Teachers' notes

Introduction

The activities in this resource relate to those sections of the new GCSE science and biology courses (first assessment in summer 2018) on communicable plant diseases, the use of monoclonal antibody diagnostic tests, and use of genome sequencing in identifying pathogens. The activities are based around tasks carried out in the 'real world' by scientists working for organisations such as Fera.

Fera has state of the art laboratory facilities at Sand Hutton, York. Over 500 staff on site test over 100,000 samples each year and deal with organisations in over 120 countries around the world to ensure the quality and safety of their products and services. Their overarching purpose is to support and develop a sustainable food chain, a healthy natural environment, and to protect the global community from biological and chemical risks.

Fera provides a wide range of research and analytical services to both the food and environmental industries. Examples of their work include identifying the cause of necrosis in carrots, the source of pollen for honey purporting to be 'Manuka honey', protecting the UK against invasive species such as the Asian hornet, and the identification of pests and disease, such as the Tobacco rattle virus which can devastate potato crops.

Activity 01 - What does a plant virologist do?

Students watch a short film (approx. 5 mins) about a plant pathologist working for Fera. With guided research they then answer questions and complete tasks based on concepts raised in the film; including the use of antigen detection using monoclonal antibodies, and the reasons why society is concerned about the spread of communicable diseases.

Learning outcomes

- describe how specific antigens can be detected using monoclonal antibodies
- describe how plant pathologists use the detection of antigens, DNA testing, and visual identification to identify and diagnose a specific plant disease
- identify economic and environmental reasons for society to be concerned about communicable plant diseases
- analyse real data

Resources

- student access to the internet
- activity sheet (could be emailed so students don't have to retype links)

Instructions

This could be set as independent study, homework, or flipped learning. The video can be downloaded so that students can independently access it. The AHDB document can also be downloaded for students, and if appropriate you could just provide students with the tables and figures required rather than the whole documents.

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Answers to student worksheet

a. Protect the food we eat, that crops are in the best condition and the grower can get the most money for their crops, and that the food we eat looks nice, tastes nice and is healthy.

b. Adrian advises growers, agronomists (someone who applies soil and plant science to growing crops), and governments. He advises on the dangers and risks of plant viruses, how to protect crops from the spread of viruses. He also runs a plant clinic where he assesses samples of plants and decides what tests need to be done to diagnose any problems or diseases.

a. 5,700,000 tonnes

b. 8,500,000 tonnes 1992 and 4350,000 tonnes 1975

c. There has been a decline in the total area used to grow potatoes, there was a sharp decline between 1960-1980, the rate of decline then slows from 1980-2015.

d. Yield has maintained from a decreasing area, this could mean plants are grown closer together or higher yielding varieties are grown that may not be disease resistant.

e. Eastern Counties, Scotland and East Midlands 65%

f. Wales

g. £3 billion

c. a. 1845-49

b. The fungus Phytophthora infestans

c. Approx 1 million people died, and 1 million emigrated (these are estimates)

5. a. Nucleus

b. Chromosomal DNA as a free loop in the cytoplasm, plasmids (small loops free in the cytoplasm

c. Sections of DNA that code for a specific protein

d. James Watson and Francis Crick (Rosalind Franklin and Maurice Wilkins)

e. 2 coiled strands

f. T (Thymine) A (Adenine) C (Cytosine) and G (Guanine)

g. Suitable diagram showing double helix and base pairing

6. The process of determining the order of bases in a length of DNA

7. 4 viruses they expected to see in British carrots, a virus that hadn't been seen in the UK for about 30 years, and 6-7 viruses that were brand new to science.

8. Suitable instructions

9. Suitable diagrams

10. Antibodies that are made to target specific cells or chemicals. They are produced by combining a mouse B lymphocyte (that makes a specific antibody) with a tumour cell to create a hybridoma cell which can be cloned, so you have identical cells producing identical antibodies (monoclonal antibodies).

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Activity 02 - Plant patient medical files

Learning outcomes

- describe the symptoms and causes of common plant diseases
- explain how these communicable plant diseases are spread and suggest ways to prevent their spread

Resources

- students' worksheet
- information sheets
- patient files to diagnose plant diseases

Students gather information about the symptoms and causes of common communicable plant diseases, information about how the disease is spread and potential ways to limit the spread. In the second part of the activity they then apply their knowledge to 'diagnose' some plant patients.

