Tropic and Nastic: The Ways Plants Move

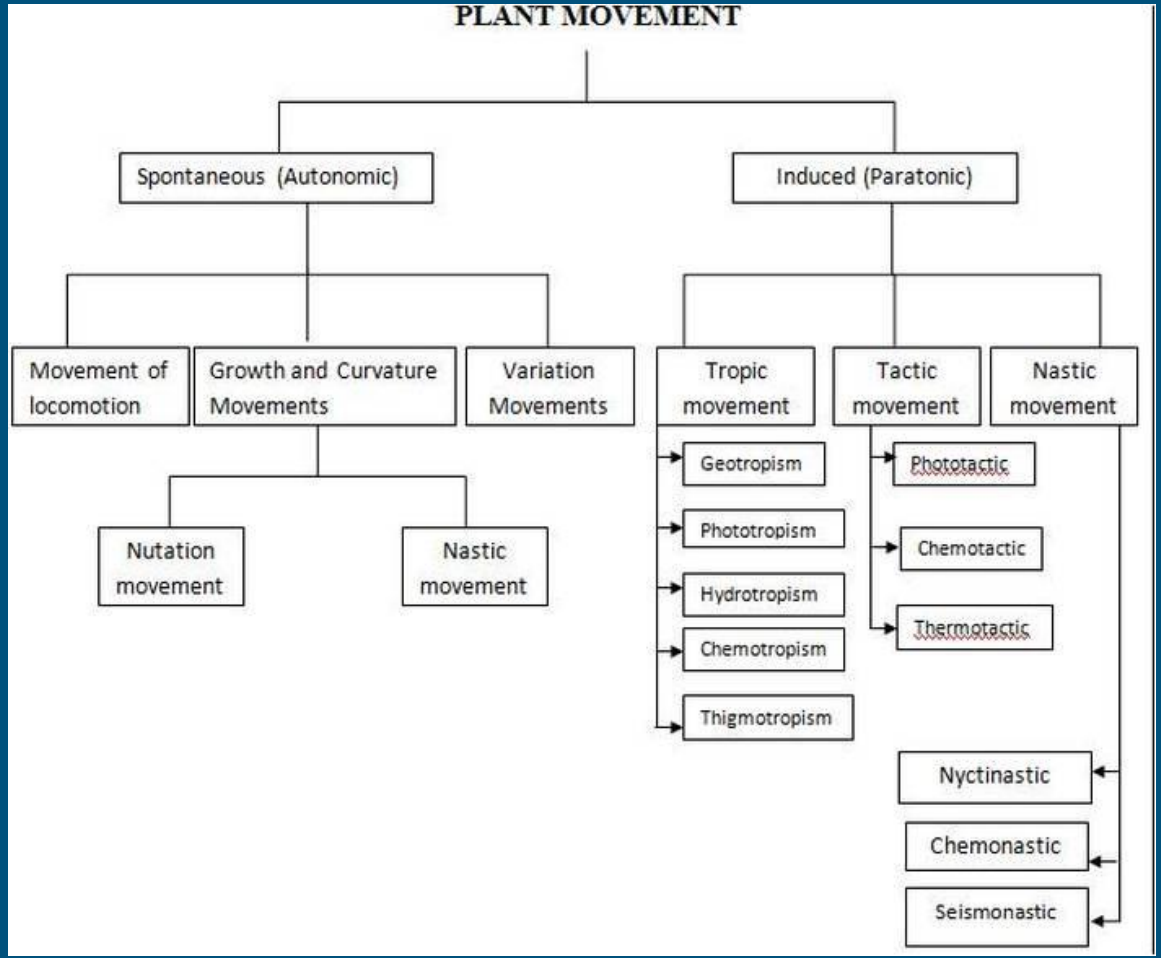
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March 5, 2021



Plant Movement as a Whole

- **Autonomic:** takes place without external stimuli
  - Cyclosis: the movement of protoplasm within the cell
- **Paratonic:** Growth movements that occur in response to unidirectional external stimuli
  - Geotropism: induced by stimulus of gravity

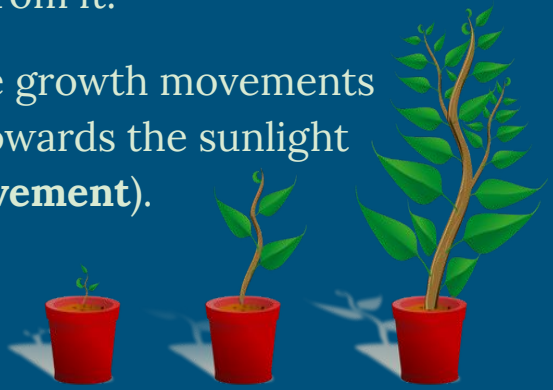


Week 1: Tropic and Nastic Movement

Tropic

Tropic growth movement in plants include the directional **movement** of particular parts of a plant in response to environmental stimuli. Notably, the ***movements*** *are slow* and are either towards the stimulus or away from it.

