I BET YOU DIDN'T KNOW...

How plants know good microbes from bad ones

Prof. Dudley Shallcross, PSTT CEO, links **cutting edge research** with the **principles of primary science**

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"PLANT TALK OR HOW DO PLANTS KNOW GOOD MICROBES FROM BAD ONES"

Plants are vital to life on Earth (do our primary school children know why?). Apart from producing oxygen through photosynthesis, without which we would not be able to inhabit the Earth, in what other ways do plants support life? Some plants produce fruit, some contain nectar, and many have other edible structures; they provide shade to animals; they provide a home to others; they prevent soil erosion, regulate light, temperature and water balance in the ecosystems that they inhabit; they are vital in the regulation of carbon dioxide, a key greenhouse gas and modify the Earth's albedo (how reflective the Earth's surface is). Why might this be important?

We may ask our primary school children, 'What do plants need to survive?' Water, sunlight and nutrients (plant food) are all essential, but how do plants obtain these vital ingredients? In the main, nutrients and water are derived from the soil that the plant resides in, through its root system. One vital nutrient is nitrogen but in a rather bizarre situation, the plant cannot access nitrogen in the atmosphere, even though the atmosphere is dominated by nitrogen (78%). Why is this? Atmospheric nitrogen, or N_2, consists of two nitrogen atoms bound together by a triple bond. What this means is that the plant would need a lot of energy to break the N_2 apart in order to use it. *Can the children think of analogies for this? Perhaps consider a sweet, locked in a very strong box.*

So how does the plant access the nitrogen? The plant uses bacteria, which are tiny microbes that attach themselves to the roots of the plant. The bacteria are able to convert nitrogen from the air into ammonia, NH_3. A symbiotic relationship is established whereby the plant benefits from the ammonia (NH_3), which it can easily break down to access the nitrogen, and the bacteria is able to extract energy from the plant. This is well known, but how does the plant know which are good bacteria that will help it and which are bad bacteria that will harm the plant? *We could ask the children for their ideas.*

In the research paper by Cyril Zipfel and Giles Oldroyd, they review how plants work out good from bad microbes. The plant cannot talk with the microbe as we might understand it, but they do have a chemical 'conversation'. **First, the plant can use shape and size: only microbes that have the right shape and size will be able to attach to the root.** But why is this not a good enough discriminator? Ask children for their ideas as to why this will not be enough. They may need clues to help them think about this. Perhaps imagine a puzzle piece that fits into a space but comes from another puzzle picture. The puzzle is complete but the picture does not make sense and is spoilt. Microbes are sneaky; they all want to attach to the root as it is a great place for them to live and some bad bacteria have adapted (*check that the children understand what this means*) so that they have the right shape and size and so can pass the first test.

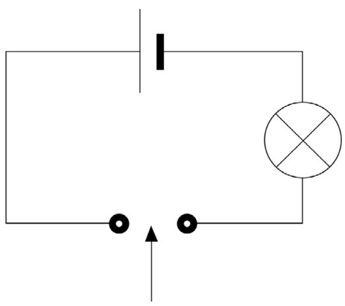
How then does the plant work out whether to let the intruder stay or to get rid of it? It turns out that the plant plays the chemical equivalent of 'twenty questions'. The microbe will release several chemicals once attached and the plant analyses them and works out if the intruder is good or bad. We could play a similar game in the classroom but are there other ways to illustrate this through science investigations? Yes, there are. First, we could set up a simple electrical circuit with a battery and a bulb but leave the circuit open and test materials to see if they will fit into the gap and light the bulb (see Figure 1). This will only happen if the material conducts electricity; it may be the right length and connect to the ends of the circuit (right shape and size) but unless it is made of the right material the bulb won't light. This is an example of using electricity to pass a signal. Many natural systems use electrical signals to pass information; these are happening in our bodies all the time. Second, we could make some red cabbage indicator (see Figure 2), use it to test a range of substances and see what colour the indicator turns in their presence. In the classroom, prepare a range of substances for children to test in advance and let them observe how the cabbage solution produces different colours when different chemicals are added.

The plant is doing something similar, testing the chemicals produced by the microbes. If they produce the right sequence of colours, in our indicator analogy, then they are allowed to stay. This is clever work on the part of the plant - the longer the sequence of testing, the harder it is for the plant to be fooled by a bad microbe.

Figure 2. Creating an indicator solution using red cabbage.

Red cabbage indicator can be made by shredding cabbage (e.g. in a food processor) and covering in boiling water for a few minutes. Strain the solution from the cabbage and allow this to cool. The neutral purple solution will turn pink/red in the presence of acids (e.g. vinegar, lemon juice, tartaric acid) and blue/green in the presence of alkalis (e.g. bicarbonate of soda, toothpaste, soap).

Figure 1. Creating a simple circuit test circuit.



We stress, however, that you need to carry out your own health and safety and risk assessments for any classroom activity.

What happens if bad microbes crack the code and can produce the correct chemicals in the correct sequence? Sometimes this means that a plant species is destroyed, at least on a regional basis, because it cannot now sort good from bad microbes.

Discuss these questions with the children:

Do you think the 'Sainsbury Laboratory' where the authors work is the same Sainsbury as the supermarket?

Why would Sainsbury be interested in research into plants?

The research paper that generated this work was:

Plant signalling in symbiosis and immunity

By Cyril Zipfel[1] and Giles E.D. Oldroyd[2]. Nature, vol. 543, pp. 328-336 (2017)

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