to a smaller group.

- Allow time to review the implementation of your plan and make changes for future years.
Developing independent learners

Increasing numbers of departments recognise the need to think about pupils, not only in terms of their capabilities in the subject, but in terms of their learning skills. Maturing towards independence is gradual; pupils do not suddenly change as they move from one key stage to another. However, the transition between Key Stage 3 and Key Stage 4 provides an opportunity to refocus attention, of both teachers and pupils, and to set up activities that could have a positive impact on pupils’ learning skills.

Expectations for the end of Key Stage 4

Pupils who are effective learners have the skills to learn on their own. They can be relied on to work independently, even for long periods. Southampton LEA worked with teachers to identify statements that describe effective learners at different stages of their development. These statements identify the learning skills that pupils need to be taught. The following statements are for the end of Key Stage 4.

By age 16 effective learners:

- are well organised and plan their work confidently, balancing priorities;
- show independence in solving problems, selecting the most effective strategy with confidence and seeking help when needed;
- gather information efficiently and take notes in a variety of ways, selecting the method to suit the purpose;
- can reorganise their work and present it with a clear sense of audience;
- are effective team members and can recognise the different roles needed to complete a task and will often take on that role to ensure completion;
- search for a purpose for learning and will challenge and question to ensure that what they are learning is appropriate;
- explore how this new learning fits with existing knowledge and accommodate any changes to their overall ‘map’;
- assess their own work and can identify areas for improvement and seek help to clarify how they can improve.

Taking this list as a goal, think about some of your current Year 9 pupils. What steps do they need to take towards becoming independent learners?

Strategies for developing pupils’ learning skills

Some pupils, or even whole classes, lack the necessary skills to work independently of their teachers. For example, in most lessons these pupils are not organised: they give up when they meet a challenge and opt out of discussion and group work. Such pupils require particular attention, but the need to develop learning skills is not confined to these groups. As they grow older, all pupils need to acquire a greater perception of themselves as learners.
Research shows that pupils can be taught to become more independent in their work and thus become more effective learners. It often pays to start small, by concentrating on a particular learning skill, such as organising information.

- Model for pupils how the particular skill is carried out.
- Select tasks carefully to match your goals and to ensure that pupils experience success.
- Give good examples and make clear what are the criteria of success.
- Monitor individuals and the whole class and deal with difficulties.
- Provide positive oral and written feedback, not just marks and grades.

As you begin to foster new habits in pupils, gradually increase expectations.

- Set challenging tasks for the whole class, building in necessary support.
- As a whole class, work collaboratively through the stages of solving a problem, gradually reducing the support you provide.
- Focus particularly on understanding problems and planning the solutions.
- Include short spells of carefully structured paired or small-group work.
- Expect pupils to share, comment on and evaluate each other’s work.
- Develop thinking skills by raising questions about ways of working and encouraging reflection on strategies for learning.

Note: This section draws on *Teaching and Learning in Secondary Schools: Pilot, Unit 8: Developing effective learners* (DfES 0348/2003).
Science: from Key Stage 3 to Key Stage 4

Following the Key Stage 3 national tests, it is quite common for departments to think of starting GCSE courses early. But what does this feel like for pupils? Since science, in one form or another, is a compulsory subject in Key Stage 4, pupils may have less of a sense of ownership of their choices than they do with optional subjects. How can you make best use of the time available to promote the features of science in Key Stage 4 that make it feel exciting, new or challenging for pupils?

By the end of Key Stage 3 most pupils have:

- developed a considerable body of scientific knowledge and understanding;
- begun to make connections between different areas of science helped by the five key scientific ideas of cells, interdependence, particles, forces and energy;
- developed skills in scientific enquiry and their understanding of how scientists work;
- begun to use their scientific knowledge and understanding to explain phenomena and events and to understand a range of familiar science applications.

In Key Stage 4 they will learn about a wider range of scientific ideas. They will consider the limitations and benefits of scientific applications and explore in greater depth the interconnection between scientific ideas. They will also:

- take more responsibility for improving their own learning and performance;
- develop their problem-solving skills to encompass a wider range of contexts and applications, within and across the strands;
- develop their communication and reasoning skills to a higher level, including using ICT skills in increasingly complex contexts;
- engage in more independent in-depth work, such as investigations and enquiry and personal research.

