



Teacher Notes

To accompany the Science on the Farm posters

Cutting edge science on the farm

This set of posters provides an opportunity to extend and enrich pupils' knowledge and understanding around food production and farming. The posters might be used as part of a Science or Geography lesson or displayed in the classroom to raise awareness and aspirations about the huge range of agri-STEM careers open to pupils.

The posters link to a number of areas from the National Curriculum in England Programmes of Study for **Science** and **Geography** at **Key Stages 3 and 4**. These include:

- The interdependence of organisms in an ecosystem
- How human and physical processes interact to influence, and change landscapes, environments and the climate
- How human activity relies on effective functioning of natural systems
- The importance of biodiversity
- The importance of selective breeding of plants and animals in agriculture
- Potential effects of, and mitigation of, increased levels of carbon dioxide and methane on the Earth's climate
- The Earth's water resources and obtaining potable water

Each of the posters is accompanied by a set of questions. Some of these questions can be answered directly by observation of the poster, whilst other questions use the poster as a stimulus for further investigation by pupils. Themes explored in the posters also provide a context for questions to develop skills in Working Scientifically.

Pupils can use the posters to begin an exploration of the many higher education and career opportunities related to the science featured in these posters. Pupils might find out about the varied roles carried out, and the qualifications that are required by soil scientists, agronomists, animal biologists and many others who are involved in the sciences related to food production.

Introduction Science on the Farm

In the next 35 years, we will have to produce more food than all of the world's production combined over the last 2000 years. New research and technologies are providing unique opportunities that have the potential to transform many farming practises. So what will the farms of the future look like? BBSRC has produced two short videos giving a glimpse into this exciting future. The videos can be viewed on YouTube or on the BBSRC website: www.bbsrc.ukri.org

- **The Farms of the Future – agriculture and technology BBSRC** [3 minutes; February 2016]
- **BBSRC Harvest 2050** [4 mins 17 seconds; October 2017]



Cutting edge science

Key ideas

The global population is growing. The UK does not produce all its own food, which means that some of our food needs to be imported from other countries.

Scientists are exploring ways that farms can produce enough food for everyone.

Questions

1. From the poster

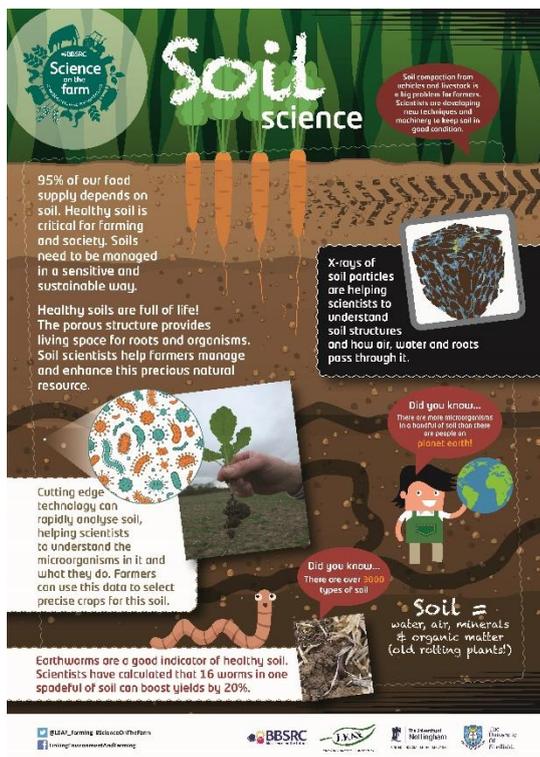
- a. What percentage of the food we eat in the UK has been imported?
- b. List some of the challenges facing the world for food production.

2. Thinking more deeply

- a. Suggest two reasons why it can be hard for us to appreciate the scale of the food production challenge.

3. Find out

- a. Find out more about **one** of the proposed solutions to this challenge. What are scientists doing? What would food producers need to do? How might this solution help?



Soil science

Key ideas

A healthy soil is essential if we are to maintain our food supply.

