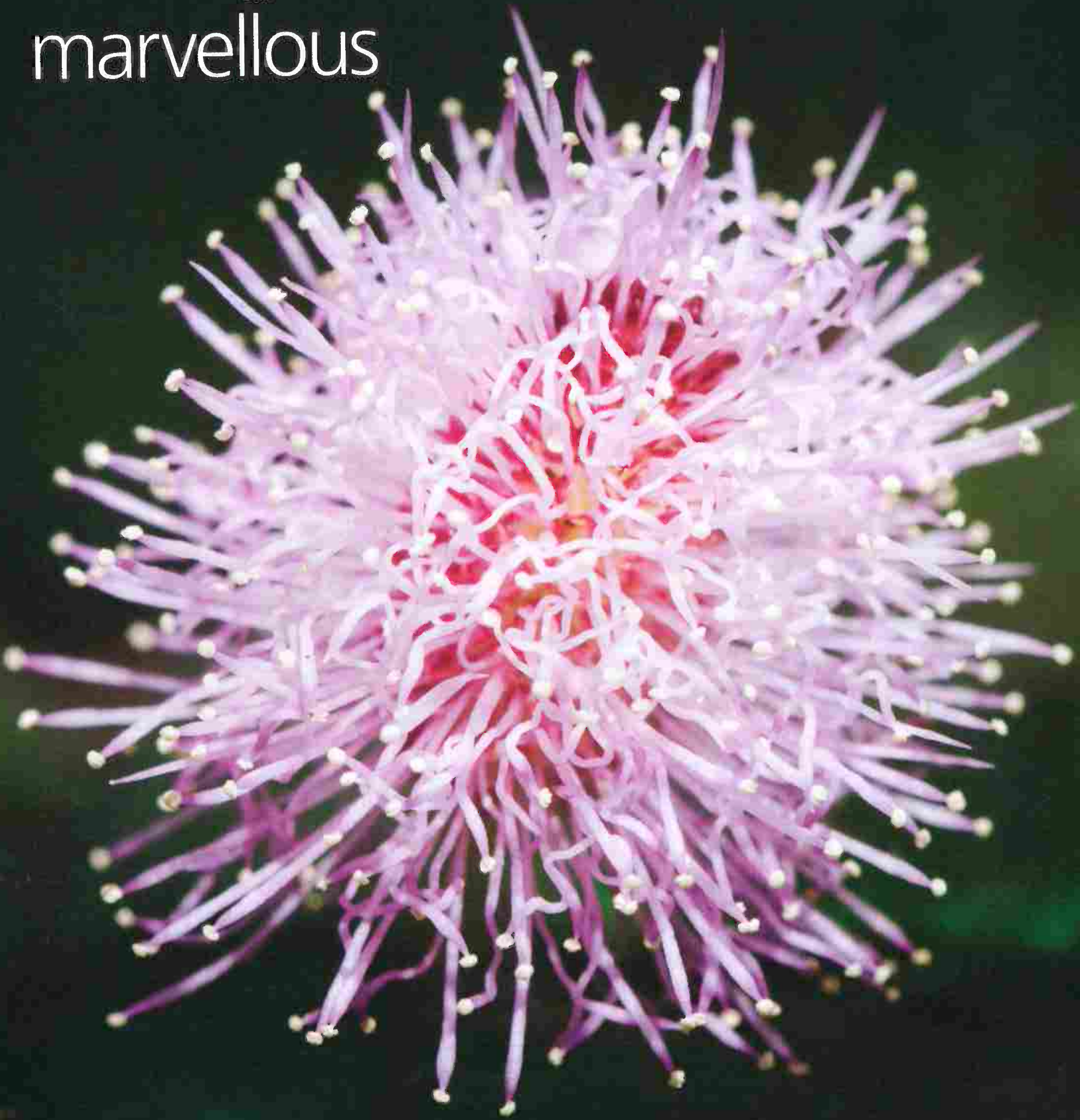
Mimosa

Moving, medicinal and marvellous



Jonny Miller

Tropical biologist Jonny Miller describes the mechanisms behind the mimosa plant's remarkable ability to move and explores its potential to save lives

Have you seen films based on bizarre alien worlds, where plants shrink away from human touch? Well, one plant can rival any of its movie imitators with spectacular reactions. *Mimosa pudica*, a plant native to Central and South America, is known by many names including the sensitive plant, the shame plant and the touch-me-not.

Key words

Plant
Movement
Mimosa
Osmosis
Action potential

Several plants have evolved the ability to move rapidly. You are probably familiar with the Venus flytrap (if not, see BIOLOGICAL SCIENCES REVIEW, Vol. 26, No. 4, back page). The trap of this plant is loaded with sensitive trigger hairs. When an insect brushes against these it causes the trap to snap shut, ensnaring the fly within. The trapped animal is then digested, and the trap re-opens after a few days.