For teachers, this transitional period offers an opportunity to continue the development of pupils’ key skills in a scientific context. You will want to:

- decide which skills and contexts are most appropriate to develop with your pupils;
- consider how bridging projects can best help pupils to approach their chosen route through Key Stage 4.
Selecting bridging projects for development

The science bridging projects table summarises four possible bridging projects in science. Several deliberately build on existing Strategy materials. You will want to select ideas carefully, taking account of what you have done in Year 9 and the time available. Consider whether you already incorporate bridging activities in your current scheme of work. If so, is there value in reviewing what you currently do? If you do not yet use bridging projects, is there value in developing one or more of the projects outlined here? You might find it useful to copy the summary table and use it as a starting point for discussion with colleagues in your department.

The last section of the booklet gives details of each project and lists necessary resources so that you can scan the suggested projects to clarify what they are offering and check whether you have, or can obtain, any materials needed.
## Science bridging projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Title</th>
<th>Time required</th>
<th>Summary</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Investigating scientific questions</td>
<td>Up to 6 hours</td>
<td>Based on Unit 9M from the QCA exemplar scheme of work. Pupils consider what sort of questions can be investigated scientifically. Groups of pupils work as teams to investigate a scientific question in an engaging context. There is the opportunity to draw attention to the important aspects of investigation: planning, obtaining and presenting evidence; analysing, considering and evaluating evidence. Pupils can also be helped to develop their skills in working independently and collaboratively. At the end of the project, pupils will report back about their work, and will have experienced all aspects of scientific investigation.</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>Self- and peer-assessment</td>
<td>Up to 4 hours</td>
<td>Based on AKSIS (Association for Science Education and King’s College Science Investigations in Schools) materials, Key Stage 3 national tests and Key Stage 3 Strategy publications. In one of two different contexts, chosen by the teacher, pupils work together to assess peers’ achievement against clear criteria for success. They give one another positive feedback and suggest points for improvement in the future.</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Ideas and evidence</td>
<td>Up to 6 hours</td>
<td>Based on DfES Science Year 2001/2002 materials and Key Stage 3 Strategy publications. Pupils use a computer role-playing game to explore a forensic science issue and to consider how different ways of interpreting evidence can lead to conclusions that conflict with one another. The pupils consider primary and/or secondary sources of evidence and present their reactions to conflicting interpretations by different specialists, observers and the media.</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Key ideas in science</td>
<td>3.5 hours</td>
<td>Based on Key Stage 3 Strategy materials and pupil discussion. There are three stages to the project: - pupils consider how models are used to explain key ideas and concepts in science; - they evaluate their own scientific models and how well they ‘explain’ some new phenomena; - they consider how their own models may need to be modified as a result.</td>
<td>21</td>
</tr>
</tbody>
</table>
Implementing your bridging plans

Working with your department

Assuming you are following the guidance on page 3, ‘How to use this booklet’, and on page 7, ‘Selecting bridging projects for development’, there are a number of other issues to consider when implementing your plans.

Actively following up in Year 10 the developments initiated in Year 9 should ensure continuity and progression – the essential purpose of your bridging plans. Whether your bridging projects are located mainly towards the end of Year 9, split evenly between Years 9 and 10, or mainly at the beginning of Year 10, there needs to be an explicit link between the key stages, so that pupils can see that they are developing what they have begun.

Discuss with colleagues how you will overcome potential obstacles to this process. For example, there may be significant changes in pupil groupings and staff allocations between Year 9 and Year 10.

- How can you ensure that these changes will not inhibit what you do and that all pupils gain full benefit from your bridging course plans?
- Do your plans involve all pupils in the year group?
- What records or notes will need to be kept by pupils and teachers?
- How will you round off the work in Year 9 and re-engage with it in Year 10?

Detailed planning, which might be delegated to a smaller group of colleagues, might raise various questions to consider.

- What adaptations will you need to make to your scheme of work in order to incorporate the selected projects?
- What new material or adaptations to existing material do you propose to include?
- How will you ensure that teachers are briefed and that resources are prepared in time?
- How will your bridging plans reflect QCA guidance about forthcoming changes to the Key Stage 4 Programme of Study?

