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How do plants fight against diseases and pests?

Key Stage 4 Biology

Resource 4

2019

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Resource Four Overview

Topic	Plant defence
GCSE Modules	Cell specialisation. Plant tissues. Communicable diseases. Detection and identification of plant diseases. Plant defence responses.
Objectives	After completing this resource, you should be able to: ✓ recognise that pathogens and pests have their own methods to avoid or deal with plant defences ✓ recognise that plants have different susceptibility to different pests and pathogens. ✓ recognise that symptoms can be visible and we can measure them to tell us how badly a plant has been affected by a disease.
Instructions	1. Read the data source 2. Complete the activities 3. Explore the further reading

Resource Four
Data Source

Section A

Pathogens and pests

Pathogens can directly cause damage or enter a plant through a wound on the plant surface. Pests like insects or larger herbivores such as grazing sheep, goats and cows also eat plants and plants have many types of defences to repel them or kill these types of organisms.

Figure 10

Pathogen and pest examples

Section B

Physical barriers

Deep Dive

You have already learnt about some of the physical barriers that plants have to protect against attack.

- The cuticle is the waxy outer layer which is thickened in some exotic plants both to help with less water loss through transpiration and to provide a thicker covering against insects.
- The cell wall made of cellulose is another obstacle for the challenging pathogen to pass. In trees, the xylem tissue of the stem secretes a secondary cell wall made of tough material called lignin. These thickened cell walls make the bark of the tree, which is added to each year to form rings and gives the trees more added layers of protection against insects and pathogens.
- The cell membrane around the epidermal cells facing the outside of a leaf also limits what can come in and out of the cells by forming a selective membrane.
- The stomata of leaves can be controlled by the plant when water is plentiful or scarce, by changing the amount of water in guard cells, which changes their shapes and consequently, the hole in between the cells widens or shrinks. Plants can also close their stomata when pathogens are detected, to stop them from using the holes as a gateway to penetrate into the cells below.

Resource Four
Data Source

Some exotic plants such as the pitcher plant or venus fly traps have extreme ways to control insects and actually prey on them so are called carnivorous plants. Pitcher plants attract insects with sweet-smelling nectars, trapping them in their very thick, waxy cuticle and then letting them fall into a sack full of digestive fluid to be degraded.

Plants have specific structures or modified cells which aid them in defence. Some plants have hairs on the surface of leaves called trichomes which are extensions of the epidermal cells which can be made up of a single cell or a collection of cells which are specialised for insect and pathogen defence. The trichome barrier looks like a furry layer made up of stiff hairs which forms a physical barrier for small organisms such as fungi and flies which cannot get through it.

Figure 11

Trichomes visible on a plant

Trichomes can also be glandular, which means they are able to produce and secrete chemicals. Trichomes of the tomato plant can produce sticky substances which can trap organisms. Some other plants can make toxic substances to repel organisms. Some chemicals made by the trichome, once ingested by an organism can slow their growth or stop the next phase of their lifecycle, making them weaker, less able to further attack the plant and more likely to become diseased or eaten by an organism which preys on them. Plants are also able to recognise when a pathogen is attacking them and can make new leaves with more trichomes on them for more defence.

Resource Four
Data Source

Nettles are another example of a plant which contain trichomes on their leaves and stems. When nettles sense movement the tip of the trichome easily falls away to reveal a needle structure which can penetrate into a nearby organism or herbivore and release weakly acidic chemicals to cause a sting. This is a good example of a plant defence strategy which also repels the human hand.

Other modified structures which provide physical defence include spines and thorns. Thorns are found on the stems of roses and are sharp and stab larger herbivores. Spines are modified leaves and are characteristic needle-like features of cacti. Leaves can also have sharp, pointy edges, for example the holly bush leaves or the aloe vera plant which has teeth-like edges along the margins of the leaves.

Figure 12

Teeth-like edges on a plant

Section C

Chemical defences

Some plants make chemicals which have properties that aid them in defence. Tomato plants for example make compounds which you can smell and these gases act as a deterrent for some organisms. Some plants make strong smelling compounds when the tissue has been damaged such as through feeding or wounding, this signals to other plants there has been an attack. Onion plants make strong-smelling compounds when damaged which irritates the attacking organism (in the case of humans, it makes our eyes water).

Resource Four
Data Source

Some plants make toxic compounds which repel insects and effect the insect nerve system. Chrysanthemum flowers make a chemical called pyrethin which deter insects and has been extracted and used to make agrochemical sprays to warn off insect pests. There are some plant chemicals which cause severe vomiting and are poisonous to pets or humans such as nightshade or hemlock. Plants such as aloe vera can make antiseptic compounds, which can kill potential pathogenic bacteria and viruses. Plants can also make antimicrobial proteins which can kill bacteria and fungi by entering into their cell membranes and causing their cells to burst.