Fast mover

Mimosa is another plant that has rapid movement. Not only can it respond to stimuli such as touch, wind, vibration, darkness, excessive heat and cold, it can also vary its response according to how strong the stimulus is. A gentle touch causes a single pair of **leaflets** to fold in on themselves, whereas a stronger strike can cause the entire shrub to seemingly wilt away in an instant. However, unlike the Venus flytrap, the leaves of mimosa return to their original position in just a few minutes. So the plant can perform this sequence over and over again. It does so daily — closing its leaves at night and then unfolding them again in the morning to soak up the sun.

Evolution has favoured the genes that allow mimosa to move not for the purpose of carnivory but for other reasons. The first is simply to appear less conspicuous and less appetising, to discourage herbivorous animals from munching away at the plant. Once the leaves have shrunk away, the plant looks remarkably bare of the juicy green food desired by herbivores (see Figure 1). Wilting of the leaves also exposes a prickly network of stems armed with curved thorns (see Figure 2). Small movements of single leaflets may have evolved to deter insects that might be tempted to eat, or lay eggs on, the leaves. When the insect lands, the leaflets snap up and dislodge the potentially harmful bug.

The motorised plant

When movements occur, it is not the whole plant that moves. Movement occurs only in specific, small regions called pulvini (singular: pulvinus). Pulvini are plant **motor organs**. By organ, we mean a collection of different kinds of specialised cells that work together to perform a particular function — the

Figure 1 (a) *Mimosa pudica* in its resting state during the day, with leaves fully open. **(b)** After being brushed with a stick, the entire bush appears to wilt away in just 1–2 seconds

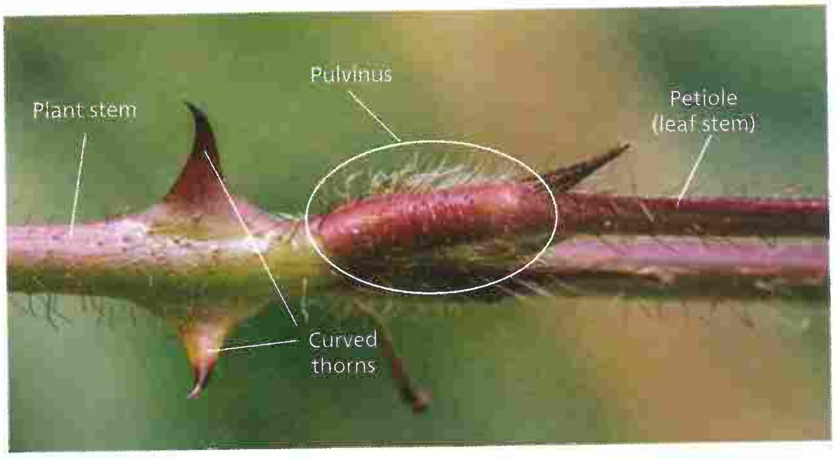


Figure 2 The pulvinus is a thickening of specialised cells at the base of the leaf stem

function for pulvini being movement. The pulvini in mimosa are thick bundles of cells surrounding the base of the **petioles**, which connect the leaves to the main plant stem (see Figure 2). There are yet more pulvini at the base of every mature leaflet (see Figure 3a). By all functioning together, whole shrubs of mimosa can shrink away very quickly (see Figures 3a–d).

So how do pulvini function like motors? There are no mechanical parts, spinning or whirring away inside the plant. Instead, pulvini use the power of hydraulics — the power to move things using the pressure of water. Plant cells retain an impressive amount of water pressure — called **turgor** pressure — thanks to their tough cell walls. But there's more too — scientists have discovered that rapid movement in *M. pudica* involves chemical, muscular and electrical elements.

Let's concentrate on a single pulvinus at the base of a leaflet. The motor works when the cells on the top side of the pulvinus — those facing towards the sky — lose water and shrink, and simultaneously the cells on the underside, nearer the ground, swell with water. Because of the way the cell wall is arranged, swelling occurs only in one dimension — lengthways towards the tip of the leaflet. This means that the top and bottom of the pulvinus change in length, with the bottom cells becoming up to

Terms explained

Action potential An electrical signal that travels along the plasma membrane of a cell, caused by electrically charged ions crossing the membrane.
Active transport The process whereby a substance is pumped across a cell membrane against its concentration gradient, using energy.
Ayurveda A type of complementary and alternative medicine that originated in India.
Invasive species A species that has spread from its original, native area to another region of the world, often causing problems to native species.
Ion channel A protein in the cell membrane that acts like a gate, which can be closed or opened to allow the flow of specific ions.
Leaflets The small leaf-like parts that make up a *Mimosa pudica* leaf.
Motor organ A body organ that generates movement.
Osmosis The diffusion of water across a semi-permeable membrane from a region of high water potential to one of low water potential.
Petioles The stalk connecting a leaf to the main plant stem.
Placebo effect When someone experiences or feels an improvement in health after taking ineffective medication, owing to psychology rather than the medication itself.
Turgor The pressure produced when water concentration is higher inside a cell than outside, causing the cell to become rigid.