Networking within your school

Effective implementation of plans needs to involve your school's senior leadership team. Support from the leadership team might include, for example:

- coordinating bridging plans across subjects;
- fostering development of pupils’ learning skills as a whole-school focus through transition to Key Stage 4.

You might seek the assistance of the leadership team in making arrangements such as:

- teacher release to develop ideas;
- timetable changes towards the end of term;
- increased access to computer facilities.

You might also want to liaise directly with another subject department:

- to work on a joint initiative, for example by linking with the English department on developing literacy in science through creative writing;
- to seek support, for example by negotiating with the PE department to collect data about diet and exercise for analysis by science classes at a later date.

**Networking with other schools and the LEA**

There are considerable advantages to setting up or linking into local development groups to pool ideas and perhaps develop shared materials. This is an effective way of making best use of local capacity. Possibilities to consider are:

- linking with one or more local departments to initiate a joint development;
- linking into LEA facilities and networks by working with your Key Stage 3 consultant and keeping them informed of developments.
Project 1: Investigating scientific questions

Learning outcomes
This project will support groups of pupils working together as teams to carry out a complete scientific investigation and, afterwards, to report about their work to the other teams in terms of planning, obtaining and presenting evidence, analysing and considering results and evaluating their methods and findings. It develops the key skill of Working with others.

Background to the project
The project is based on Unit 9M from the QCA scheme of work. Pupils consider what sort of questions can be investigated scientifically, and work as teams to investigate a scientific question in an engaging context. There is a good opportunity here to draw attention to the important aspects of investigation: planning, obtaining and presenting evidence; analysing and considering evidence; and evaluating. The project will also help pupils to develop their skills in working independently and collaboratively.

Resources
- Science: a scheme of work for Key Stage 3 (QCA/00/445)
- AKSIS Investigations – Targeted Learning, Anne Goldsworthy, Rod Watson, Valerie Wood-Robinson (ASE)
- Key Stage 3 Strategy CPD materials:
  - Scientific enquiry (DfES 0348/2002)
  - Literacy in science (DfES 0560/2002)
  - Effective teaching and learning in science (DfES 0238/2003)
- Framework for teaching science: Years 7, 8 and 9 (DfES 0136/2002)
Structure of the project

<table>
<thead>
<tr>
<th>Introduction</th>
<th>The teacher sets the context for the investigations that will take place and explicitly introduces the criteria that will be used for recording and reporting back.</th>
<th>Up to 1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main body of the project</td>
<td>Teams of pupils work independently, investigating their chosen scientific question. Teams prepare their reports as annotated posters.</td>
<td>Up to 4 hours</td>
</tr>
<tr>
<td>Plenary stage</td>
<td>Teams share and evaluate their work.</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

Managing the project in Year 9

Set the tone for the whole project in the introduction. Say that pupils are going to have an opportunity to:

- carry out a complete scientific investigation;
- show that they can work both independently of you, the teacher, and together as part of a team, developing the key skill of working with others.

Discuss with pupils the different kinds of investigation (fair test, survey, research, model, etc.) that they may choose to carry out, and also the stages (planning, obtaining and presenting evidence, analysing and considering results and evaluating) into which their investigative work will fall.

Make obvious the link between the pupils’ existing experience of scientific investigations and the ways that this will be developed in Year 10 and beyond.

QCA Unit 9M: *Investigating scientific questions* begins with a section entitled ‘What sort of questions can be investigated scientifically?’ This is a good starting point for the project and you can use it to remind the pupils that there are some questions that can be investigated scientifically, and some that cannot. You can use this to arrive at a list of possible investigations. All of the questions given in the unit are related to the theme of water, but you can choose other questions on your own theme or context.

Introduce the grouping arrangements at this stage. The pupils will work in independent teams of between three and five people to investigate their chosen question. It is important that they know how much time they have and the limitations that apply to their resources and materials.

