Roots find their way through the soil by avoiding solid objects; plants whose branches are touched regularly will tend to be shorter and more compact . . .

Explaining tropisms – what makes plants react?

Botanist Fiona Eadie, continues her series on the basics of how plants really work

TROPISM is the "turning of an organism, or part of one, in a particular direction in response to some special external stimulus," according to the Shorter Oxford English Dictionary.

You may well be wondering where this is all leading. Read on!

One could say that virtually all living organisms respond to outside stimuli of one form or another.

We humans are not exempt. If it is very cold we turn to find shelter, if it is very sunny we will look for shade — although it does take some of us a bit longer than others to get to that point. Then there is the cold beer on a hot day. Some of us will find that irresistible whilst the rest will think, 'it's just a glass of beer isn't it!' Any true scientist would tell you that the latter is not a very good example and that it is really an act of free will, not a natural instinct — sometimes I would beg to differ.

In a tropic sense, plants are different from animals. Most animals cannot only turn, but can also move, as a reaction to an external stimulus. As for plants, well, most are rooted to their spot, so rather than move away from an unfavourable stimuli they must be able to adapt or respond to it. If you think about this, plants really only have the option of either trying to grow toward or away from the source of the stimulus.

The two main stimuli that plants react to are light and gravity. The former is more correctly termed phototropism and the latter gravitropism.

As science techniques improve the importance to plants of thigmotropism, a reaction to a mechanical stimulus such as touch, is becoming more apparent.

Hydrotropism, a reaction to a water gradient, is also considered very relevant for some plants but has not been noted for all, yet!! Just because science has not found a means of measuring something does not mean that it does not exist, as we will see with thigmotropic responses in plants.

If you start to think about this you realise that different parts of a plant will react to these stimuli in different ways. For example, most stems will grow towards the light whilst roots will grow away. The former is considered to be positively phototropic and the latter negatively phototropic. With gravity it is the other way around, the stems are negatively gravitropic (away from gravity's pull) and the roots positively.

The most common example of phototropism is of stems bending towards the light. With a woody plant exposed to a stimuli for a long time such a kink can remain a permanent reminder of the individuals past, but with young green stems and shorter exposure the plant will often right itself over time.

Not all shoots will head for the light though. Classic examples are vines, climbing plants. Such plants require a host to climb and suitable hosts do not occur in the sun. The young seedlings will often aim for the shade and on coming in contact with a suitable surface will affix themselves one way or another. At this point the plant will try to go upward: positive phototropism and/or negative gravitropism taking over.

Why negative gravitropism? Often a tree's canopy will be so dense that very little light penetrates below it, so positive phototropism is not always of benefit to the vine at this stage.

On reaching the light at the top of the tree phototropism can take control again. Most of you will have seen species of Clematis, Muehlenbeckia and climbing rata spreading out on reaching the crown of a tree, whether it be in scrub or in a mature forest. Upward growth is no longer necessary, flowering becomes the priority.

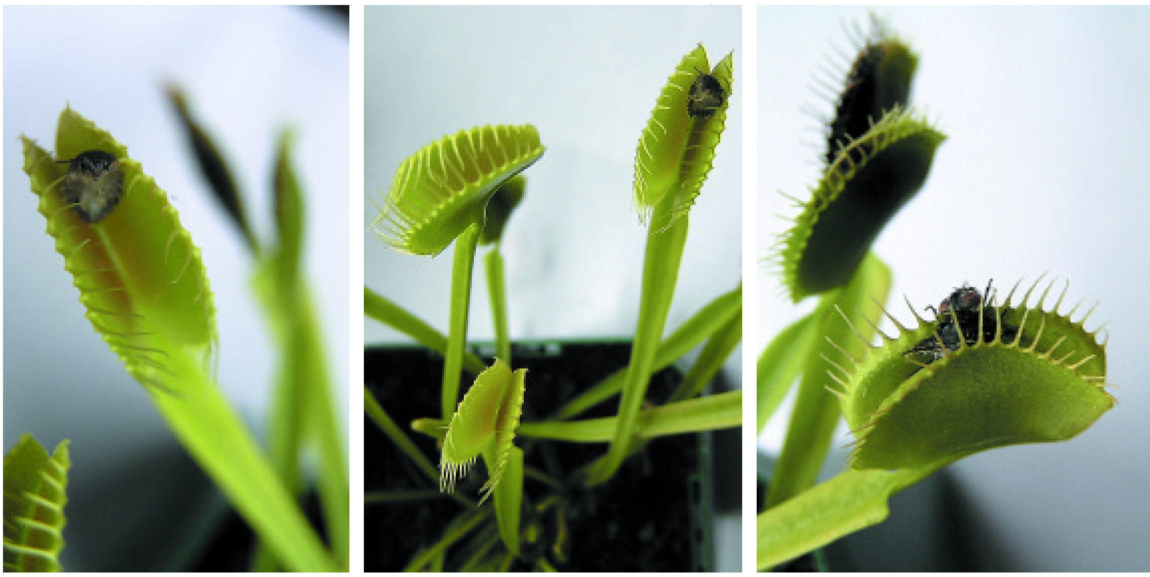
Time lapse videos of vigorous vines in action are quite a sight to behold. The tendrils appear alive, like tentacles moving in search of food; the boundaries between plants and animals seem to almost disappear.

