What do we mean by evidence?

Background

The following point needs to be made explicit to pupils

- Evidence is the outcome from measurements (data as in tables, graphs) and observations

We use evidence to:

- support or challenge an idea/prediction/theory/hypothesis/model
- make links
- identify differences
- decide whether something is changing over time
- raise questions for further investigations

A pupil working at:

Level 4

- can suggest what to collect as evidence to challenge or support an idea/prediction/theory/hypothesis/model
- can decide if they have enough readings to make an informed judgement about pattern or cause and effect

Level 5

- is able to discriminate between relevant and irrelevant evidence and to distinguish between fact and opinion
- decides whether the evidence found was sufficiently accurate and/or reliable
- decides whether the evidence is secure because of sufficient range and sample size, or not

To move pupils from level 4 to level 5

1. Teach pupils to make sensible decisions about what evidence to collect.
2. Teach pupils how to decide whether they have sufficient data and a suitable range of data.
3. Teach pupils how to decide if something is evidence or just true but not helpful.
4. Teach pupils to begin to distinguish between fact and opinion.

Suggested teaching sequence

The following activities could all be done in one lesson or split into separate activities and spread over more than one lesson.

1. **To teach pupils to make sensible decisions about what evidence to collect**
   - Discuss with pupils what evidence scientists need and where they get it from. Use the exercise 'Is this evidence?' (sheet 5) to prompt discussion.
   - Give pupils the exercise 'What evidence do I need?' (sheet 6) where they have to decide what they could measure or observe to provide the evidence for the investigation. The activity could be done in small groups and answers written on the sheet, or the investigations could be put onto OHT and discussed one at a time in small groups. Other investigations could be used that pupils may be more familiar with. In each case collect answers from each group and discuss differences of opinion across the whole class. Ask the following types of question:
     – Were some investigations easier to decide about than others?
     – What made some easier to decide?
     – What helped you to decide what to measure or observe?
     – Were there any clues in the title of the investigation?
     – Did you feel you needed more information to help you?
     – What sort of information do you think would be helpful?
   - Give pupils the exercise 'The right evidence?' (sheet 7) where they discuss whether the pupils in each example were collecting the right evidence. These examples could be given as a printed sheet or used as an OHT. In each case there should be feedback from groups and whole-class discussion, especially if there is a difference of opinion. You could ask the following types of question:
     – What helped you to decide if the pupils were collecting the right or wrong evidence?
     – If you don't think they were collecting the right evidence, what would you suggest they ought to do?
     – Why do you think they might have picked the wrong thing to measure or observe?
     – Could the pupils have collected other evidence that would have been just as useful?

2. To teach pupils how to decide if they have sufficient data or a suitable range of data

- Use *AKSIS Investigations: developing understanding in scientific enquiry*, pp. 50–55, if you are looking at evidence for fair tests not involving living things.
- Use *AKSIS Investigations: developing understanding in scientific enquiry*, pp. 56–62, if you are looking for evidence for fair tests or pattern seeking with living things.
- You can use the above activities to create some prompts for pupils to consider when they are planning to collect evidence, or use sheet 8, 'Getting useful evidence'. Pupils can then review their own investigations (or copy some from other classes if that is less threatening) and consider whether the evidence they collected was useful.

3. To teach pupils how to decide if something is evidence or just 'true but not helpful'

- Use the evidence cards from the *Scientific enquiry* unit on smoking (task J, page 101) (*Scientific enquiry: resources pack for participants*, DfES 0391/2002).
- Use sheet 9, 'Which statements support the view that the Earth is spherical?'
- Use the Upd8 material from the ASE website (www.ase.org.uk), e.g. *Global Warming* – use the cards to decide if the statements are evidence for global warming, or *Shuttle Disaster* – read this and highlight statements that are true but are not evidence for the disaster.

4. To teach pupils to begin to distinguish between fact and opinion

- Discuss with pupils the difference between fact and opinion, i.e. facts are backed up by evidence. For example, many pupils think that evolution is a fact when it is only a theory. Facts and opinions are often intermingled in books to try to make a text more accessible.
- Use sheet 10, 'Fact or opinion?', with pupils. This article is taken from Upd8 which is available on the ASE website. The site has further articles which could be used in the same way.

- Use newspaper articles or information from the Internet to get pupils to look at conflicting evidence. The BBC website is useful here (www.bbc.co.uk/science/hottopics).

  The example on sheet 11, 'Are mobile phones dangerous?', contains statements for and against this question. Pupils can decide which of these are fact and which are opinion.

Relevant Key Stage 3 national test question

- **2003 paper 1, tier 3–6 question 2**
  Using results to decide whether a conclusion is true, false, or you cannot tell

Is this evidence?

- An experiment carried out by a famous scientist
- A table of results
- What my dad said when I asked him
- A graph
- An experiment carried out by me
- A newspaper article
- An interview with a professor on the radio
- What is written in my science textbook
- What my teacher told me
- What I found on the Internet
- A survey I did in school
- What my best friend told me
- A science-based television programme

What evidence do I need?