The activity can be run in a number of ways. For the greatest stretch and challenge students can be given only the case files and asked to research the answers either as an open search or using the following sites:

www.bspp.org.uk/outreach/article.php?id=100
www.rhs.org.uk/advice/plant-problems/diseases-disorders

Alternatively you could provide the students with the information sheets which they then use to diagnose the disease. A worksheet is also provided for students to compile notes on all the communicable plant diseases referred to across AQA, ORC, EDEXCEL, and WJEC specifications. This has been written for students to complete first, but if you wished to provide more challenge it could be left as a plenary activity.

This activity was adapted from a resource developed by the Science and Plants for Schools (SAPS) programme. The original resource can be downloaded from: www.saps.org.uk/secondary/teaching-resources/1362-plant-disease-detectives

Answers

Patient A: (barley) powdery mildew
Grow varieties of crops that are resistant/ treat crops with fungicides/ avoid planting a new crop into the stubble left from an infected crop that's been harvested.

Patient B: Chalara ash dieback
Report to Forestry Commission or Animal and Plant Health Agency, if confirmed that the trees are infected with Ash Dieback the trees will be removed and destroyed.

Patient C: Rose black spot
Collect up fallen leaves, or cover them up/ cut back infected branches and plants/burn any infected leaves, branches, plants rather than compost/ use fungicide/ can try growing newer resistant variety.

Patient D: Crown gall disease
Remove infected plants/ grow an unaffected species (eg grass/potatoes) on the land for a few years.

Patient E: Tobacco mosaic virus (TMV)
Remove infected plants/ wash hands and equipment in between planting/ space out plants/ grow resistant varieties.

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Disease	Plant species affected	Symptoms (could draw annotated diagram	How does the disease harm the plant?	Cause - type of pathogen	How is it spread?	How could you prevent it spreading?
Tobacco mosaic virus	Over 200 species	Yellow and brown spots on leaves, distorted leaves, and stunted growth	Stops cell processes like photosythesis	Virus	Direct contact between plants, plants and machinery, and plants and hands	Removed infected plants, space plants out, wash hands and tools, grow resistant varieties
Rose black spot (Diplocarpon rosae)	Roses	Black spots on leaves, leaf drop, less vigour	Loss of leaves means the plant can't photosynthesise	Fungus	By spores on infected leaves, and spores in the rain	Collect or cover infected leaves, remove infected branches and burn material. Fungicides. Resistant varieties
Crown gall disease (Agrobacterium tumafaciens)	Over 1,000 species	Galls (lumps) on the roots	Affects plants' transport systems	Bacteria	Via wounds on the plant from the soil	Remove and destroy infected plants, grow unaffected species for a few years to eliminate bacteria from the soil
Chalara ash dieback (Hymenoscyphus fraxineus)	Ash trees	Infected leaves wilt, go brown and die, lesions appear on the bark, tree eventually will die	Stops the trees' transport systems	Fungus	Spores travel on the wind, and on infected trees and timber that are imported	The Forestry Commission & Health Agency will remove and destroy infected plants. Strict controls on movement of ash trees & timber within / into UK
Barley powdery mildew (Erysiphe graminis)	Barley (although there are many different powdery mildews that affect different species)	Powder white fluff grows on the leaves	Limits the plants' growth and crop yield	Fungus	Spores travel on the wind	Fungicide, resistant varieties, avoid planting barley into infected stubble after harvest

Teachers' notes

Additional resources on the identification of plant diseases

Identifying the cause of brown rot

Brown rot is used here as an example of a plant disease common in Britain. Students explore how the technique of re-infection (using infected material to infect healthy plant tissue) can help to identify the cause of a plant disease.

The activity will help students to demonstrate the following learning outcome at KS4:

- describe ways to identify a plant disease in the lab and in the field

It also enables students to practise the following KS4 practical techniques:

- use of appropriate apparatus and techniques for the observation and measurement of biological changes and/or processes.

Powdery mildew

In this practical and data analysis activity students collect samples of leaves showing samples of infection with powdery mildew; the samples can be sent for analysis as part of the Powdery Mildew Survey citizen science project. Students analyse data from the survey at the end of this activity.

Investigating violet bramble rust

Students use magnification to examine leaves showing symptoms of a common plant disease, and produce labelled drawings of the fungal spores.

Students could work in pairs/groups to examine the infected leaves, depending on the availability of apparatus and time. However, if possible, each student should have a go at setting up and focussing the light microscope, produce their own labelled drawing to illustrate what they can see using the microscope, and answer the questions.

Deadly diseases and plant pathology

Students study leaf pathogens under the microscope, as a starting point to consider the global impact of disease on society and the environment.

