**Plant Pathogens – Identification**

**Teaching Notes**

### ****Introduction and context****

### **Ideas about communicable diseases in plants are included in the updated programmes of study for Key Stage 4 biology published in December 2014. These ideas will be included in GCSE science courses from 2016 (for first assessment in summer 2018).**

### **This bundle of resources will help develop the following learning outcome at KS4:**

### **describe different ways plant diseases can be detected and identified in the lab and in the field.**

### **Note that this learning outcome is required in GCSE Biology, but is **not** required in GCSE Combined Science.**

### Teaching Notes

### **The poster ‘Plant Pathogens – Identification’ illustrates diagnostic tests that are commonly used to identify plant pathogens in the lab and in the field.**

### **The poster is accompanied by a presentation, which can be used as a step-by-step walkthrough of the ideas in the poster.**

### ****Notes to accompany the presentation****

Throughout the presentation, try to develop the idea that a plant pathologist will usually have to use several diagnostic tests in order to be confident that they have accurately identified the pathogen that is causing symptoms in an infected plant. Each test provides evidence that helps to narrow down the possibilities and increases confidence in the eventual diagnosis.

It is also worth noting that some of the diagnostic techniques mentioned here – namely antibody tests (slides 20-22) and genome analysis (slides 24-28) are much more accurate than the others (because of the specificity of monoclonal antibodies for their antigens, and the specificity of gene probes for their target sequences, respectively).

In the following notes relating to specific slides, there are suggestions of how students’ knowledge and understanding could be probed; these suggestions **could be used as the basis for class or small group discussion as students work through the presentation or perhaps at the end.**

*Slide 2:* Students could be asked to suggest examples of staple foods (as opposed to luxuries we could live without) and important materials derived from plants. It may be interesting to give some statistics; for example, according to the Food and Agriculture Organization (FAO) of the United Nations online database rice, wheat, and maize are the three leading food crops in the world and together they supply more than 50% of the calories consumed by the world population; approximately 50% of the world’s population relies on rice alone for their primary calorific intake. The impact of plant disease on human food security could be illustrated with some statistics, for example: it has been estimated that plant pests and diseases reduce the global harvest by 10-16% (US$220 billion) per year. Students could also be challenged to suggest other ecosystem services contributed by plants (including but not limited to: habitat, medicines, cycling of substances, and aesthetic benefits). Again, some statistics could be given; for example, in 2015 it was estimated that woodland was worth £270 billion to the UK economy, not just in timber and related products but also because of factors such as flood management and recreation (Woodland Trust Broadleaf 85, 2015).

*Slide 5:* Ensure students understand what is meant by “in the field”; this refers to any diagnostic testing that takes place outside of the lab, and does not just refer to plants or testing in fields! Throughout the presentation, or afterwards, students could be asked to discuss and suggest which techniques could be done in the field and which ones are likely to only be done in the lab. Recognising symptoms (slides 7-8), microscopy (16-18), antibody tests (20-22), and gene probes (24-26) can all be used in the field.

*Slide 8*: Students could be asked to use information on plant diseases to find examples of different pathogens that cause similar or identical symptoms in infected plants. They could also be challenged to construct an identification guide or key, based only on visible symptoms, to illustrate the problem, and then asked which other diagnostic tests could be used to help narrow down the identities of the pathogens responsible for the symptoms. Information about plant diseases, symptoms and pathogens is available from, for example:

### ***British Society for Plant Pathology* information sheets at:** <http://www.bspp.org.uk/outreach/article.php?id=100>

### ***Royal Horticultural Society* advice pages at:** <https://www.rhs.org.uk/advice/plant-problems/diseases-disorders>

*Slides 9-14:* Note that the word “culture” is used to describe the process of growing cells in a growth medium in favourable conditions (often in an incubator), and is also used to describe the resultant growth. It may be worth explaining this to students, or at least checking that they are not confused.

*Slide 11:* GCSE Biology students are expected to be able to explain the aseptic techniques used in culturing organisms. This slides provides an opportunity to develop ideas about (or check students’ knowledge and understanding of) aseptic techniques that might be used. Techniques include sterilising equipment and growth media (e.g. in an autoclave), disinfecting work surfaces (e.g. using alcohol), wearing personal protective equipment (e.g. gloves), working next to a Bunsen burner to create an updraft of air (or in a laminar flow cabinet or biosafety cabinet), and flaming bottles and wire loops. It is also an opportunity to discuss *why* this is important – i.e. to avoid contamination of samples and cultures that could lead to a false diagnosis.

*Slide 14:* Students could be asked to suggest substances that could be added to the growth medium. For example, antimicrobial substances (including antibiotics) can be added to the agar. A particular pathogen may grow when an antimicrobial substance is absent, but not when it is present. This can help the pathologist to identify which pathogens were present in the sample.

*Slide 16:* Students could be asked to explain why viruses cannot be seen using a light microscope. The simple answer is that most viruses are too small. The resolution of light microscopes limits what can be seen; even with the best light microscopes it is usually difficult to tell objects apart that are closer together than 1 μm, and very difficult to even see objects that are smaller than 1 μm in diameter. Most viruses are between 0.02 and 0.3 μm in diameter; recently discovered “giant viruses” such as megaviruses and pandoraviruses can be up to 1 μm in diameter; the largest virus ever discovered, in ancient permafrost, was 1.5 μm in diameter (see: <http://www.smithsonianmag.com/science-nature/worlds-largest-virus-was-just-resurrected-34000-year-old-permafrost-180949932/>).

*Slides 20 and 21:* It may be worth noting that scientists have been searching for ways to identify the causes of diseases for centuries, but the perfect tool for recognising pathogens already existed in the immune systems of animals – antibodies are very well adapted to recognise specific pathogens, thanks to millions of years of evolution. Pathologists now exploit antibodies as a useful, and highly specific, diagnostic tool.

*Slide 24:* A genetic marker is a specific sequence of bases (a genetic variant) in the DNA or RNA of a pathogen.

Slide 25: A gene probe (also known as a DNA probe or hybridisation probe) is a short section of single-stranded DNA or RNA comprising a sequence of bases (typically 100-1000 bases long) that will pair up with the bases in a target genetic variant. The probe will bind to the target sequence if it is present in the sample. The probe can be joined to a molecule of a ﬂuorescent or radioactive substance, and then detected in the sample using a computer.

*Slide 28:* The genome sequence in the background of this slide is the first 2325 bases from the RNA of tobacco mosaic virus [see: Goelet, P., et al. (1982). Nucleotide sequence of tobacco mosaic virus RNA. *Proceedings of the National Academy of Sciences of the United States of America*, 79(19), 5818–5822. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC347001/>].

*Slide 31:* A simplified implementation of the principles of Koch’s postulates using readily-available, non-specialist apparatus is provided in the SAPS plant disease practical “Identifying the cause of brown rot” (<http://www.saps.org.uk/secondary/teaching-resources/1361-plant-disease-practicals-identifying-the-cause-of-brown-rot>). A fuller treatment of Koch’s postulates, requiring specialist equipment, is provided in “SAPS Student Sheet 18 - Koch's Postulates” (<http://www.saps.org.uk/secondary/teaching-resources/302-student-sheet-18-kochs-postulates>).

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