Are there fairies at the bottom of the garden?

Science content

Electrons, electric current, electrostatic phenomena, sensors, (neutrinos), nature of scientific evidence.

Science curriculum links
AT 1 Exploration of science
AT11 Electricity and magnetism
AT12 IT including microelectronics
AT17 The nature of science

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

Lesson time
1 hour
(more for practical work)

Links with other SATIS materials
907 Your Stars – Revelation or Reassurance?

NERIS
Search on
ELECTRONS and UPPER SECONDARY
or on
ATOMIC STRUCTURE and UPPER SECONDARY

SUMMARY

What is the evidence for the existence of fairies, electrons and neutrinos?

STUDENT ACTIVITIES

- ☐ Information and questions considering the evidence and the tentative nature of proof: the fake Cottingley fairies.
- ☐ Information and questions on the properties and detection of electrons and neutrinos.
- ☐ Design, make and test a fairy detector (optional).

AIMS

- ☐ To provide opportunities to consider the nature of scientific evidence and belief
- ☐ To link with work on static electricity, electromagnetism and sensors in microelectronics
- ☐ To revise and deepen students' understanding of the properties of electrons and to link with new ideas on particle physics
- ☐ To consider evidence and spurious results
- ☐ To design, make and evaluate a piece of experimental apparatus

USING AND ADAPTING THE UNIT

- ☐ The questions may be answered by students working in small groups and reporting back to the class. Alternatively the unit may be done as a pencil-and-paper exercise.
- ☐ Students could prepare demonstrations of the experiments they describe in Q6 and show them to the class or to younger children.
- ☐ Build and test a fairy detector is an optional activity that may be linked to work with sensors.

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Teaching notes

This unit may be used to draw together work on electricity, microelectronics, atomic theory and cosmology.

The neutrino is introduced to indicate some of the imagination-stretching ideas used by physicists. Many physicists are working on experiments to detect and understand the origin of neutrinos produced in thermonuclear reactions such as occur deep inside the Sun.

Fairies appear in British folklore as fairies, elfs, pixies, leprechauns etc. Belief in the existence of 'fairy creatures' pervades many cultures from Eskimoes to Australian aborigines. A large encyclopaedia may provide a good starting-point for information on this subject.

It seems that the rigorous requirements of scientific evidence no longer enable people in Western cultures to sustain a belief in the existence of fairies.

Apparatus requirements

Fairy detectors: a wide range of solutions is possible for a pencil-and-paper activity – using light sensing circuits, pressure detectors, mechanical traps etc. If students are to undertake practical work it may be advisable to restrict them to using a range of equipment such as microelectronic kits or possibly electromagnetism kits.

Answers to the questions

Q1 *The quality of the photographs was not up to modern standards. They were examined to see if the fairies had been superimposed but the idea of strings was not taken seriously. People (including scientists) were predisposed to accept the evidence. A similar example of the gullibility of scientists is in Professor Blondlot's discovery of 'N-rays', which were eventually explained as due to streaking of the photographic plates by uneven development. A more recent example might be cold fusion.*

Q2 *It is hard to prove fairies do not exist. However, there is no scientific evidence that stands up to scrutiny to support their existence.*

Q3 *The existence of a Loch Ness monster may seem slightly more plausible: the Loch is deep and there have been recent discoveries elsewhere of animals believed to have been extinct. However, the lack of firm evidence seems to indicate that sightings, like those of fairies may be a result of wishful thinking. The tourist industry has a financial interest in perpetuating the monster myth.*

Q4 *Some captured specimens, photographs, video, triggering sensors such as IR, UV, magnetic, pressure etc.; less reliable evidence would be personal accounts of witnesses, drawings from many cultures.*

Q5 *Suggested answers:* ***1*** *C,* ***2*** *B,* ***3*** *A,* ***4*** *C,* ***5*** *A,* ***6*** *A/C?,* ***7*** *A/C?,* ***8*** *B,* ***9*** *A/C?,* ***10*** *A/C.*

Q6 *Effect of a current – heating, lighting, chemical (battery/electrolysis), magnetic (electromagnetism and electromagnetic induction); also electrostatic demonstrations, cathode rays (TV/oscilloscope), thermionic emission (Teltron tube), photoelectric emission (photocell), hydrogen line spectra, beta emission.*

Q7 *Spurious results. In a garden, sensors may be triggered by insects, leaves, pets etc.*

Acknowledgements

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Are there fairies at the bottom of the garden?

For generations people believed in fairies – small creatures with magical powers.

In Shakespeare's time, believing in fairies was common. Some of his plays had fairy characters like Titania and Ariel in the cast. There were numerous reports of sightings. However, fairies were only seen by people who were said to have 'second sight'.

A look at the problems of detecting fairies, electrons and neutrinos.

- ○ Reading, questions for written answers or discussion
- ○ Design a demonstration
- ○ Design a fairy detector

The Cottingley fairies

By the twentieth century fairy folklore was declining – most fairies being relegated to children's story books and the top of the Christmas tree.

Then one day two young girls, Elsie Wright and Frances Griffiths, produced photographs. They had been playing in the garden.

Figure 1 The 'Cottingley fairies'. One of the photographs that fooled the world for 70 years

This was the proof believers had been waiting for. Girls so young and innocent could not have faked the photographs. The photographs were examined by experts. No evidence of forgery was found.

The girls held firmly to their story. There *were* fairies at the bottom of the garden!

Many believed them. After all, other people had seen fairies too. The reason nobody else had photographed fairies before was easy to explain – the girls had 'second sight', the ability to see fairies which were invisible to adults.

