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EDITORIAL

Sniff and run—the chemistry of attraction

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Fitness represents the gold standard of evolution. This scintillating term generally describes the efficiency by which organisms can multiply their genetic constitution. The first step in the life cycle of any sexual organism is simultaneously the one most crucial for this task: Since the formation of an egg cell with its rich resources represents a much larger investment than the production of the smaller sperm cells, the number of male cells usually exceeds those of their female targets. This leads to harsh competition between male germ cells providing strict selection for efficient targeting and efficient translocation. In animals, it is the efficiency of chemotaxis that will decide over the fate of a given spermatozoid. In higher plants that have replaced mobile sperm cells by a mobile gametophyte, selectivity is provided by the efficiency of chemotropism. Two contributions in the current issue address the molecular and cellular mechanisms establishing the targeted transport of the male nucleus to the egg cell in animals and plants. Since the mechanism for sperm mobility is so fundamentally different (free swimming versus polar growth), it is interesting to have a look on the commonalities and differences between the two types of organisms.

In their review on sperm guidance in animals, Sugiyama and Chandler (2014) focus on the role of calcium signalling for sperm guidance and integrate most recent results on the calcium signature in the flagellum into the context of classical work reaching back for more than a century. They dissect the molecular events that are responsible for the asymmetric flagellar bend that is responsible for directional movement. Although the model for the targeting mechanism dates back several decades, it has been difficult to test the proposed mechanisms experimentally, because the events are extremely fast. In their historical survey of the field, the authors work out very clearly how conceptual advances have been enabled by methodological progress. The fact that calcium influx and cGMP signalling are relevant for the correct processing of the chemoattractive signal had been elucidated some time ago, but this did not really help to understand what is happening because it is not so much the molecular nature of these signals that matters. It is rather the issue, where and when they are generated, that defines the efficiency of chemotaxis. To elucidate the spatiotemporal signature of these signals required sophisticated methodology, such as specific mixing chambers that allowed to obtain extremely precise application of chemical cues or ultrashort excitation devices that allowed to obtain extremely precise readouts from calcium fluorophores. A further methodological aspect is worked out in this review—the need to quantify the cellular response (chemotaxis), in order to be able to correlate signalling events and biological effect. The combination of these techniques allowed to dissect signalling and also to uncover that the effect of chemoattractors is multilayered. For instance, proton-dependent calcium channels can be directly gated by progesterone, which will accentuate the signalling carried by cGMP and the phosphoinositide pathway. The review concludes with a look on other guiding cues (such as thermo- and rheotaxis) that seem to complement chemotactic orientation in mammals.

The development of a pollen tube that can transport sperm cells without the need for free swimming was a breakthrough that around 200 Mya secured the explosive radiation of seed plants that now became able to colonise the more arid regions of our planet. Pollen is a structure optimised for motility, which implies that growth and metabolism have to be arrested and are released only in the moment, when the pollen touches the surface of the stigma. Then, in extremely short time, not only metabolic activity has to be boosted rapidly to sustain rapid growth of the pollen tube, but also the polarity of the emerging cell has to be adjusted efficiently in concert with chemoattractive signals from the egg cell and the conductive

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tissue of the style. In their review, Lang et al. (2014) focus on the role of proton pumps as synchronisers of the signalling. The polar growth of the pollen tube relies on an oscillatory network of calcium-dependent signalling, actin dynamics, and vesicle transport to the growing tip that is guided and modulated by chemical signals from the female partner (reviewed in Vidali and Hepler 2001). Again, calcium signalling is cross-connected with phosphoinositide. And again, proton gradients are important, because they provide the chemical energy necessary to drive the transport of other signals (such as calcium) across the membrane. The authors work out that the plasma membrane-based proton ATPases can act as integrators that cross-link and “negotiate” different directional cues (similar to animal fertilisation, in addition to chemical signals, also physical signals, such as osmotic potential, or mechanic impedance by the guiding stylar tissue are relevant) to transduce them into changes of growth rate.

Thus, although the mode of motility is completely different, and the molecular players are different as well, some of the molecular signals and their functionalities seem to be shared when the directional motility of animal and plant germ cells is compared. These commonalities probably arise from convergence rather than homology, probably because they just exploit general cybernetic principles of self-organisation rather than being the product of strict genetic control.

Conflict of interest The author declares that there is no conflict of interest.

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