By the end of Year 9 most pupils will be able to plan and carry out a full scientific investigation, with some guidance. During the main body of the unit the teams will be working independently. The teacher’s intervention role is to ‘oil the wheels’, to provide appropriate challenge and support and to gather information about ways of working that can be discussed later in the feedback stage.
Each team produces a report that summarises their work and their findings. The teacher can have a real input into what form this takes, and which aspects of the investigation are reported. Some examples of formats for reporting are annotated posters, formal reports, newsletters, magazine articles, scripts etc. In terms of focusing the reporting on one aspect of the investigation, you may, for example, want to specify that all teams produce a report about how they obtained their evidence so that different methods can be compared during the team feedback. Alternatively, teams may report on different aspects so that the way in which they contribute to the whole investigation can be discussed.

The plenary stage is an opportunity for you and the teams to share the outcomes of the project. You may decide to organise this in one of a number of ways (see Key Stage 3 Strategy science publications: *Literacy in science* and *Effective teaching and learning in science*). Whatever you decide, it is important that the pupils evaluate what they have achieved, identify how they responded to the challenge and indicate areas where they can continue to develop.

**Developing the project in Year 10**

There are good opportunities to link this project to work carried out early in Year 10 by emphasising an enquiry-led approach in practical lessons and by reinforcing explicitly to pupils the different aspects of investigative skills. For example, explicit reference can be made to the project as a precursor to pupils’ early scientific investigations in Year 10. If the written outcomes of this project are kept, Project 2: Self- and peer-assessment can easily be adapted to allow pupils to assess their earlier work in the light of their introduction to the expectations for Key Stage 4.
Project 2: Self- and peer-assessment

Learning outcomes
In this project, pupils will explore how they can help themselves, and their peers, to assess how well they succeeded in a task. They will look at how clear, positive feedback can help them to improve their learning and performance. The project suggests a number of different contexts in which the task can take place, and different methods of assessment and positive feedback. It develops the key skill of **Improving own learning and performance**.

Background to the project
The project draws on some of the material published from the King’s College AKSIS research, on tests done at the end of key stages and on various Key Stage 3 Strategy publications. It gives the teacher the opportunity to choose one of two different contexts that will allow pupils to work together to assess a peer’s achievement against clear criteria for success and to suggest points for improvement in the future.

Resources
- **AKSIS Investigations – Targeted learning**, Anne Goldsworthy, Rod Watson, Valerie Wood-Robinson (ASE)
- **Developing Understanding in Scientific Enquiry**, Anne Goldsworthy, Rod Watson, Valerie Wood-Robinson (ASE)
- **School Science Review** 83 (302) (ASE)
- Key Stage 3 Strategy CPD materials:
  - **Literacy in science** (DfES 0560/2002)
  - **Effective teaching and learning in science** (DfES 0238/2003).
- **Inside the black box** and **Working inside the black box** (King’s College London, Department of Education and Professional Studies)
- **Assessment for learning: Beyond the black box** and **Testing, motivation and learning** (Assessment Reform Group)
- **Testbase** or **Year 9 National Curriculum test questions and mark schemes** (QCA)
## Structure of the project

**Context 1:** using the type of questions found in Key Stage 3 National Curriculum tests, with their mark scheme, as a medium for assessment and positive feedback

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>The teacher uses a video clip and discussion to introduce some important principles of assessment and feedback. Teacher and pupils discuss the ground rules for the main part of the project.</td>
<td>Up to 1 hour</td>
</tr>
<tr>
<td><strong>Main body of the project</strong></td>
<td>Pupils use questions, such as those in the Year 9 National Curriculum test, and a marking scheme to assess a partner's work and to give positive feedback.</td>
<td>Up to 2 hours</td>
</tr>
<tr>
<td><strong>Plenary stage</strong></td>
<td>Teacher and pupils share and discuss the experience of self- and peer-assessment and consider how it can be used to help them to improve their learning in Key Stage 4.</td>
<td>Up to 1 hour</td>
</tr>
</tbody>
</table>

**Context 2:** using the outcomes of a scientific enquiry

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>The teacher uses a video clip and discussion to introduce some important principles of assessment and feedback. Teacher and pupils discuss the ground rules for the main part of the project.</td>
<td>Up to 1 hour</td>
</tr>
<tr>
<td><strong>Main body of the project</strong></td>
<td>Pupils assess their completed reports on an enquiry, using the aims of the lesson to identify the qualities they are assessing.</td>
<td>Up to 2 hours</td>
</tr>
<tr>
<td><strong>Plenary stage</strong></td>
<td>Teacher and pupils share and discuss the experience of self- and peer-assessment and consider how it can be used to help them to improve their learning in Key Stage 4.</td>
<td>Up to 1 hour</td>
</tr>
</tbody>
</table>
Managing the project in Year 9: context 1

