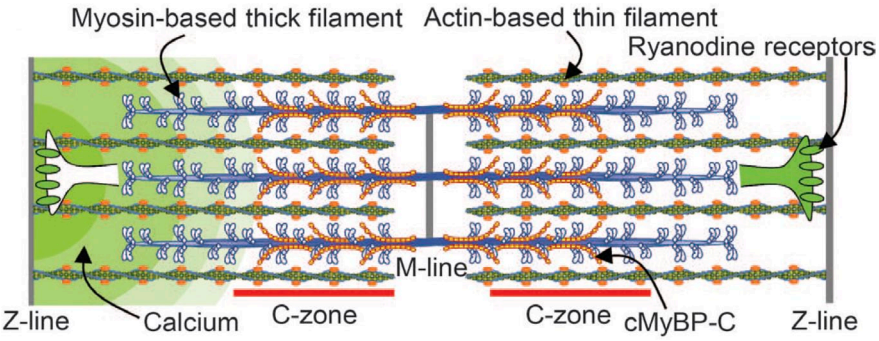
Generally Physiological

Thinking of calcium and fleeing flies

This month's installment of *Generally Physiological* considers mechanical activity at the cellular, tissue, and organismal level, discussing how myosin-binding protein C (MyBP-C) counteracts sarcomeric calcium gradients to ensure uniform activation of the contractile machinery, the distinct roles of different calcium channel subtypes in determining cerebral arterial tone, and the role of touch in fly collective behavior.



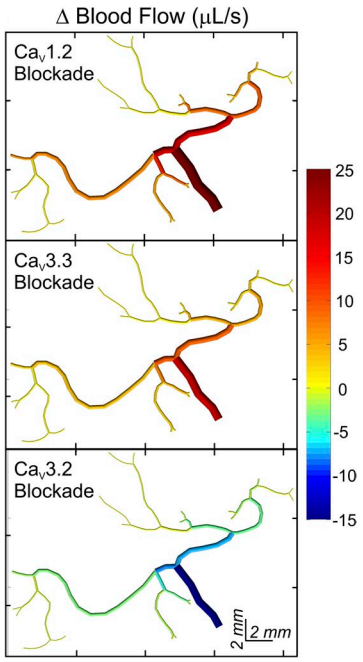
Organization of cardiac sarcomeres, showing the localization of SR ryanodine receptor calcium release channels at the ends of the sarcomere, development of a calcium gradient, and the location of MyBP-C bound to thick filaments toward the sarcomere center. From Previs et al. *Sci. Adv.* 2015;1:e1400205 (20 February 2015). This work is licensed under CC BY-NC (http://creativecommons.org/licenses/by-nc/4.0/).

Countering the calcium gradient

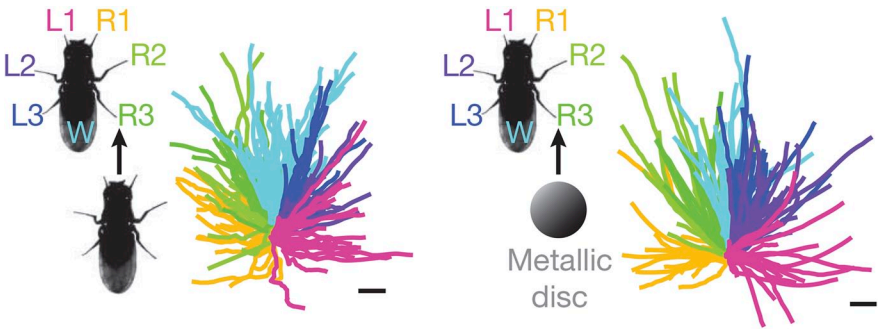
For every heartbeat, calcium is released from the SR to diffuse through the sarcomere and bind to the troponin–tropomyosin complex, enabling the actin–myosin interaction that mediates the contractile response. The location of the SR ryanodine receptor release channels at the ends of the sarcomere, however, predict that calcium release will generate a spatiotemporal gradient that could result in nonuniform activation of the contractile machinery. Previs et al. (2015) determined that electrical stimulation of mouse cardiac myocytes did, in fact, lead to development of such a calcium gradient (60–140-nM average gradient from the end of the sarcomere to the middle), which peaked ∼13 ms after stimulation and persisted for ∼20 ms. In vitro assays indicated that the existence of such a gradient should lead to inhomogeneity in activation of the actin-based thin filament, but that MyBP-C, which interacts with the myosin-based thick filament near the center of the sarcomere, increases the effective sensitivity to calcium to enhance actin activation. The authors thus propose that MyBP-C, by virtue of its location to a region of the sarcomere that experiences a delayed increase in calcium, provides an elegant mechanism to counterbalance the calcium gradient and ensure the rapid and uniform development of force.

