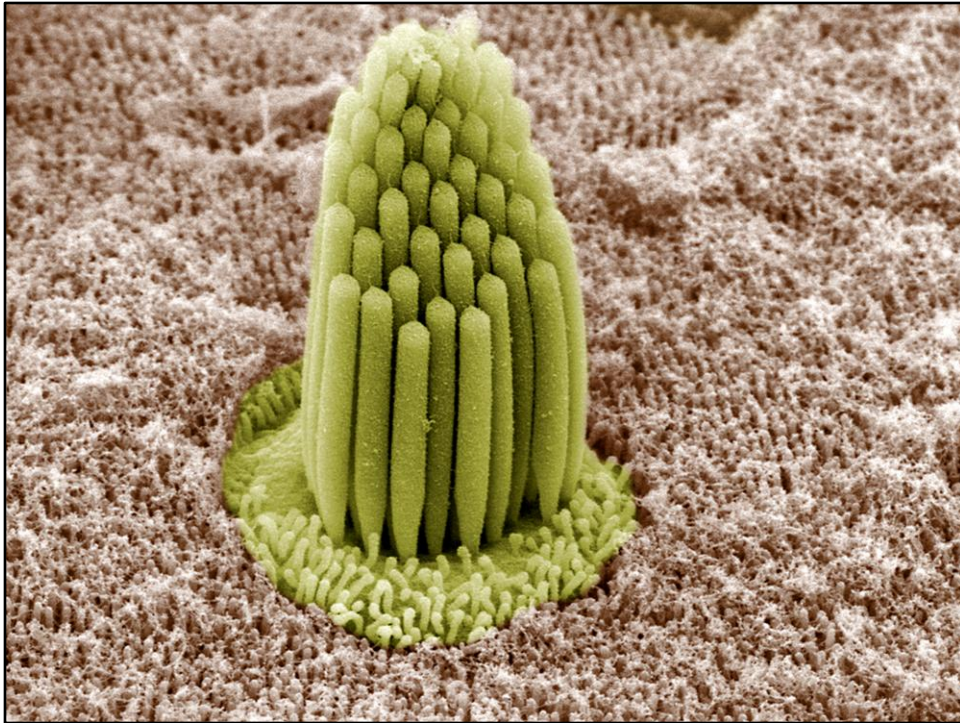


# Electron Microscope Images of Inner Ear

[http://www.cell.com/cell\\_picture\\_show-hearing?utm\\_source=ECE001&utm\\_campaign=&utm\\_content=&utm\\_medium=email&bid=8Z41P2F:LR484](http://www.cell.com/cell_picture_show-hearing?utm_source=ECE001&utm_campaign=&utm_content=&utm_medium=email&bid=8Z41P2F:LR484)