Figure 3 (a) There is a pulvinus at the base of each leaflet (circled). **(b)** When the edge of the leaf (circled) is touched, the leaflets fold up in pairs. **(c)** A stronger stimulus causes adjacent leaves to fold up. **(d)** An even stronger stimulus causes the whole petiole to droop down via activation of the main pulvinus (circled)

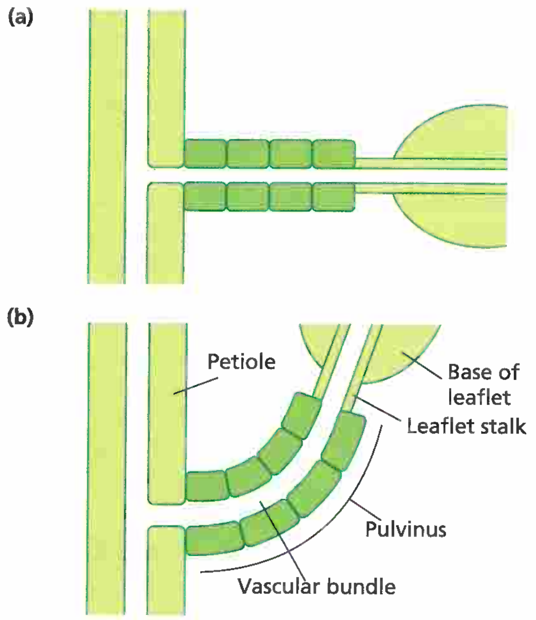


Figure 4 Diagram of a pulvinus, showing a row of cells on the top of the organ and a row of cells on the bottom. In reality, there are many rows of cells, forming a tube. **(a)** In the normal state, all the cells are roughly equal in length, keeping the leaflet horizontal. **(b)** After a stimulus, the cells on the top of the pulvinus lose water and shrink. The cells on the bottom swell and lengthen. This forces the pulvinus to bend, shifting the leaflet stalk upwards

Traditional Ayurvedic medicine is a form of alternative medicine that dates back to 5000 BCE. Mimosa is used for a wide range of complaints, as a painkiller, sedative, anti-depressant and anti-asthmatic

four times longer than the top cells. This forces the pulvinus to bend, driving the leaflet upwards (see Figure 4). Meanwhile, the leaflet on the other side of the petiole does the same thing so that the two leaflets fold towards each other.

Molecular magic

Now let's take an even closer look by concentrating on the upper (top) cells of the pulvinus. When a plant detects a stimulus, it sends a signal to these cells via an **action potential**. It is perhaps surprising to find an action potential in a plant, because they are normally thought of as the electrical impulses we see in animal nerve cells.

As in many cells, active transport keeps important charged ions, such as potassium and chloride, inside the cell at a higher concentration than outside the cell. However, when the action potential reaches a top cell, potassium- and chloride-specific **ion channels** are opened in response to the change in electrical charge. This allows ions to cross the cell membrane through the channels (see Figure 5). They diffuse out of the cell down a concentration gradient, from a region of high concentration (inside) to a region of low concentration (outside).

As the ions move out of the cells, water follows by **osmosis** from the cytoplasm to the outside of the cell. Much of this water comes from the cell vacuole — a large internal reservoir of water found in most plant cells. The vacuole becomes smaller, causing the cell to shrink. A large amount of water can leave the cell very fast, in 1–2 seconds, which is how mimosa leaves can fold and droop so rapidly. But how so much water diffuses across the cell membrane quite so quickly was a mystery to scientists for decades. Then they discovered that special water-transporting channels called aquaporins are involved. Aquaporins are selective transporters, allowing only water to pass through while blocking the passage of other molecules or ions. Scientists also found evidence to suggest that strands of protein called actin — also found in muscle cells of animals — speed up water exit by contracting around the cell vacuole, like squeezing a water bottle.

