Making sense

Sensory Transduction

by Gordon L Fain

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Reviewed by Jonathan Ashmore

What you know about this page so far has come to you through your senses. Batteries of sensory cells—and not just in your eye—have been used to ensure that you, gentle reader, are still reading and not mopping up coffee that you have just spilled down your front. Understanding the processes whereby physical stimuli, light, mechanical displacements, odor and taste chemicals, and so on are converted into codes for the nervous system is what studies of the physiology of sensation are all about. The surprise is that, until recently, many of the cellular mechanisms have been opaque to nonspecialists and specialist researchers alike.

Sensory Transduction concentrates firmly on how sensory receptor cells work. Gordon Fain, one of the central players in the unraveling of phototransduction, takes the position that we have now, thanks to some genetics, molecular biology and cell physiology, 'cracked the problem'. His strategy, unashamedly, is to describe cellular mechanisms of transduction, emphasizing a molecular unity and how this links to other branches of neuroscience. The central claim, and it is a remarkable one, is that we know in outline how sensation occurs in all the major senses of the body and that this is one of the great achievements of physiology and neuroscience in the twentieth century.

It does not take much to realize that, in our anthropocentric way, we know more about transduction in vertebrate systems than in invertebrates. *Sensory Transduction* does attempt to redress this imbalance. The kinds of senses possessed by bacteria or unicellular organisms inspire a sort of astonishment that so much can be packed into so little. Here we can learn about chemotaxis by way of introducing smell, or about the literature of fly gustation as an introduction to our sense of taste. The approach is pursued with a light touch (no joke). The book can be read by anyone with a basic knowledge of neuroscience along with a smattering of electrophysiology and molecular biology. The membrane biophysics that you need (or knew and have forgotten) is supplied engagingly in an early chapter. The combination provides a simple way of making you a connoisseur of biological engineering in vertebrate and invertebrate systems.

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There have been key stages in unlocking many of the transduction mechanisms described here. The discovery, by patch recording, in the mid-1980s that rod membranes contained cyclic nucleotide-gated channels, and that the internal second messenger from the visual pigment was cGMP and not calcium (as was then widely believed), came as a great surprise. Understanding rods and cones also means knowing how currents circulate around the cells. The enabling technology there was learning how to suck a cell into, rather than onto, a pipette. Olfactory cells suddenly became objects of intense scrutiny when patching also showed cyclic nucleotide-gated channels on their cilia and molecular biological studies revealed a profusion of odor receptors. For hair cells in the ear, the enabling step may have come a little earlier when it became possible to deflect the sensory hair bundle of individual cells through piezoelectric manipulation (an approach now 'rebranded' as nanotechnology).

The book is a model of how to use simple, uncluttered diagrams. The minor quibbles hardly bear mentioning. Sensory hair cells do not all have kinocilia; they do not in the adult mammalian cochlea. Sentences such as "there are 12 million olfactory cells in a human but 4 billion in a German shepherd" tax those of us who do not know our dogs. It could also have been helpful to have had more about noise in sensory systems—which arises, for example, because light is made of discrete photons and odors of molecules, or because thermal fluctuations make molecules vibrate. The surprise is that most sensory receptors operate at the limits set by physical laws. Although many sensory systems have evolved to operate at these limits, it is often necessary to navigate through the detail to re-emphasize this important feature.

What emerges from *Sensory Transduction* is that there are still underexplored cellular mechanisms in the more 'exotic' senses (exotic to us, if not the animals concerned; consider electroreception or magnetoreception). The last few years have revealed the molecules for temperature sensing, and this is well described. But, although we know some of the key channels in touch sensation, there the detail still has to be filled in. At the core of our understanding of hearing and balance, despite the most strenuous efforts, the vertebrate hair cell transducer channel—the first step in mechanical displacement sensing—has stubbornly resisted identification. The reasons are not hard to identify. Hearing depends on relatively few transducing channels and hair cells. And the traditional assay, described in this book as cloning followed by functional expression, is a significantly harder proposition for fiddly mechano-sensing channels.

If you want to understand how different sensory cells work, this is a broad-ranging and accessible book. The delight is, for once, to find not just a cluster of chapters on the senses buried in a more general text but a book written by a single author, which makes it almost unique. Although it is directed probably at the graduate level or above, there is much that an undergraduate could take away from reading this volume, and it succeeds in summarizing the enormous strides of recent years. The book even starts with a Homeric maxim and dedication. (I do confess that I had to look that up.) But having got that far, you, too, will have to read the rest. ■