This Week in The Journal

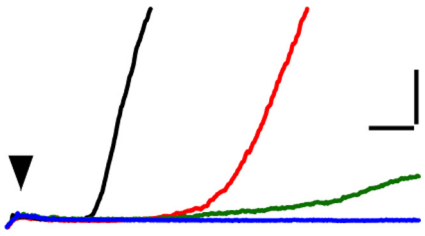
Cellular/Molecular

Neuronal BK_{Ca} Channels May Be Gated Primarily by Ca^{2+}

Henrike Berkefeld and Bernd Fakler

(see pages 7358–7367)

As their name implies, large-conductance calcium- and voltage-activated K+ channels (BK_{Ca}) can be activated by changes in either voltage or intracellular calcium concentration ($[Ca^{2+}]_i$). Which of these gating mechanisms is most prominent under physiological conditions in neurons—in which BK_{Ca} channels form complexes with voltage-gated Ca^{2+} (Ca_V) channels—is unclear. Because of technical challenges, most studies of BK_{Ca} kinetics have varied voltage while keeping $[Ca^{2+}]_i$ constant. Berkefeld and Fakler, however, used a piezo-driven application system to produce rapid step-changes in $[Ca^{2+}]$ while holding voltage constant. In inside-out patches from heterologous cells expressing homomeric BK_{Ca} channels, $[Ca^{2+}]_i$ and voltage steps induced currents that had similar amplitude but different kinetics. Notably, current onset was delayed after a $[Ca^{2+}]_i$ step, particularly after small steps at low holding potentials. Coassembly of BK_{Ca} and Ca_V channels reduced the preonset delay. Whole-cell patch-clamp recordings suggested that in BK_{Ca}–Ca_V channel assemblies, depolarization serves chiefly to activate Ca^{2+} channels, and BK_{Ca} channels are gated by the resulting Ca^{2+} influx.



Onset of current through BK_{Ca} channels is delayed after $[Ca^{2+}]_i$ is stepped from 0 to 1 (blue), 3 (green), 10 (red), or 100 (black) μM. Arrowhead indicates the start of effective solution exchange. Horizontal scale, 1 ms; vertical scale, 0.2 nA. See the article by Berkefeld and Fakler for details.

Systems/Circuits

Chronic Stress Reduces Synchronous Oscillations in Hippocampus

Supriya Ghosh, T. Rao Laxmi, and Sumantra Chattarji

(see pages 7234–7244)

Chronic stress has opposite effects in the hippocampus and amygdala: it suppresses long-term potentiation (LTP) and causes retraction of dendritic spines in hippocampus, but enhances LTP and promotes dendritic growth in the amygdala. Although many connections exist between hippocampus and amygdala, interactions between these structures during stress are rarely examined. Therefore, Ghosh et al. recorded auditory evoked potentials (AEPs) in lateral amygdala (LA) and hippocampal CA1 and CA3 before and after daily exposure to restraint stress. Initially, stress increased AEP amplitude and the power of ~20–40 Hz oscillations in all three areas. But chronic stress diminished these effects in hippocampus. In addition, the auditory stimulus initially increased phase synchrony of oscillations between CA3 and CA1, but this increased synchrony was no longer induced after chronic stress. Finally, Granger causality analysis identified dominant directional coupling from CA3 to CA1 early in the experiment, but this coupling decreased after 10 stress episodes, while dominant directional coupling between LA and CA1 increased.

Behavioral/Cognitive

Honeybees Exhibit Contextual Learning

Syed Abid Hussaini and Randolf Menzel

(see pages 7154–7164)

In the simplest form of associative learning, animals learn that a specific cue indicates that reward or punishment is impending. In more complex tasks, animals learn contextual cues that serve as "occasion setters," that is, cue A precedes reward only in context X. More complex still is the transwitching task, in which stimulus A predicts reward only in context X and stimulus B predicts reward only in context Y. Restrained honeybees exhibit simple associative learning: they learn to extend their proboscis when presented with an odor that predicts delivery of sucrose solution. Hussaini and Menzel report that honeybees can also learn contextual cues. Approximately 35% of bees learned to respond to a rewarded odor only in the appropriate context of color or temperature; ~47% responded appropriately when both color and temperature defined the context. Few bees learned the transwitching task, however. Both odors and contexts altered firing of mushroom body extrinsic neurons, but in opposite directions: rewarded odors reduced, whereas rewarded contexts increased neuron firing.

Neurobiology of Disease

Selective Activation Remains a Challenge for Retinal Prostheses

Lauren H. Jepson, Paweł Hottowy, Keith Mathieson, Deborah E. Gunning, Władysław Dąbrowski, et al.

(see pages 7194–7205)

Blindness often results from photoreceptor loss without loss of retinal ganglion cells (RGCs). In such cases, some visual function could be restored by stimulating RGCs with epiretinal prostheses. A major challenge for developing such prostheses is achieving single-cell selectivity of stimulation. This is paramount, because functionally distinct RGCs with different response properties and projection targets are intermingled in the retina. To investigate the feasibility of stimulating single RGCs, Jepson et al. examined responses of the five main RGC types in isolated primate retina using high-density multielectrode arrays. The electrical activation thresholds were similar for all RGC types, and the charge density required generally fell within safe limits for both electrodes and tissue. Approximately 50% of midget cells could be activated without activating other RGCs in the preparation. In the remainder, untargeted cells—including some with distant somata—were activated, often via axonal stimulation. Axons of unrecorded cells may have likewise been activated. Therefore, single-cell spatial resolution remains a challenge for retinal prosthesis design.