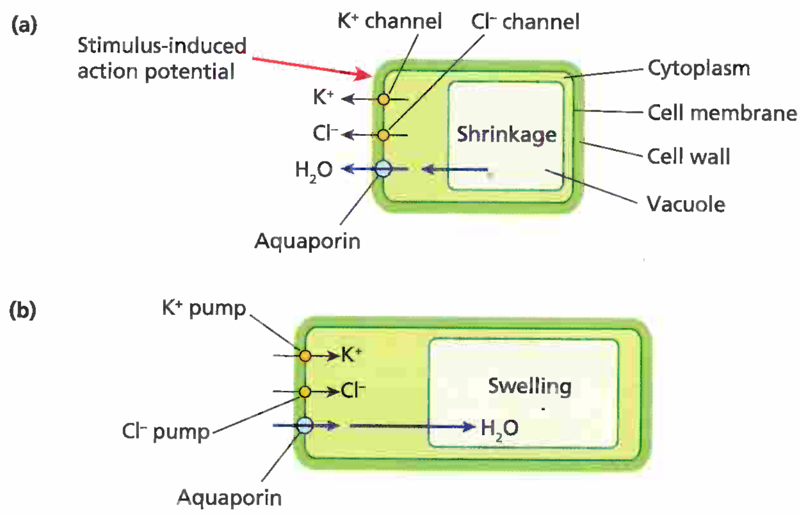


Figure 5 Movement of ions and water across the cell membrane of **(a)** the top cells and **(b)** the bottom cells of the pulvinus, following a stimulus

If you are bitten by the venomous Indian cobra, extracts from the root of *Mimosa pudica* could save your life

Next, ions released by the top cells are pumped into the bottom cells by **active transport**. The bottom cells now have a high ion concentration. Water moves in, again due to osmosis, and is stored in the vacuole, causing the bottom cells to swell.

If a stimulus is big enough, pulvini at the bases of the leaves and the petiole also react (see Figure 3). However, in these pulvini the behaviour of the top and bottom cells is reversed, which means that activation drives the petiole downwards rather than upwards. So the combined effect is that leaflets fold up but the whole leaf is pushed closer to the ground, giving the appearance of wilting.

Medicinal marvel

Although native to Central and South America, mimosa has now become a well-established **invasive species** in tropical areas around the world. In India it has become an important part of traditional **Ayurvedic medicine**.

Indian medics have long recognised that *M. pudica* has an array of health benefits. It has traditionally been used to treat diarrhoea and genitourinary infections and as an ointment on wounds, piles and insect bites. It has also been used to treat chronic psychological problems and serious infections such as syphilis, dysentery and leprosy. And it is effective in treating the otherwise fatal bites of Indian snakes.

Sometimes, traditional herbal remedies are ineffective — they may appear effective but this is actually due to the **placebo effect**. In other cases, they are absolutely spot-on. Recently, scientists have been investigating which problems mimosa can treat effectively and how it works. They have shown that *M. pudica* extracts have anti-bacterial and anti-fungal properties, can improve wound healing and promote regeneration of nerves, and can help to protect against disease-causing reactive oxygen species and toxins.

Research has shown that mimosa has anti-depressant, but not anti-anxiety effects in rats and humans. Extracts from the roots have also shown anti-fertility effects in female mice. It is therefore possible that some ingredient of mimosa may have the potential to one day be used as a contraceptive. In male mice, root extracts act as an aphrodisiac by increasing testosterone and libido. Last, but certainly not least, extracts from the root have been shown to reduce the damage and risk of death from the bites of several deadly snakes, including the Indian cobra and several pit vipers.

Thanks to curious botanists, those who practise traditional medicine, and modern-day biomedical scientists, our understanding of mimosa is changing. What was once thought to be simply a fascinating little contorting shrub may turn out to be a bona fide superplant.

Things to do/points for discussion

- Being stationary, plants seem to be easy food for animals. How has evolution produced mechanisms or structures that allow other plants to avoid being eaten?
- What other plants have medical uses, either traditionally or in modern medicine (or both)?
- Maybe you have some *Mimosa pudica* in your garden or nearest botanical gardens? If so, gently touch the leaves and see for yourself what happens.

Dr Jonny Miller studied for a BSc in biology and PhD at the University of Manchester. He currently lives in Honduras where he researches reptiles and teaches ecology and jungle expedition skills.

Further reading

www.kew.org/plants-fungi/Mimosa-pudica.htm

Key points

- Some plants produce rapid movements in response to a stimulus.
- *Mimosa pudica*, the sensitive plant, folds its leaflets up and petioles down, giving the appearance of wilting.
- Mimosa leaves fold away, exposing thorns, and thus avoid being eaten.
- The movement is caused by transport of water between the cells of special motor organs called pulvini.
- Water movement is controlled by chloride and potassium ions moving in and out of the cells, causing some cells to shrink and others to swell.
- Mimosa has many medical uses and has been used traditionally to treat different illnesses, including snake bites.