Scientists and farmers have vital roles to play in maintaining a healthy soil.

Questions

1. From the poster

- What is soil?
- How many types of soil are there?
- Why do scientists take X-rays of soil particles?

2. Thinking more deeply

- Explain what is meant by **'95% of our food supply depends on soil'**
- What do the terms **'sensitive'** and **'sustainable'** mean in relation to how soil is managed?

3. Find out

- What types of microorganisms are found in soil and what is their role?
- How do earthworms **'boost yields'**?

4. Working scientifically

- You may have seen the apparatus that is used to find which animals are living in a sample of soil or leaf litter. The leaf litter is placed in a funnel. The animals move away from a lamp held above the funnel, fall through the mesh and are collected in a beaker below. The animals are then observed through a magnifying glass and a key is used to identify them. Suggest how this experiment could be modified to investigate the microorganisms found in soil.
- Design an experiment to estimate the population of earthworms in a farmer's field.



Grassland management

Key ideas

Large areas of the UK are covered with pasture, used for grazing animals such as cows, pigs and sheep.

Scientists are improving the quality of this pasture, so that we can produce more food.

Questions

1. From the poster

- What is silage?

2. Thinking more deeply

- Why are some areas of UK grassland unsuitable for growing crops?
- What are the advantages of extending the growing season of grass?

3. Find out

- How can livestock breeding programmes give us 'food that is better for people and the planet'?
- Why do farmers need to know the nutritional content of silage?

4. Working scientifically

- A farmer used two different techniques to control a common weed called dock, in two of his fields during the spring and early summer of one year. In mid-summer, he wanted to find out how effective these two methods had been. Design an investigation to help the farmer decide which method of dock control had been most effective.



Future wheat

Key ideas

The UK carries out world-leading research into improving wheat yields and quality.

Questions

1. From the poster

- What is **agromony**?
- Describe two changes that have already been made in modern varieties of wheat and two that scientists are working towards.

2. Thinking more deeply

- Suggest some of the 'useful characteristics' that scientists might be looking for as they explore wheat seed collections.

3. Find out

- What impact does *Septoria* fungus have on wheat yields?
- How can research lead to the development of less susceptible varieties?
- Why are scientists trying to develop types of wheat with more 'fibre, resistant starch and minerals'?

4. Working scientifically

- Look at the poster to see the damage to wheat leaves caused by *Septoria*. Scientists grew two different varieties of wheat in trays in a laboratory to see which was most resistant to *Septoria*. Suggest a way you could compare the results.



Enhancing biodiversity

Key ideas

Farmers have a key role to play in maintaining and enhancing biodiversity.

Scientists carry out research to help farmers understand the best ways to do this on their farms.

Questions

1. From the poster

- a. What is biodiversity?

2. Thinking more deeply

- a. What does each of the three photographs show?
- b. Why do farmers have such a key role in enhancing biodiversity?

3. Find out

- a. What is an emerging disease?
- b. Why do UK scientists work with international teams to investigate emerging diseases?
- c. How are pollinators 'vital to food production'?
- d. Find out about the threats to pollinators from pests, diseases and environmental changes.

4. Working scientifically

- a. Explain how you could carry out a pollinator survey in your local area and show how you would record the results.



Water is essential for life

Key ideas

Water is a precious resource, which we cannot afford to waste.

Scientists are working on ways to protect our water supplies, so that we always have enough water available to us.