Setting arterial tone

Calcium influx through voltage-gated calcium (Ca_v) channels plays a critical role in determining tone in cerebral arteries and thereby the spatial and temporal distribution of blood flow in the brain. Noting that L-type and T-type channels have been identified in rodent arteries, in this issue Harraz et al. set out to identify the complement of Ca_v subtypes present in human cerebral arterial smooth muscle and define their roles in determining arterial tone. After using quantitative PCR and Western blot analysis to reveal that L-type ($Ca_v1.2$) and T-type ($Ca_v3.2$ and 3.3) α_1 pore–forming subunits were expressed in human cerebral arterial smooth muscle, the authors combined pharmacological analysis with patch-clamp recording to characterize them. Intriguingly, myographic analysis revealed that $Ca_v1.2$ and $Ca_v3.3$ promote arterial constriction (with the former predominating at higher and the latter at lower pressures), whereas $Ca_v3.2$ promoted vasodilation through a mechanism involving activation of the Ca^{2+}- and voltage-activated BK



The predicted effects of blocking $Ca_v1.2$, $Ca_v3.3$, or $Ca_v3.2$ on blood flow in human cerebral arteries are distinct. See Harraz et al. (2015).



Stereotyped walking responses elicited in flies in response to light touch by another fly (left) or a metallic disc (right). (Reprinted by permission from Macmillan Publishers, Ltd. P. Rmadya et al. *Nature*. http://dx.doi.org/10.1038/nature14024, copyright 2015.)

channel. Thus, each of the different Ca_v subtypes appears to play a distinct physiological role in the regulation of cerebral artery tone and, consequently, blood flow in the brain.

Group dynamics in flies

Simple interactions between individual organisms can lead to the emergence of complex behaviors in groups; Ramdya et al. (2015) investigated the mechanisms underlying one such collective response: avoidance of aversive odors in flies. Although *Drosophila* is considered a solitary species, they congregate to feed. Ramdya et al. determined that, whereas isolated flies spent little time avoiding an aversive odor (5% CO_2), high density groups showed a markedly enhanced avoidance response. Computational simulations incorporating three observed behaviors (flies walk more frequently when exposed to 5% CO_2 than in odor-free air; are more likely to retreat upon entering an odorous area from odor-free air than vice versa; and proximity to another fly stimulates walking) reproduced the collective behavior. Observation of groups of flies at high spatiotemporal resolution revealed that active flies stimulated walking in stationary flies through gentle touch; touch on the distal leg elicited a stereotyped walking response that could be reproduced by touch with a metal disc. Analyses of transgenic flies in which neurons were silenced through expression of tetanus toxin or activatable through channelrhodopsin-2 implicated leg mechanosensory sensilla neurons in the walking response. Furthermore, flies in which these neurons were silenced failed to show the collective odor avoidance response, as did flies mutant for the mechanosensory channel NOMPC (the latter also showed a diminished walking response to touch). In contrast, mutant flies anosmic to CO_2 showed odor avoidant behavior in response to interactions with wild-type flies. The authors thus conclude that mechanosensory interactions mediated through distal leg mechanosensory sensilla neurons and NOMPC are crucial for the emergence of a collective odor avoidance behavior in *Drosophila*.

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