Seed germination aptly displays how different parts of a 'plant' react to gravity; show gravitropic responses. You may have already noticed that no matter how you orientate a seed in a tray the primary root will grow down and the shoot up, even when covered with soil.

The root is off to find water while inadvertently providing stability and the primary shoot is off to find light so the plant can begin photosynthesis and thus provide the energy necessary for continued growth both above and below ground.

Left: These seedlings were germinated in a moist paper towel. When they reached 3cm in height, I placed them in a darkened room with the light source focused in one direction. After 2 hours the tips had already turned to face the light. Next month we'll see why only the tips turn towards the light.

Right: This cabbage tree has been kept as an indoor potplant. The room is not brightly lit so the tip bends towards the highest light source – positive phototropism – which is the window. The kinks occur because the poor plant has been turned 180 degrees every few months!



A Venus flytrap (Dionaea sp) at lunch. The two halves of the leaves have folded along the 'hinge' entrapping the slater. Thigmotropism in action

Thigmotropism

Thigmotropism, the response to mechanical stimuli, can be through touch or by contact with a solid object. It is amazing the lightness of touch that plants can detect as shown by Steffan Vertanium (1).

HUMAN SKIN can feel a thread weighing 0.002mg being drawn across it

SUNDEW will react to 0.0008mg.

Sicyos TENDRIL will react to 0.00025mg.

Some researchers consider that this tropism is more important in controlling a plant's growth than gravitropism.

For example, roots find the easiest path through the soil, avoiding solid objects through negative thigmotropic responses and plants whose branches are touched regularly will tend to be shorter and more compact (2) (the touching replicates branches coming together in the wind, thus a plant growing in a windy site).

Plants feel your touch

In 1973 Jaffe (3) found that stroking a plant for only a few seconds a day led to a shorter plant with a greater girth. In fact it was shown that it only took 30 minutes before the stems began thickening.

More interestingly, a few years ago a group of scientists showed that greenhouse-grown trays of seedlings, brushed with a sheet of paper, survived transplanting better. They tended to be shorter and more robust like outdoor grown specimens (4).

More visually evident thigmotropic responses can be seen in the way grape or passionfruit tendrils wrap their way around any twig or other suitable surface they come in contact with. This entwining process can take place in well under an hour.

When it comes to speed though, the insectivorous plants are in a different league: the venus fly trap reacts in 1 second and the Utricularia bladder in 0.01 seconds (5). The speed at which this happens is reminiscent of animals not plants. More on this below.

How do plants do it?

This is still up for debate in some situations but there are two main processes. The first is controlled by hormonal differences between one side of the plant and the other resulting in cell elongation on one side causing curvature.

In some cases the inner side cells have been seen to contract, normally through water loss. The other, faster response is through an electrical impulse. Yes, many plants have what could be considered a primitive 'nervous system'.

Animal electrical impulses along nerve fibres travel at speeds of 1 – 100 m/sec, whilst most plant impulses travel at only 1 – 10 cm/sec (3).

These electrical impulses in plants often create a movement, at the appropriate point, through cells losing or gaining water and thus causing a part of the plant to move one way or the other.

For example Mimosa leaflets droop (dropping the herbivore to the ground) or sundew leaves fold (ensnaring their prey). Over 1000 species are known to have rapid responses to stimuli through electrical impulses (4) and this number will probably only grow as more research is carried out.

There is so much more to it all of course but at least you now have some idea of how and why plants react to some things and why they do what they do.

Note: It is important to note that plants vary greatly and tropism is but one of the ways in which they can react to their environment.

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