The purpose of the introduction is to familiarise the pupils with the ideas of assessment and feedback. It can also be used to emphasise that the project is an opportunity for them to develop the key skill of improving their own learning and performance. The video clip Writing conclusions (Literacy in science CPD unit) can be used in the introduction. The clip shows a teacher modelling a good conclusion to a class and then allowing them to work on a conclusion of their own afterwards. Draw out with your pupils that:

- the teacher makes it clear which criteria are used to judge a good conclusion;
- assessment should be concerned with making decisions about the quality of a piece of work, based on clear and agreed criteria for success;
- positive feedback is concerned with giving guidance about how quality of work can be improved.

In the introduction, explain the ground rules for assessment and positive feedback: each demands honesty, trust and openness. Assessment and feedback must be guided by the assessment criteria and the quality of the work, and not by appearances and relationships. Point out the value of words and phrases such as:

- because, if, explain, describe;
- when you, try to, next time;

in helpful feedback.

Give pairs of pupils a question that has been ‘answered earlier’ to assess and comment on together, using a mark scheme. They can then discuss their assessment and feedback in groups of four and come to a common agreement in a mini-plenary session.

In the main body of the project, pupils begin by working individually to answer a Year 9 National Curriculum test question (or similar) that is challenging, but within their capability. The most productive questions are those in which there is an element of explanation as well as factual recall. You can decide whether the question should be answered with or without the use of reference material.

Pupils now work in groups of four to assess and give feedback on completed questions. They do not assess their own work at this stage. Each pair uses the mark scheme to assess the work of the other pair in the group and, at the end, agrees on one or two points of positive feedback that will help to improve future learning.

When pupils get their work back, there is an opportunity to consider the assessment and the feedback before pairing up for discussion with one of the people who assessed it.

The plenary stage of the project is led by the teacher and brings the whole class together to discuss the outcomes of their work. The purpose is to help the pupils to consider how they decided on their assessments (in this case with the scaffolding of a mark scheme) and how they decided on which feedback was the most important to give. This can be organised as an open discussion, or by using a group-work technique (see Key Stage 3 Strategy science CPD publications: Effective teaching and learning in science and Literacy in science).
Managing the project in Year 9: context 2

The introduction to the project can be run in the same way as in context 1.

The main body of the project involves the pupils working together to assess their reports of an enquiry they have previously completed. Using this context, this project may be combined with Project 1: Investigating scientific questions. Each group uses the teacher’s planned lesson objectives and outcomes to decide success criteria and feedback for the reports. The source material for this part of the project is *AKSIS Investigations – Targeted Learning*, chapter 3, Activity 3.2.

The plenary discussion period is structured in the same way as for context 1.

Developing the project in Year 10

In Year 10, there is an early opportunity to link the achievements pupils have made in this project explicitly to the school’s teaching and learning policy for Key Stage 4. For example, at the beginning of a teaching unit, pupils can be set homework designed to elicit their existing scientific knowledge and understanding of the intended subject matter. This is followed by a discussion lesson that uses the pupils’ developing self- and peer-assessment skills to identify areas where knowledge and understanding are weak and where misconceptions exist.
Project 3: Ideas and evidence

Learning outcomes
In this project pupils will play the part of an investigator seeking a scientific explanation for a seemingly inexplicable event. They will use creative thinking and scientific reasoning skills in the context of a computer role-playing game to collect evidence and make conclusions. There is an opportunity for pupils to carry out practical work to test evidence and assertions in the computer program. The outcome of the project is a piece of creative writing or role-play. It develops the key skill of Communication.

Background to the project
This project presents an opportunity to use ASE Science Year ICT material and Key Stage 3 Strategy publications to help pupils to explore how scientists work. It will help teachers to lead pupils to consider how conflicting conclusions can arise from different ways of interpreting evidence, and how this affects the public perception of what science is.