Questions

1. From the poster

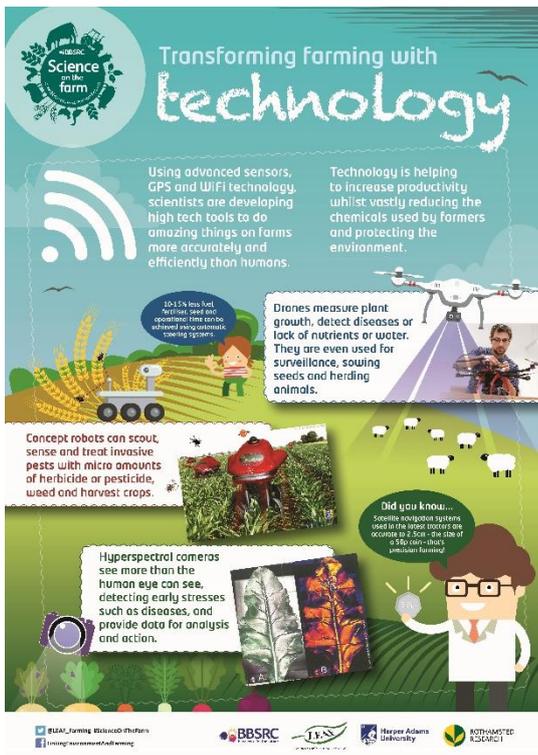
- How does the long-rooted grass variety help with flood management?
- Describe two ways in which plants are used to reduce water loss from farms.

1. Thinking more deeply

- Perennial ryegrass is a type of grass that is quick to establish in farmers' fields, whilst meadow fescue has longer roots than most grasses. The new grass is a **natural hybrid** of the two.
 - Use your knowledge of biology to explain how a natural hybrid arises.
 - How might farmers benefit from the hybrid?

3. Find out

- Find out about some of the ways that farmers 'harvest water'.



Transforming farming with technology

Key ideas

Scientists are developing new technologies to help farmers monitor crops and livestock, to increase productivity and also to reduce the chemicals that they use on their farms.

Questions

1. From the poster and using further research

- How can technology increase productivity, whilst reducing the chemicals used by farmers?
- List some of the ways that drones, concept robots and hyper-spectral cameras are used in farming.
- Explore other new technologies that are being used on the farm.

You could present your findings as a table, a poster or in another format that makes clear the uses on farms for each type of technology.



Animal welfare standards & Animal feed



Key ideas

Scientists study the behaviour of farm animals so that they can help farmers look after their animals in the best way.

It is important that animals are given high quality feed, both for their welfare and to make sure that their productivity is as high as possible.

Questions

1. From the posters

- List some of the foods you eat that come from the animals mentioned on the **animal welfare** poster.
- Describe some of the conditions that farmers monitor to ensure that their animals are healthy and productive.

2. Thinking more deeply

- Farm animals can be fed meat-free human food waste. Suggest some advantages of this.

3. Find out

- Find out why the food we give ruminants such as cows has an impact on greenhouse gases.
- Find out why feeding meat products to farm animals is banned.

4. Working scientifically

- Carry out research and present your findings on what you would consider a 'good life' for a farm animal.



Answers Cutting edge science



1. From the poster

- a. 40%
- b. The global population is rising; there is insufficient new land available for growing enough crops to meet their needs.

2. Thinking more deeply

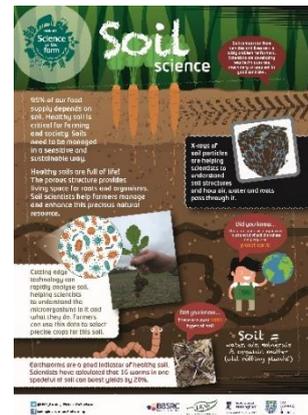
- a. It can be hard to appreciate the scale of the problem because in the UK our supermarket shelves are usually full of food and there is an epidemic of obesity.

3. Find out

- a. Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.



Answers Soil science



1. From the poster

- Water, air, minerals and organic matter.
- Over 3000 types.
- To understand soil structures and how water and roots pass through soil.

2. Thinking more deeply

- Almost all our food crops are grown in soil. The animals raised for meat on our farms depend on grass and other plants that have been grown to produce animal feeds.
- Sensitive** management means looking after the soil in a way that does not damage the environment (e.g. rivers, wildlife and the human population in the surrounding area). **Sustainable** management means looking after the soil in a way that maintains it as a valuable resource for future generations.

3. Find out

- Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.