- Examples include growth movements of plant shoots towards the sunlight (**phototropic movement**).



Nastic

Nastic movement in plants are *reversible and repeatable* ***movements*** in response to a stimulus whose direction is determined by the anatomy of the plant.

- Examples include the diurnal movement of leaves and the response of insectivorous plants, such as the **Venus fly trap**, to prey.



Tropic Movement

Thigmotropism:

the movement or change in orientation of a plant's growth as a response to touch stimulus.



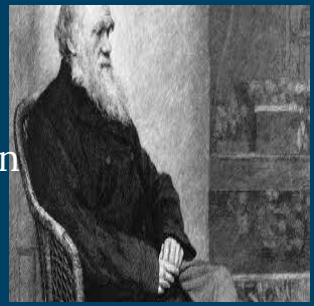
When growing, one side of the tendril touches the object, for instance, a stick. This signal is transmitted to the side that isn't in contact with the stick and curling occurs. The rate of growth on the non-contact side increases, while the rate slows down on the side that is in contact with the stick. This is called *differential growth*. It leads to elongation of the non-contact side, which eventually leads to curling of the tendril.

Tendril Development

- Keep in mind this is a helical-growth leaf modification special to flowering plants.

The tips of growing stems and other organs exhibit circumnutation (rapid circular movement) as they extend and interact with components of the environment, be it light, other vegetation, or soil

The renowned naturalist, Charles Darwin studied circumnutation in pea plant (*Arabidopsis thaliana*) roots. He observed that roots of many plants, when growing down an inclined surface, etched a trace of their movement in a wavy or spiral pattern, which he attributed to circumnutation.



This root waving results from the signal transduction pathways in thigmotropism. We interpret this flattened spiral growth pattern as a result of a geotropism-dependent thigmotropic response.

Robotic Roots: The Hidden Dance of Roots

Collaborators at Georgia Tech and the University of California, Santa Barbara, built a soft pliable robot that unfurls from its tip like a root and set it loose in an obstacle course consisting of unevenly spaced pegs.



To create the robot, the team took two inflatable plastic tubes and nested them inside each other. Changing the air pressure pushed the soft inner tube from the inside out, making the robot elongate from the tip. Contracting opposing pairs of artificial “muscles” made the robot’s tip bend side to side as it grew.

Nastic Movement

Thigmonasty:

touch-induced movement



The Shameplant, or *Mimosa pudica*, are plants of the pea family famous for their rapid leaf movement in response to touch. The leaves of the Mimosa achieve this *rapid folding* by a change in turgor pressure.

There are interesting Autonomic Plants...

Variation Movements:

movements occur due to periodic variations in the turgidity of cells of an organ.



The Indian Telegraph Plant, or *Codariocalyx motorius* Here the compound leaf shows three leaflets, one terminal large leaflet and two very small lateral, opposite leaflets. The two lateral leaflets show rhythmic movements during the day. These move up, then move back, and then move down finally back to the original position. This type of movement is due to variation or change in the turgor pressure at the base of the stalk of each leaflet.

