Research Roundup

Vesicles slide on a synaptic body

In vision and hearing, all-or-nothing action potentials are insufficient because they cannot transmit small changes in intensity. Thus, neurons in these areas use the synaptic body (SB), an unusual presynaptic organelle that is specialized for continuous transmitter release. This requires a lasting supply of synaptic vesicles. A new article by David Lenzi, William Roberts (University of Oregon, Eugene, Oregon), and colleagues suggests that the SB is a source of these vesicles.

The distribution of vesicles on the SB changes sharply in response to stimulation, as seen in electron tomography maps of inhibited versus strongly stimulated synapses. Vesicles near the plasma membrane side of the SB were released most rapidly. This generated a gradient of vesicles, most of which remained on the cytoplasmic face of the SB. “The redistribution is what you expect if vesicles bind to the synaptic body and then move along to reach the release site,” says Roberts.

After stimulation, fewer vesicles were found at the plasma membrane just below the SB than in a surrounding ring. Thus, stimulation establishes vesicle gradients on both the SB and the plasma membrane that may be sources for ongoing release. Roberts hopes to determine whether the movement of vesicles down the SB is passive or is powered by a transporter. So far, only three SB components are known, which limits the number of proteins that could be tested for transporter activity.

Reference: Lenzi, D., et al. 2002. Neuron. 36:649–659.

PiT: a motor on steroids

Many gram-negative bacteria, including the human pathogen that causes gonorrhea, use type IV pili for attachment to host cells. Retraction of the pilus is strong enough to propel a bacterium along cells. Berenike Maier, Michael Sheetz (Columbia University, New York, NY), and colleagues have now measured just how much force is released by pilus retraction, a process known to require the PiT ATPase. Their findings make PiT the strongest known molecular motor.

The strength of pilus retraction was measured by its ability to pull an attached bead from a laser trap of varying stiffness. Retraction frequency was proportional to PiT concentration, indicating that PiT is the molecular motor powering retraction. The retraction of one pilus generated forces in excess of 100 pN, between 2 and 20 times that released by kinesin and polymerases.

PiT’s exceptional strength may stem from its unusual mode of action. Unlike most motors, which move bidirectionally along filaments, PiT’s action was irreversible. PiT apparently powered retraction by dissociating pilus subunits into the bacterial membrane. The dissociated subunits may be unable to reassemble directly into the filament. PiT belongs to an ATPase family that works in hexameric form and may therefore hydrolyze up to six ATP molecules for each pilus subunit released. This would generate several times more energy than is required for disassembly. As yet, no analogous motors have been found in eukaryotes. If they are prokaryote-specific, PiT-like motors may be convenient targets for drugs to treat certain bacterial infections.

Reference: Maier, B., et al. 2002. Proc. Natl. Acad. Sci. USA. 99:16012–16017.

Neurons go toward the light

Like a miniature version of the famous tractor beams of sci-fi lore, beams of light known as optical tweezers have been used to hold and manipulate anything from atoms to cells. Now, Allen Ehrlicher, Josef Käs (Universität Leipzig, Germany), and colleagues show that laser beams can also manipulate a biological process—the growth of an axon.

In their new report, the authors direct axonal growth by focusing a beam of light just ahead of the leading edge of a lamellipodium. Forces of light lower than those used for optical tweezers accelerated growth at the leading edge. Shining the laser on one side of the growth cone caused filopodia to accumulate on that side, thereby initiating as much as a 90° turn of the growth cones.

Although the mechanism behind the effect of light is yet unproven, Ehrlicher describes the group’s favorite explanation as “biased monomer diffusion.” According to the theory, the electrical field gradient created by the beam, which polarizes the nearby pool of actin monomers, draws the monomers toward the beam’s focus, thus favoring polymerization. “In effect, we trick the actin polymerization process,” says Ehrlicher.

Whatever the mechanism, Ehrlicher is excited by the possibilities that light control over cell motility may offer. One immediate use will be to construct more precise and longer-lasting in vitro neural networks, in which a small number of neurons are connected in a specific fashion to study neuronal interactions. A long-term goal is to use lasers in vivo to guide the regrowth of severed peripheral nerves in accident victims.

Reference: Ehrlicher, A., et al. 2002. Proc. Natl. Acad. Sci. USA. 99:16024–16028.