4. Working scientifically

- A finer gauge mesh will be needed to exclude the larger invertebrates. A microscope will be required to view the animals, used in conjunction with an appropriate identification key.
- This question lends itself to developing CORMMSS skills, and the answer could be rearranged to fit well under those headings.
- Determine the area of the field; choose a quadrat of known size; choose suitable random sampling technique, e.g. generate random coordinates / eq in the field; suitable method, e.g. laying tapes, number of paces; pour a weak detergent solution in the quadrat area, (which will bring the worms to the surface without harming them); count the number of worms; repeat a suitable number of times (at least three); calculate an average; divide the area of the field by the area of a quadrat, multiply this answer by the average number of worms.



Answers Grassland management



a. From the poster

- a. Grass is cut to make silage, which is winter feed for ruminants. (Silage is essentially 'pickled' grass).

2. Thinking more deeply

- a. Various reasons, including too wet, too sloping (for large machinery to be used and also increased soil runoff), too little soil, too salty.
- b. Animals can continue to eat grass, which incurs much less cost than providing alternative feeds (such as maize) and also needing to house them, which incurs additional labour costs.

3. Find out

- a. Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.

4. Working scientifically

- a. This question lends itself to developing CORMMSS skills, and the answer could be rearranged to fit well under those headings. Choose a quadrat; choose a suitable random sampling method eg. generate random coordinates / eq in the field; suitable method for placing quadrats on coordinates, e.g. paces; count the number of dock plants / note presence or absence / use an abundance scale / eq in quadrat; repeat suitable times in first field; calculate an average; repeat in second field; compare the results; e.g. using bar graph.



Answers Future wheat



1. From the poster

- The science and technology of crops, including plant genetics, plant physiology, meteorology and soil science.
- Changes that have already been made are plants that have more grains (for higher yields) and shorter stems (to make harvesting easier and so that less of the plant's energy is invested in producing stem at the expense of grain); changes that scientists are working towards include developing new types of wheat that are easier to digest and healthier for us and breeding varieties that are less susceptible to damage by *Septoria* fungus.

2. Thinking more deeply

- Abilities to withstand the impact of climate and other environmental changes such as drought, new pathogens, waterlogged soils

3. Find out

- Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.

4. Working scientifically

- This question encourages pupils to consider how they will observe, measure and record the differences in the plants. A suitable method would include: Suitable random sampling technique to select leaves to measure (such as random coordinates across tray); suitable measurement of leaf damage (such as estimating % cover with *Septoria* / photographing and measuring damaged area / eq); comparison of the results for both trays (e.g. bar graphs of average damage to leaves).



Answers Enhancing biodiversity



1. From the poster

- a. The variety of life on earth (or in specific habitats).

2. Thinking more deeply

- a. Threatened habitats or species. From top to bottom, the photographs show a traditional lowland meadow, a newt (probably great crested) and a honey bee.
- b. 70% of the UK is farmland, so farmers have direct responsibility for a large proportion of our land.

3. Find out

- a. Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.

4. Working Scientifically

- a. Identify the area to carry out the survey; record the survey area (e.g. park) time of year, time of day and weather conditions; take suitable equipment (e.g. camera, hand lens, identification key, notebook, pen / equipment); Carry out observation for an appropriate time (at least 30 minutes); identify and record pollinator sightings; ethical considerations, e.g. do not touch pollinators; risk assessment, e.g. bee sting allergy, hay fever.



Answers The power of plants



1. From the poster

- 77%
- Currently up to 40% of crops grown are lost to pests and diseases; as the demand for food increases with the growing global population, it becomes even more important to avoid any unnecessary food waste.

2. Thinking more deeply

- Pupils should give a more accurate explanation of photosynthesis, to include: the role of sunlight as an energy source (not a raw material, as might be inferred from the description on the poster); the use of carbon dioxide (not simply 'air'); the production of glucose (not simply 'food')
- Fruit production is dependent on successful pollination; if a plant blooms too early, the flowers may be killed by late frosts / there may be a lack of available pollinators; late blooming may mean that there is too short a growing season for sufficient fruit development to produce a marketable crop.
- Year round availability to the consumer; less reliance on imports; increased profits for the farmer.
 - Additional light / heat will be required; associated environmental impacts; Disconnection of consumers from seasonality of foods.