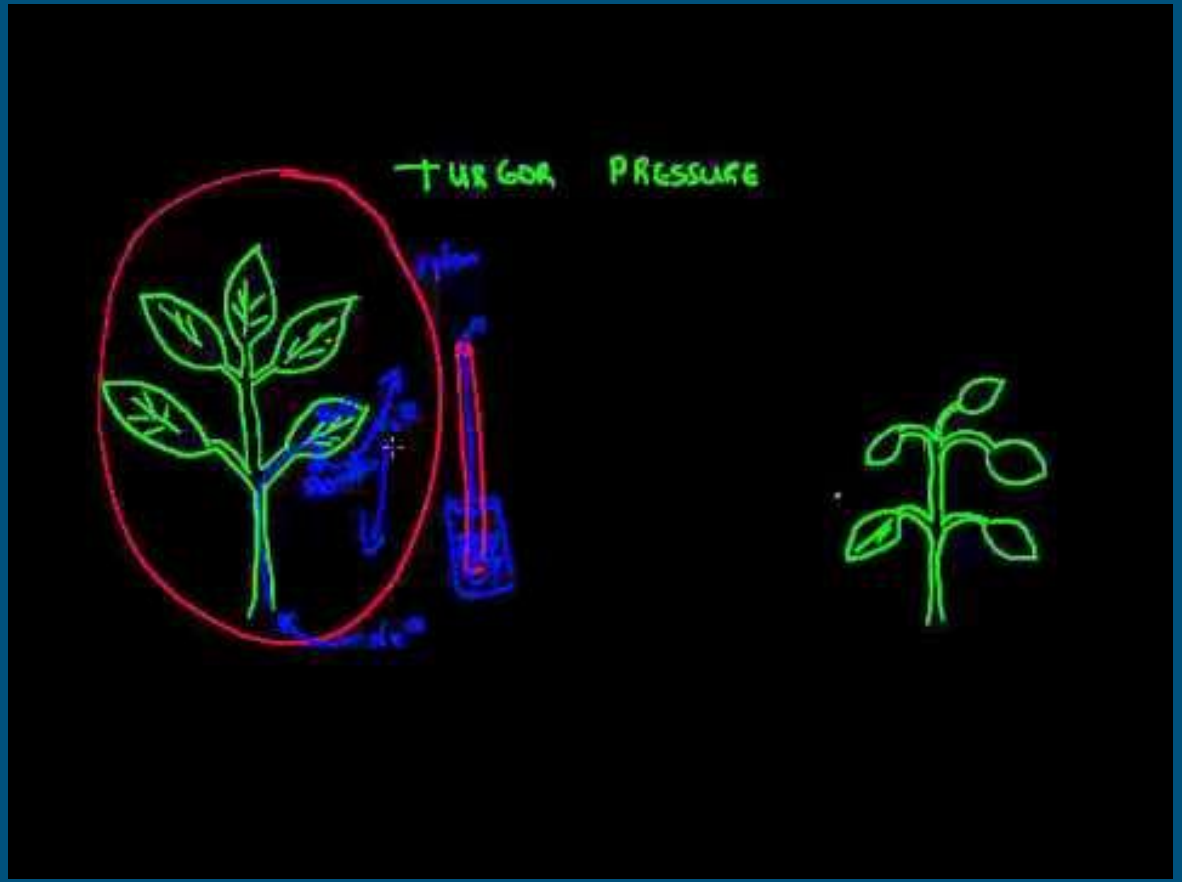
There’s a recurring mechanism of Turgor Pressure adjustment...

What is Turgor Pressure?

Turgor pressure is the amount of water pressure in the cell that is pushing up against the cell wall.

When there is a lot of water pushing against the cell wall the turgor pressure is high, and cell is rigid.

When water moves out of the cell, the turgor pressure decreases and the cell becomes flaccid



Application

What can engineers gather from these mechanisms of plant movement?

Sensor responses

- External or Internal stimuli
- Growth movement vs rapid and reversible movement

Model Design

- Tendril
- Rapid folding
- Rhythmic

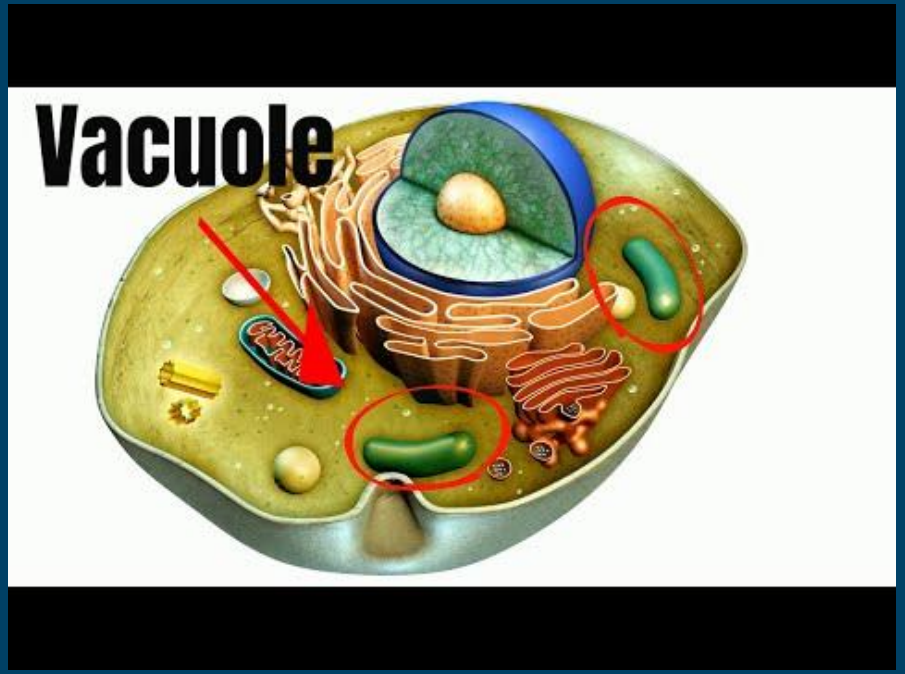
Turgor pressure

- Plant's solution to gravity
- Fluctuating water concentration

Here's a sneak peak into Week 2's Friday Morning Coffee ...

Plant Cell Strutures

The Mighty Vacuole!



Next week we will dive into the tremendous responsibilities that the vacuoles carry out specifically for plant cells. Understanding this will also shed light on how Turgor pressure functions in the plant cell movement.

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