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when tough is soft

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The way to fertility can be a long one. When a bee innocently drops a grain of pollen in a flower, there is no guarantee that the ovary is close by. Mother Nature has not given pollen the means to walk but she has armed it with a built-in system – the pollen tube – which grows longer and longer until it reaches the ovary. The procedure is simple and effective, and in some respects not so different from our own reproductive system. Needless to say, such a structure needs to be both rigid and supple in order to preserve its shape while it elongates. How does it do this? At the end of the tube is a budding tip – the only part which grows. Here, a host of enzymes are hard at work either solidifying or softening the cell wall as the pollen tube germinates. Amongst these enzymes are the pectin methylesterases which are capable of turning the cell wall polysaccharide pectin into a rigid frame or soft jelly…

A bee at work, by Daehyun Park (Korea)

courtesy of the artist

Pollen tubes are intriguing entities. Besides being graceful, not only do they flourish for the sake of sex but they can do it at a mind-blowing rate – the maize pollen tube, for example, can grow up to 1cm per hour. And by the end of a day, it can reach the length of an adult's foot! But what is it that grows? Does the whole tube stretch? Or only half of it? No, it is the very tip of the germinating pollen tube which grows, as it is attracted to the flower's ovary by way of a mechanism which is still a mystery to all. The germinating tip requires both plasticity and rigidity to prosper. Why? It has to be soft so that it can get longer, and the rigidity helps it to follow a given direction.

A pollen grain is just one cell, and when chance deposits a lucky one on the right female tissue of the correct species, it bounces into life and gives birth to a small protrusion on its surface, which subsequently elongates to become the pollen tube. The pollen tube – like the rest of the cell – is surrounded by a cell wall, the greater part of which consists of the polysaccharides cellulose and pectin. Cellulose and pectin fibres lend a plant cell its shape and firmness. As they do the pollen tube. But the latter has to soften at the tip so that it can grow further. This is made possible thanks to the pectin methylesterases which have the ability to break down pectin fibres thus breaking down the cell wall or, on the contrary, causing pectin fibres to link to one another. In the first instance, the cell wall softens locally. In the second, it stiffens.

Pectin methylesterases look like tiny cylinders, the inside of which carry the active site for pectin deesterification. Indeed, pectin is incorporated into the cell wall once it has been highly methylesterified in the Golgi apparatus – methylesterification can occur to as much as 80% of the pectin polysaccharide. Demethylesterification – performed by pectin methylesterases – is brought about by the deesterification of the methoxyl group of pectin to form pectic acid thereby releasing methanol and protons. As a result, the changes in pectin structure cause changes in cell adhesion, cell wall plasticity, the pH gradient and the surrounding ionic content. Yes, but this does not explain how pectin methylesterases know when to break down the pectin fibres thus loosening the cell wall or when to promote their binding to one another which stiffens it.

It is thought that the pH gradient, the ionic content and the degree of pectin methylesterifcation are what trigger off either the softening or stiffening of the cell wall in the first place. In the event of cell wall softening, the pectin methylesterases attack the pectin fibres in a random fashion. This behaviour promotes the action of pH-dependent cell wall hydrolases which pursue the break down of pectin thus causing the cell wall to loosen locally. In the event of cell wall toughening, however, the pectin methylesterases move along the pectin fibres in a linear fashion. The chemistry involved ultimately gives rise to a kind of Ca2+ glue which promotes the bonding of one pectin fibre to another thus toughening the wall locally.

Besides pollen tube elongation, pectin methylesterases take part in a number of other important biological processes such as cellular adhesion and separation, plant growth and development, leaf growth polarity, fruit ripening, and even plant defense mechanisms. It is hardly surprising then that pectin methylesterases – in this case usually of bacterial and fungal origin – are extensively used in commerce for a variety of reasons. In fact, the first commercial applications date back to the 1930s when they were added to the preparation of wines and fruit juices to tamper with their haziness. Besides these beverages, pectin methylesterases are also used in the preparation of textiles fibres such as jute, hemp and ramie as well as in the production of Japanese paper, the fermentation of tea leaves and coffee beans, and the extraction of vegetable oils! Little does a bee know what it triggers off as it rummages around the inside of a flower collecting nectar.

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