Men of learning were convinced too. Articles appeared in the press suggesting that fairies be studied seriously.

Time passed. Elsie and Frances grew up and grew old. But they always denied the fairy photographs were fakes. Public interest in fairies waned as no new evidence was found. The 'Cottingley fairies', named after the village where they were discovered, remained a baffling curiosity.

Figure 2 The 'Cottingley fairies'

A scientific explanation

Just over seventy years later in 1979, science solved the mystery of the Cottingley fairies. James Randi, a magician, suspected the photographs had been faked.

Randi examined the photographs using image enhancement. This is a computer process more often used to increase the clarity of pictures taken from satellites and spacecraft.

Randi found the 'fairies' were held up by black threads!

Two young girls had fooled the world for more than seventy years. In old age, they eventually confessed.

Q1 *Why were people so easily fooled?*

Q2 *Does the fact that the Cottingley fairies were fakes prove that fairies don't exist?*

Q3 *People have reported sightings of a monster living in Loch Ness, Scotland. Scientists have investigated and no monster has been caught or photographed.*

Do you think that sightings of the Loch Ness monster are in any way different from sightings of fairies?

Q4 *What would you regard as proof that fairies exist?*

The physics of fairies?

You may not find a scientist who admits to believing in fairies. But physicists have discovered even stranger things.

At the time that interest in fairies was fading, physicists were finding particles whose properties were just as bizarre. In 1897 J. J. Thomson, experimenting with cathode rays, reported they were made of particles so small they seemed to have no size! Heinrich Hertz claimed that cathode rays were *waves* not particles. Eventually these particles with their strange properties were called **electrons**.

Electrons are so small, they are impossible to capture and look at. The best that scientists can do is look for evidence of their effects.

The discovery of electrons led to the technology of electronics. Television and computers are two examples.

Electrons

- have negative electric charge of 1.6×10^{-19} coulomb
- have a mass of 9×10^{-31} kilogram
- behave like particles or waves
- are acted on by magnetic and electric fields

Q5 *Are electrons like fairies? Decide which of the following statements describe:*

A **electrons,**
B **fairies,**
C **both electrons and fairies.**

1 They are invisible to the eye.
2 They have wings.
3 They move inside your calculator when you do sums.
4 They have almost no mass.
5 They make the picture light up on your TV screen.
6 They can get through solid metal.
7 They can travel nearly as fast as light itself.
8 They have magic powers.
9 They make magnetic fields when they move.
10 If you try to trap them they escape.

Q6 *Describe how would you demonstrate the effects of electrons to a friend or child.*

- *What experiments would you choose?*
- *How would you set them up?*
- *How would you make them interesting?*
- *How would you explain what is happening?*

The elusive neutrino

After the negatively charged electron was identified, a similar particle, the positron with a positive charge, was found. Another particle, but with no charge was suggested as long ago as 1931 and christened the neutrino. It remained undiscovered until 1956.

Physicists now know there are billions of neutrinos everywhere. They have no charge, little if any mass and are very difficult to detect. Neutrinos from the Sun usually pass right through the Earth as though it were not there.

Is believing in neutrinos like believing in fairies? Scientists have been able to detect the effects of neutrinos but no evidence for fairies has been found.

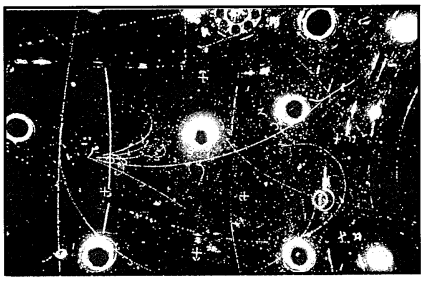

Figure 3 Photographic evidence of the effect of a neutrino. Neutrinos leave no track but they produce other particles which do leave a track. The photograph was taken in the Gargamelle heavy liquid bubble chamber at CERN

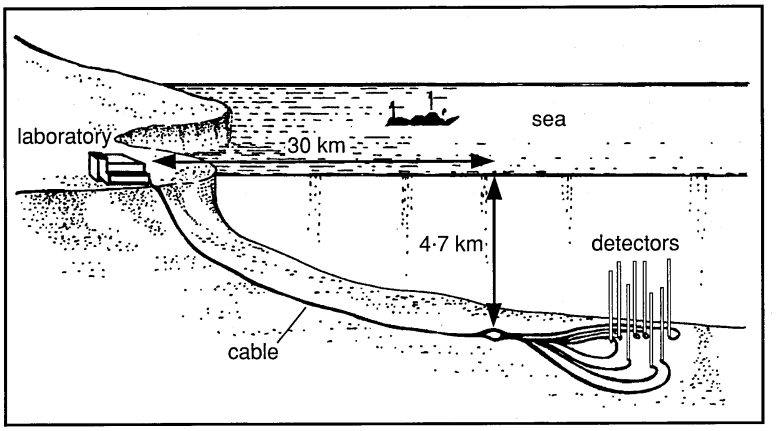

Figure 4 A neutrino detector which is being built more than 4 km under the ocean off the coast of Hawaii. It will detect neutrinos from outer space

Activity

You are asked to investigate a report of fairies in a garden. Design a fairy detector that you can make with science apparatus normally available to you.

- What effect or property of fairies would you try to detect?
- Make a list of the apparatus you would need.
- Draw a diagram of how you would put it together.
- Describe how it should work and what measurements you would take.
- If you have the opportunity, build and test it. Say what modifications you made to your original design.

Q7 If your detector 'works', what will you make of the result?

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