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> ONE MONTH, ONE PROTEIN <

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a taste of light

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Light gave life a chance to be. Without it, our planet would not be inhabited by so many living beings of all shapes and sizes. Over time, animals, plants and all sorts of microorganisms have emerged and evolved using this source of photons in different ways. Like hosts of other creatures, we use light for vision so that we can discern individual entities that make up our environment, as well as movement within it. Bereft of that faculty, it becomes difficult to hunt prey, shun predators and attract a mate – life's basic needs for all species. Not all species have eyes though, so have devised different ways of coping with these needs. But they still use light for other purposes such as the vital metabolic pathway known as photosynthesis in plants, circadian rhythms or metabolism changes in bacteria for instance. Light can also stimulate movement, as is the case for the very small worm known as *Caenorhabditis elegans*. However, for all this to happen, there has to be a system in each of these organisms that can catch light and transform it to meet their requirements. This is done by way of photoreceptor proteins. And *C.elegans* uses one of a very special kind which is known as high-energy light unresponsive 1, or Lite-I.

watercolour by Sky Kim

Courtesy of the artist

C.elegans is a tiny worm – barely 1mm long – that was first described by Émile Maupas (1842-1916), a French librarian and naturalist then living in Algeria. Following studies in the laboratory in the 1940s, it became apparent that the relative simple structure of *C.elegans* combined with an invariant cell lineage, made it a good candidate for genetic studies. In the 1960s, after having made important contributions to the understanding of the genetic code, the South African molecular biologist Sydney Brenner felt that the basics of molecular biology had been discovered and its future lay in other fields of biology, namely cellular development and the nervous system. But he needed a model organism with which he could play. *C.elegans* was soon brought to his attention, and he began studies in 1963. Ever since, *C.elegans* has remained one of the most popular invertebrate model organisms, and even made the headlines in 2003 when specimens survived the crash of the space shuttle Columbia.

C.elegans is widely used as a model for understanding sensory transduction, i.e. the processes involved in sensing what is going on in the environment. Worms have olfactory and gustatory neurons that are able to respond to chemical stimuli, and they react to mechanical forces via touch receptor neurons. However, scientists recently discovered that *C.elegans* reacted to light as well. Since these worms live in soil, and therefore rather dark conditions, this came as a surprise. Yet light is well able to penetrate the superficial layers of soil and is thus prone to damaging, or even killing, cells by photo-oxidative reactions. So, over time, *C.elegans* found the means to protect itself.

How organisms are able to grasp light and extract the energy that is in it for their own benefit – a process known as phototransduction – is a fascinating, and poetic, chapter of biology. Light is caught by way of specific cells, known as photoreceptor neurons. The most familiar of these neurons are perhaps those that are found in vertebrates' eyes which use light to see. And it's not just a case of switching on a bulb and brightening the environment. Light is made of photons. Photoreceptor neurons are laden with photoreceptor proteins, or photoreceptors, that can interact with photons. It is this interaction that ultimately leads to the opening of channels that riddle the length of neurons' membranes, and to the simultaneous transmission of a message from the neurons to the brain that answers with a "this is what we are looking at".

So what is Lite-1? Like all known photoreceptors, Lite-1 is a G protein-coupled receptor. Surprisingly though, it bears no sequence resemblance to any of the photoreceptors characterised to date: indeed, Lite-1 belongs to the taste receptor family. As a consequence, it doesn't seem to have the classical chemical entity known as a chromophore which actually interacts with photons – although the atomic structure of Lite-1 remains to be determined – but instead requires the presence of two membrane-embedded tryptophan residues that interact with photons. So here is a sensory receptor initially sculpted for taste which, along the years, has been twisted into a photoreceptor. Lite-1 responds to UV light (short wavelengths) which represents 10% of light, and can be particularly harmful. It is hardly surprising then that *C.elegans* worked out a means to deal with it. But how exactly?

Lite-1 is found in photoreceptor neurons located at the tail-end of the worm. It is transmembrane and its topology is inverted with regards to that of the more classical photoreceptor – a fact that also seems to be of importance for Lite-1 function. When UV light seeps through the first layers of soil, Lite-1 senses it. This triggers off the process of phototransduction, i.e. a G protein cascade that ultimately stimulates the opening of downstream G protein-dependent gated channels, and hence the transmission of a message that spells danger, causing the worm to retreat rapidly and avoid the incoming and harmful UV light.

The existence of a photoreceptor such as Lite-1 demonstrates that Nature has its ways of using what it has at its disposal and modifying it to serve a different purpose depending on the circumstances. This said, a few photoreceptors are multifunctional and it is possible that Lite-1 reacts to other chemical cues that have remained hidden so far. When scientists introduced Lite-1's particular tryptophan residues into other taste receptor family members, they were able to promote photosensitivity. Is it possible, then, to genetically engineer new photoreceptors? Could Lite-1 be harnessed, for instance, and used as a tool to photoactivate neurons in living cells to understand similar synaptic signalling pathways in invertebrate and vertebrate systems? And if Lite-1 is used as a sun screen for *C.elegans*, could it be used to protect human skin against harmful UV light too? These are just a few of the exciting prospects in store for a protein whose initial purpose in life does not seem to have been for sensing light in the first place. Or perhaps it has found a way of tasting it.

Cross-references to UniProt

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