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> ONE MONTH, ONE PROTEIN <

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more to it than meets the finger

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There is a huge cucumber growing in the middle of our lawn. I paid it a visit the other day, pushing aside the huge leaves, and in so doing got stung on the tips of my fingers. I knew the sting came from the small hairs protruding from the stem but, until very recently, I had never given them much thought. Not until I discovered the world of trichomes. Trichomes and I have been co-habiting for many years. They give out stings or release perfume. They feel like velvet. Or like an unshaven chin. They are on my poppies, on my geraniums, on the nettles, on the tomatoes, all over my son's cactus and on the cucumber plant's stems. In truth, most plants have trichomes. Trichomes look like hairs and protrude from a plant's leaf, stem or flower. Very little attention had been given to them by scientists when they were first observed, well over a century ago. However, trichomes have turned out to be precious minute entities on the surface of plants and we now know of a protein which has a direct role in trichome differentiation: trichome differentiation protein GL1.

"Epidermic trip" by Emmanuel Boutet

Courtesy of the artist

Until the second half of the 20th century, trichomes had been dismissed as places where plant waste products are stored. This is because chemical substances such as heavy metals had been discovered there. Consequently, trichomes were believed to be specialised litter bins collecting the equivalent of human body wastes such as urine, faeces and perspiration. However, with time it became obvious that trichomes were in fact little worlds of their own which, yes, could collect waste products but also synthesize specific compounds whose purpose was to ward off predators – by producing toxins which sting or molecules which interfere with the herbivores' digestive proteinases – or to attract pollinators by creating colours or smells for instance. Consider this when you chop up herbs – such as basil or thyme – as the perfumes which rise to your nose are released by trichomes.

Needless to say, there are many types of trichomes. They can be long and slim, or short and stubby. They can be multicellular or unicellular. They can be hard or soft. They can be branched, or not. Many produce substances. Others seem not to. However, despite these many differences, their architecture is designed as a barrier against harm by preventing insects or pathogens from reaching the epiderm. What is more, many plants carry more than one type of trichome on their surface and their distribution can be either scant or abundant. So it seems that all combinations exist to ensure the survival – one way or another – of a species. It is surprising that, for so long, scientists thought that the sole existence of so many different-sized and different-shaped trichomes was simply for the benefit of ridding the plant of its waste.

Recently, the much studied mouse-ear cress (*Arabidopsis*) revealed one protein that is directly involved in triggering off trichome differentiation: the trichome differentiation protein GL1. Without GL1, the characteristic appendages – which look like an amputated starfish sitting on a stool – on the surface of the plant's leaves do not appear. GL1 belongs to the huge MYB family of transcription factors which play regulatory roles in

developmental processes and defence responses in plants. *Arabidopsis* – the model higher plant system – seems to possess well over one hundred of such transcription factors that are all structurally related to those of animals, despite being quite distinct in their mode of action. GL1 is not a very long protein – barely over 200 amino acids – and contains the DNA-binding domain essential to transcription factors.

Although GL1 is necessary to promote trichome differentiation, it is not sufficient. Indeed, on its own, *Arabidopsis* does not grow its spiky protuberances. It needs the help of two other proteins: a second transcription factor GL3 and protein transparent testa glabra 1, or TTG1. Together, the three of them form a complex that binds to transcription factor GL2, which in turn binds to the promoter region of the gene which will trigger off trichome differentiation, branching and expansion. Very little is known about the actual biochemical processes involved. However, it is now apparent that there is a strict order in the binding of the trichome complex. TTG1 can only bind to an already formed GL1/GL3 complex. And only the GL1/GL3/TTG1 complex is capable of activating GL2.

Despite having been ignored for so long, trichomes are now regarded as ideal model systems. This is because they function as mini independent chemical factories. They are not linked in any way to the plant's main vascular system. They produce their own compounds, most probably from sucrose which is easily imported – for *Arabidopsis* trichomes have no photosynthetic activity – and which would provide both the energy source and the first building block. And these compounds are, more often than not, intended for secretion. As a result, trichomes are perfect sites to investigate specific biosynthetic pathways and plant morphogenesis. What is more, these tiny factories are all found at the surface of plant epiderm – so, in principle, they are easy to "pick off". Consequently, it didn't take long before researchers imagined using trichomes as their own little mills for producing large amounts of engineered chemicals or proteins of commercial value such as pharmaceuticals, perfumes, food additives and pesticides, to name a few.

It sounds very promising. And so easy. Yet trichomes will no doubt show resistance in having their fates twisted. In fact, there is a chance that their peculiar architecture and biochemistry would not suit mass production of this nature. For instance, many trichomes tend to release instead of store compounds they synthesize. This would make it difficult to recover products which have just been made. Moreover, very few biochemical pathways actually take place in trichomes. As a result, there may not be the basic prerequisites a novel pathway would need. It is all a very interesting development. And one to follow. Little did they know, one hundred years ago, that there is much more to a trichome than meets the finger.

Cross-references to UniProt

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