Some diseases (eg black spot on some herbaceous plants) will change the colour of infected plant cells dramatically (eg from dull green to a bright pink), allowing cells, stomata, guard cells and trichomes to be much more clearly seen. This may therefore make an interesting alternative practical when looking at specialised cells under the microscope.

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Activity 03 - Sequence matching

Students take on the role of a scientist analysing given 'DNA sequences' from different batches of carrots. They need to match the sequences to given information sheets and interpret the results to identify potential pathogens, food contaminates, and harmless organisms. Students then report back with their recommendations based on the findings.

Learning outcomes

- interpret DNA sequencing results and make judgements based on those results

Resources

- activity sheets
- information sheet
- optional – print out news stories if students can't access links

Instructions

Students will need to use the information sheet to match the DNA sequences to known sequences, and make conclusions based on their results. Students should then look at the news story before writing their conclusions and feedback to the client.

Answers

1. Carrot B, rat, harmless bacteria – harmless bacteria isn't a problem but the presences of rats means the food must not be sold or eaten, and the Local Health Inspector should be informed straight away as the factory will probably need to be shut down until they have their rodent problem sorted out.

2. Variety B, peanut – if the food is contaminated with peanuts it is a serious health risk as some people are allergic to peanuts, the allergic reaction can even kill people. The food should be labelled to show it may contain peanuts.

3. Variety B - if the carrots are being mis-sold as a more expensive variety the supermarket is breaking the law, remember they may have been sold the carrots as variety A in which case it may be the importer who is mis-selling them.

4. Invasive beetle – the containment should be seized and sealed, and any beetles in the contents and container need to be destroyed.

5. Carrot A, powdery mildew – the farmer needs to treat his crop for powdery mildew (refer to activity 1)

6. Carrot B, TMV -– the farmer needs to take precautions to prevent further spread of TMV (refer to activity 1)

7. Carrot B, harmless bacteria – nothing wrong with the crop

8. Carrot B, beef, and horse – the food is being mis-sold, this is against the law, but the supermarket may have been mis-sold horse meat as beef.

Teachers' notes

Activity 04 - Detecting plant viruses using the ELISA technique

Suggested learning objectives

- describe a plant disease
- describe different ways plant diseases can be detected and identified, in the lab and in the field

Potato crops are affected by a number of viruses, leading to either reduced yield or potatoes which are rejected due to their appearance, though there is no known evidence of these viruses causing harm to humans. Visual inspection, especially of the growing plants, is often not sufficient to enable the detection of disease, so other techniques are needed as well.

Fera tests crops for the presence of specific viruses using the ELISA (Enzyme-Linked Immunosorbent Assay) technique which enables the virus to be identified in any sample of the plant, without having to lift the crop.

The Enzyme-Linked Immunosorbent Assay (ELISA) is an immunological technique which uses monoclonal or polyclonal antibodies to detect specific molecules in extracts from plant or animal tissues. The technique is extremely sensitive and can be made highly specific, so it can be used to detect very small quantities of specific organisms or molecules.

The video shows how an ELISA test is carried out in the lab, but test kits are available for use in the field from **pocket diagnostics**.

If you wish to purchase a potato testing kit you could test potatoes for Potato Virus Y, which is commonly found in potato crops and is the most widespread of the potato viruses. These tests rely upon a colour change indicator, similar to those used in pregnancy testing kits and the same as the kit used by Fera.

The student worksheet 'pocket diagnostic potato testing' guides students through the use of the kit, describing the steps they need to take and the result that will be seen if the virus is found in their potato. As this kit costs £5 per test, you may prefer to carry this out as a demonstration of what farmers and scientists use in the field

Risk assessments need to be carried out and data sheets can be found on the company's website. The pocket diagnostic test device contains no hazardous materials to humans, animals, plants or crops. The accompanying extraction buffer contains a very small amount of sodium azide (0.05%) as a preservative – avoid ingestion and skin contact. Refer to CLEAPSS guidelines for the disposal of sodium azide.

SAPS ELISA kit for Botrytis

If you have more able students, and wish to explore the use of ELISA further, Science and Plants for school (SAPS) supplies an ELISA kit enabling students to use the ELISA technique to test for the Botrytis virus in samples of raspberries. Although it is targeted at post-16 students, the support materials could be adapted for use by more able students at GCSE: **www.stem.org.uk/elibrary/resource/180484/investigations-elisa-using-saps-elisa-kit-botrylis**