Resources
- Can we; should we? CD-ROM (ASE: www.ase.org.uk)
- Key Stage 3 Strategy CPD material:
  - Strengthening teaching and learning of particles in Key Stage 3 science (audio clip)
### Structure of the project

| Introduction | The teacher:  
|--------------|------------------------------------------------|
| **| - sets the context and the focus (ideas and evidence) of the project for the pupils;  
| **| - explains the structure of the project (at the computer, in the laboratory, recording feedback).  
| **| Up to 1 hour  
| Main body of the project | Pupils work in small groups at the computer to complete the game and collect enough evidence to explain convincingly what has happened (Missions 1 to 5 of the game).  
| **| The groups may take part in a circus of laboratory investigations to test the evidence gathered from the game.  
| **| Each group records its findings using one of a range of contexts given by the teacher.  
| **| 3 hours  
| Plenary stage | Groups present their findings to one another and discuss ways in which ideas and evidence are an important part of how developments and discoveries happen in science.  
| **| Up to 2 hours  

### Managing the project in Year 9

All of the resources for this project, including teachers’ and technicians’ notes, are in the activity *Human Torch* on the ASE CD-ROM: *Can we; should we?* As well as meeting learning objectives related to ideas and evidence within scientific enquiry, the original materials also cover aspects of burning, simple chemical reactions and health and safety. Teachers should be aware that the photocopiable pupil material on the CD-ROM is pitched for pupils working at levels 4 and 5, and so it should be modified to suit your own context and your pupils.

The introduction is used to set the project in context, which is an investigation of a case of spontaneous human combustion. Explain to pupils that they will work in small groups to play the computer game. The game is all about using ideas and evidence to explain a puzzling observation. They will take part in a circus of practical work that demonstrates or tests some of the evidence gathered from the game. Teachers can be explicit here about how this links to the way scientists work. Describe to pupils how you want their findings to be presented, e.g. in the form of a case-report, a magazine article, a TV or radio report or a drama script. Say that effective communication of their scientific findings is an important key skill that they can develop in this project. Emphasise that, although the format for their presentations can be a creative one, it is important that its content is supported by the evidence they will gather in the project.
The main body of the project has three aspects:

- work at the computer;
- practical work;
- reporting.

There is considerable flexibility for the teacher to decide exactly how this part of the investigation will be organised, and useful guidance is given in the teacher’s notes on the CD-ROM. For example, it is possible to concentrate the pupils’ attention on specific aspects of the computer investigation or to extend it to another level, to carry out the practical work as a circus or as assigned tasks. For this reason, it is vital that teachers have gone through the CD-ROM material carefully themselves before using it in this project.

The reporting stage allows pupils to communicate their work in a creative and engaging way. The focus for reporting is the importance of ideas and evidence in investigations, and teachers will need to remind pupils to concentrate on this aspect in whatever style they choose from the range offered. There needs to be enough time allocated for pupils to plan, complete and share their feedback meaningfully.

During the plenary stage, draw out from the pupils how the project helps them to:

- respond to sensationalist news headlines such as ‘Asteroid could hit Earth any day’ or labelling like ‘Biscuit bar: 70% fat-free’;
- understand how scientists work, e.g. teachers could use the commentary by Professor Sir Harry Kroto (in the Key Stage 3 Strategy science unit: *Strengthening teaching and learning of particles in Key Stage 3 science*) as a stimulus for discussion.

**Developing the project in Year 10**

This project can be linked through into Year 10 by choosing a contemporary science context to extend and enrich an early topic in the Key Stage 4 curriculum. Pupils can be involved in identifying and researching the scientific evidence and opinion, including interpretation, behind the topic. There is ample scope for this approach in the Key Stage 4 programme of study, e.g. by using media claims about the perceived benefits of a particular dietary regime, compared with the scientific evidence for those benefits.
Project 4: Key ideas in science

Learning outcomes
In this project pupils are introduced to waves, a key area of understanding that is taught in Key Stage 4. They investigate some of the properties of wave behaviour and apply their understanding of the particle model in a new context to explore and explain some aspects of how waves behave. The project develops the key skill of Problem solving.

Background to the project
This project, based largely on Key Stage 3 Strategy materials and on pupil discussion, allows teachers to develop further the important role of models in science. In the context of waves, an important scientific idea in Key Stage 4, pupils evaluate their own scientific models and how well they ‘explain’ new wave phenomena.