Section D

Sensory defences

Movement can trigger some of a plant's armoury. In venus fly traps, the trichomes on the inside of the traps 'feel' the insect movement and triggers a closing mechanism. In the nettle example, the movement caused the loose end of the trichomes to expose the sharp needle.

Plants can use colourful flowers and sweet-smelling nectar to attract pollinators. They also use chemicals to attract predators which eat the prey organism feeding on the plant. Ladybirds can be attracted by a plant through the release of gases during an aphid attack to bring ladybirds to the plant to control the aphid population.

The passionflower has natural patterned, pigmented spots on its leaves which look like butterfly eggs. This adaptation deceives butterflies into thinking they have already laid their eggs on the leaf which deters them from laying their eggs 'again' and prevents all their newborn larvae feeding on the leaf material. This strategy of plant defence is called mimicry.

Figure 13

Mimicry in the passionflower

Resource Four Activities

Activities

1. Draw your own picture of a 'Super plant' which has been mutated to include as many defences on it as you can think of. Make sure you label the parts of your plant that help defend it and include how each part helps it fight off insects/animals or micro-organisms.

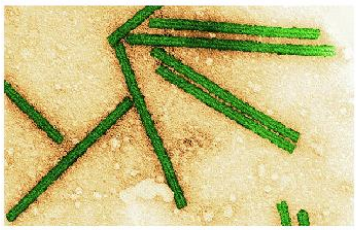
2. Give 3 examples of chemical defences that plants have developed against pests/pathogens and herbivores.

3. Just as plants have developed strategies to defend against pathogens and pests, pathogens and pests have their own defences. Match up the images and labels below to the disease-causing pathogen or pest. There are also some statements about the plant defence and some statements about how the organisms get around the defence. Try to match these up to the appropriate organism.

Tiny pathogens which cannot pass through the cuticle, cell wall or membrane.

Small enough to penetrate through stomata

Prefer to probe stylet into smooth leaves



Bacteria & Fungi

Aphids

Viruses

Secrete compounds which force the stomata to stay open or prevent the plant closing them.

Avoid leaves with trichomes or hide on the underside of leaves

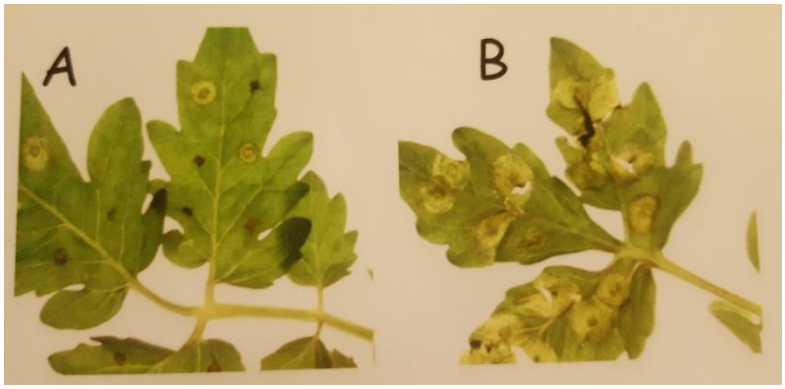
Are carried into the plant by insect saliva and wounds

Resource Four Activities

Activities

4. Spot the difference between the two leaves below.

5. The images A and B below show leaves from two different species of tomato plants which have been infected with a fungus called Botrytis for 48 hours. Botrytis causes yellow and brown lesions on the leaf surface. The lesions are shown by the arrows.



a. Use a ruler to measure the diameter of the lesions (the length across the width of the lesion). Measure the diameter of any 3 lesions on each of the leaves and calculate the average lesion diameter for each plant.

b. The plant leaf on the left (A) is more resistant to the disease-causing organism. Suggest a reason why this plant might be more resistant?

c. The plant leaf on the right is more susceptible to the disease-causing organism. How do we know this and why do you think this may be?

Resource Four
Further Reading

Explore

- Very good video outlining methods of plant defense.

The amazing way plants defend themselves - Valentine Hammoudi

- Video which goes into more detail about chemical defences.

Plant Defenses Against Herbivory

- news article giving more information and depth about pathogen defences. It is not expected that you understand all of this article at GCSE level.

http://www.global-engage.com/agricultural-biotechnology/stomata-and-wounds-constant-dilemma-pathogen-infection/

- news article giving more information about plant defences and pathogens. It is not expected that you understand all of this article at GCSE level.

https://phys.org/news/2018-12-news-hormone.html

- Practical experiment: plant adaptations and how nettles sting.

http://www.saps.org.uk/secondary/teaching-resources/869-investigating-leaf-adaptations-why-do-nettles-sting

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