3. Find out

- Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.



Answers Water is essential for life



1. From the poster

- It can hold much more water than usual (grasses) and reduce water runoff by 51%.
- Long-rooted grasses (reasons as above); log jams (also called 'woody dams') to slow the flow of water when river levels rise.

2. Thinking more deeply

- At KS3, this question could be used to reinforce concepts in plant reproduction and at KS4 Genetics and Variation. At KS3, answers should include detail of successful fertilisation, seed formation, dispersal and germination. At KS4 answers should focus on chromosomes, genotypes, phenotypes and variation.
- Pollen from one of the two parent grasses (perennial ryegrass or meadow fescue) reaches the stigma of the other (pupils may need to be reminded that grasses are wind-pollinated).
- It may exhibit the best characteristics of both parent plants, ie. be quick to establish in fields and possess long roots to hold water.

3. Find out

- Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.



Answers

Transforming farming with technology



1. From the poster and using further research

- a. An overview of drones, concept robots and hyper-spectral cameras is given on the poster. Pupils should research these and other uses of technology, and they may need support to keep their answers focused on the farm applications of this technology.

One inspiring example of technology being adapted for use in farming is the ‘Hands Free Hectare’ - the *world-first* project run by Harper Adams University and Precision Decisions to drill, tend and harvest (in 2017) a crop without operators on the machine and agronomists in the field. Find out more about the project here: www.handsfreehectare.com.



Answers

Animal welfare standards & Animal feed



1. From the posters

- Burgers, kebabs, omelettes, roast chicken, sausages etc
- Diet (quantity and quality of feed appropriate to age and breed); ability to express natural behaviours such as play, mothering; monitoring and reduction of stress.

2. Thinking more deeply

- Valuable use of food that would otherwise be wasted, as it is used for further food production; meat-free to avoid introduction of pathogens that could spread disease in animals or humans (discussion could include reference to the foot and mouth epidemic of 2001).

3. Find out

- Pupils should research these topics individually or in groups and report their findings in a suitable way, e.g. poster, debate, blog, slides.

4. Working Scientifically

- This question is linked to the 'development of scientific thinking' strand, particularly to ethical issues and the evaluation of associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments.
- Pupil research in this highly controversial area will need to be carefully guided. There is plenty of opportunity for discussion of bias and the importance of using reliable, peer-reviewed sources.



The Science on the Farm posters and teacher notes have been produced by LEAF (Linking Environment And Farming) with support from BBSRC.



LEAF (Linking Environment And Farming)

LEAF is a leading organisation delivering more sustainable food and farming. We work with farmers, the food industry, scientists, teachers and consumers, to inspire and enable sustainable farming that is prosperous, enriches the environment and engages local communities. Our work includes educating and engaging the public in sustainable food and farming. In July 2017 LEAF merged with FACE (Farming and Countryside Education) which strengthened our education and public engagement work. Our team of FACE Regional Education Consultants work closely with schools providing advice, resources, links to farmers and support with farm visits. FACE also operate accredited teacher training courses in partnership with universities.

www.leafuk.org www.face-online.org.uk



BBSRC: Schools and young people

Biotechnology and Biological Sciences Research Council (BBSRC) is part of UK Research and Innovation, a new organisation that brings together the UK's seven research councils, Innovate UK and Research England to maximise the contribution of each council and create the best environment for research and innovation to flourish. The vision is to ensure the UK maintains its world-leading position in research and innovation. BBSRC has funded the development of a number of teaching resources to download for primary and secondary school science education, and information on school-scientist links. Most of their activities for young people are conducted through RCUK Science in Society Unit. BBSRC schools' resources can also be downloaded from the Association for Science Education's schoolsience website. This is a comprehensive directory of resources, information and contacts for teachers and students.

<https://bbsrc.ukri.org/engagement/schools/>



Countryside Classroom

Managed by LEAF, Countryside Classroom connects schools with food, farming and the natural environment by providing access to teaching resources, venues for school trips and links to advice and support.

www.countrysideclassroom.org.uk/