Resources
- Key Stage 3 Strategy materials:
  - Strengthening teaching and learning of particles in Key Stage 3 science (DfES 0243/2003)
  - Effective teaching and learning in science (DfES 0238/2003)
  - Assessment in science (DfES 0369/2002)
  - Misconceptions in Key Stage 3 science (video clip) (DfES 0287/2002)
- Website: www.gmi.edu/~drussel/Demos.html
- Teaching secondary physics (John Murray)

Structure of the project

<table>
<thead>
<tr>
<th>Introduction</th>
<th>The teacher demonstrates some of the properties and effects of waves to pupils, e.g. reflection, refraction and diffraction.</th>
<th>1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main body of the project</td>
<td>Pupils work together in groups. They attempt to use and adapt their existing particle model to explain the wave behaviour that the teacher has demonstrated.</td>
<td>1.5 hours</td>
</tr>
<tr>
<td>Plenary</td>
<td>Teacher and pupils discuss and compare their models, and also compare them with other scientific models.</td>
<td>1 hour</td>
</tr>
</tbody>
</table>
Managing the project in Year 9

The introduction is an opportunity to:

- explain that the project involves the pupils using the particle model, with which they are familiar from Key Stage 3, to try to explain some new phenomena;
- develop the problem-solving skills that they will need to use in order to do this.

The teacher shows the pupils simple waves as empirical events, using a ripple tank to demonstrate linear and circular waves. If equipment allows, the pupils can use the apparatus themselves in groups. At this stage there is a mini-plenary to discuss what might be happening to particles in the water in each case. The teacher is not looking for ‘correct’ answers at this stage, but allows pupils to speculate on how their understood particle model can explain this, or how it has to be modified.

The teacher begins the main body of the project by demonstrating reflection, refraction and diffraction, though the pupils could carry out this practical work themselves if equipment allows. The pupils now work in groups, discussing explanations of what they see in terms of the behaviour of water particles. The teacher’s role at this stage is to listen to what groups are saying and to use open-ended questions to encourage pupils to extend their ideas and explanations (see Key Stage 3 Strategy science unit: Assessment in science: developing effective teacher questioning). Pupils can usefully record their explanations as text, concept maps or annotated posters.

In the plenary session, pupils and teacher discuss their models and how they have used and adapted them to explain the events that they have seen. The teacher can emphasise here that this kind of problem solving, involving ways to answer scientific questions with creative solutions, is an important key skill both in science and in learning in general. The session can end by showing some of the scientific models for wave behaviour on the website listed in the resources.

Developing the project in Year 10

This project can be adapted in two ways, and either of these may be used early in Year 10 to complement the work that the pupils did at the end of Year 9.

- More aspects of wave behaviour can be investigated in the context of how particles behave, e.g. the transfer of energy through waves, how waves can be transmitted through solids.

- Other key ideas and models can be extended into Key Stage 4 contexts, e.g. using an energy transfer model to explain how energy is transferred from power stations to consumers or using the cell concept to explore how variation and selection can lead to evolution.
Bridging plans: from Key Stage 3 to Key Stage 4

- Do you have specific plans for lessons that bridge between the end of Key Stage 3 and the beginning of Key Stage 4?
- Do you plan units of work that give Year 9 pupils a fresh learning experience after the national tests in May?
- Do your pupils have a sense of a new beginning when they start Key Stage 4 courses?
- Do you develop pupils’ expectations for future learning in your subject?
- Do you take the opportunity to enhance pupils’ skills as independent learners?

Giving attention to these questions can ensure that Year 9 pupils receive a fresh stimulus at the end of Key Stage 3 and that their work links effectively with the challenges of Key Stage 4.

This booklet is one of an initial set of three, focused on the core subjects of English, mathematics and science. The aim is to capture and make best use of time at the end of Year 9 and into Year 10. Each booklet:

- suggests a common approach to fostering pupils’ development as independent learners;
- identifies aspects of the chosen subject that might be developed to improve transition from Key Stage 3 to Key Stage 4.

The maximum benefit will be found where senior managers lead and support these developments across the school.