In your group, read each question to investigate and decide what could be measured or observed to provide evidence to help answer the question.

Question to investigate	*What could I measure or observe to provide the evidence to help answer the question?*
Will the temperature of the water make a difference to how much salt dissolves?	
What happens when acid is added to different metals?	
Which type of sugar is best for pollen tube growth?	
Will the number of coils of wire make a difference to the strength of the electromagnet?	
Does hearing range decrease with age?	
Which is the best fuel to burn?	
What conditions do woodlice prefer?	
Does the number of layers of insulation affect how quickly the water cools down?	

The right evidence?

1. Pupils wanted to find out if people with the longest arms could throw a bean bag the furthest.
   They measured the length of people's arms and how heavy the bean bag was.

2. Pupils wanted to find out how much water there is in an apple.
   They timed how long it took for the apple to cook.

3. Pupils wanted to see if different soils soaked up (absorbed) the same amount of water.
   They used the same amount of water each time and measured how much water dripped through the soil.

4. Pupils wanted to find out whether different coloured objects were the same colour when they looked at them in beams of different coloured light.
   They drew what the object looked like in each light beam and coloured it in.

5. Pupils wanted to find out if more dandelions grew on rough ground than on the school field.
   They counted the number of leaves each dandelion had. They looked to see if the dandelions on the rough ground had more leaves.

6. Pupils wanted to know if more sugar made yeast grow faster.
   They measured the height of froth on the yeast after 30 minutes.

7. Pupils wanted to find out if plants grew faster when they were given fertiliser.
   They tested a leaf from each plant to see if it contained starch.

8. Pupils wanted to find out if acids affected metals.
   They measured the pH of the acid to see if it was nearer to pH 1 or to pH 7.

Getting useful evidence

Some questions to ask when planning what evidence to collect during scientific enquiry, including investigations

For a fair test investigation (but not with living things)

- Have I got enough values to show a pattern?
- Are the values spread out enough to show a difference?
- Are the values going up in equal steps to make it easier to see a pattern?
- Are there any values that are not helpful?

For investigations with living things

- Is my sample size too small?
- Is my sample size too big because it will take too long to collect the evidence?
- Am I taking my samples from different places?
- Am I taking my samples fairly?

Which statements support the view that the Earth is spherical?

Read each statement and decide whether it is evidence which helps or does not help to decide if the Earth is spherical.

When ships sail towards you, the mast appears first	The Earth has a magnetic field
The Earth looks spherical when viewed from space	If you travel west you get back to where you started
The Sun travels across the sky in the same direction every day	The Earth takes a year to travel round the Sun
Globes are spherical	The Moon and the Sun look round
People don't fall off the Earth when they travel a long distance	The Earth spins on its axis

Fact or opinion?

Highlight in yellow any statements that are facts.
Highlight in red any statements that are opinion.

The last bananas

Bananas are under threat from a deadly fungus called Black Sigatoka, which damages the fruit and kills the plants within a couple of years. The banana industry could die completely within 10 years.

All fruits are attacked by pests and disease. But other plants have a weapon – sexual reproduction. This gives rise to new genes which can protect the plant against invaders. The banana is different. It has no seeds or pollen, and so does not reproduce itself. It has no way to evolve ways to resist disease.

How do we get new banana plants? By taking cuttings from the stems of the old plant and replanting them. Every banana you eat is genetically the same. There are some varieties of banana which can reproduce sexually. But they have hard seeds and are unpleasant to eat. It is the 'mutant bananas', with delicious fruit but no seeds, that people have enjoyed since the Stone Age.

To fight the fungus, growers have been spraying banana plants up to 40 times a year. But the chemicals cause problems. In Costa Rica, one-fifth of male banana workers are now sterile.

Are mobile phones dangerous?

The statements below provide a case against the use of mobile phones (Yes) and support the use of mobile phones (No). Decide which statements are fact and which are fiction.

Yes	*No*
Radiowaves given off by mobiles can heat up body tissue, having damaging effects	Radiowaves are not powerful enough to cause heat damage to the body
Magnetic fields created by mobile phones can affect the way that your body cells work	The magnetic fields are incredibly small, and so unlikely to affect cells in our body
People who make long mobile phone calls sometimes complain of fatigue, headaches and loss of concentration	The same results have never been reported in laboratory conditions and may be due to other factors in modern lifestyles
Mobile phone users are 2.5 times more likely to develop cancer in areas of the brain adjacent to their phone ears	Researchers admit it's unclear this increase is linked to using mobiles
The International Agency for Research on Cancer found a link between childhood cancer and power lines. Like mobile phones, power lines also emit radiation	The radiation produced by power lines is a different kind of radiation, with much more energy than that coming from mobile phones
Radiofrequency waves similar to those in mobile phones altered the worms	Worms are not humans; there is no guarantee that our brain cells will behave in the same way