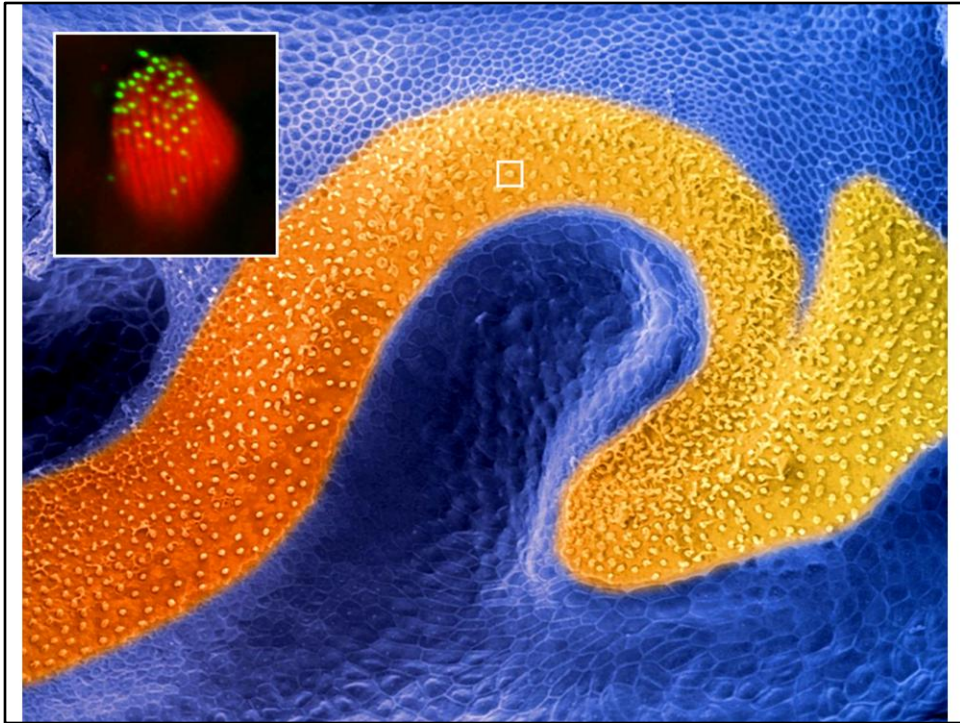


### **Stereocilia Stairsteps**

By Leonardo Andrade and Bechara Kachar, NIDCD/NIH

We can enjoy music and hear the city traffic because of clusters of specialized cilia (green) in the inner ear, called stereocilia. These actin-rich bundles protrude from the apical surface of hair cells lining the inner ear and vibrate in response to sound waves.

Image: Here, a single bundle of stereocilia projects from the epithelium of the papilla, a sensory patch in amphibian ears. A single stereocilia bundle, false-colored in green, emerges from the apical surface of an inner hair cell.



## Hearing Harmonies

By Cole Graydon and Bechara Kachar, NIDCD/NIH and Rachel Dumont and Peter Gillespie, Oregon Health and Science University (inset)

Auditory hair cells in the frog are arranged in tonotopic stripes along the papilla (orange), cells at the rostral, crooked end are sensitive to low frequencies (light orange) whereas those at the straighter end are responsive to higher frequencies (dark orange). Hair cells transduce sound-induced mechanical vibrations into changes in membrane potential when their hair bundles are deflected.

(Inset) Each hair bundle is composed of stereocilia (red), which are filled with polarized cables of actin and topped with a transduction apparatus, which contains the protein, harmonin (green).

Image: A scanning electron micrograph of the surface epithelium of the amphibian papilla false colored in Adobe Photoshop. (Inset) A confocal projection of bullfrog hair bundles, highlighting their actin rich nature (phalloidin staining, red) and the location of the harmonin protein (immunostaining, green).

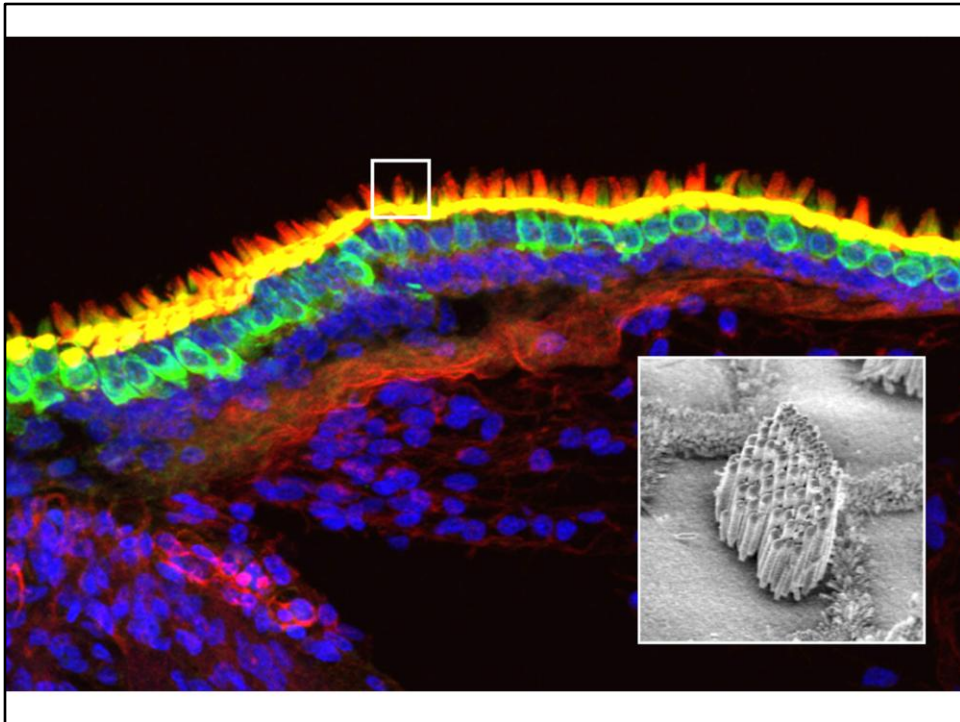


## How Flies Hear

By Yashoda Sharma, Sokol Todi, and Daniel Eberl, University of Iowa

Hearing in flies relies on the same basic principles used for sound perception in vertebrates: sensory neurons react to sound-wave induced vibrations, converting mechanical force into electrical signals. In flies, these neurons reside in a specialized stretch receptor in a fly's antenna, called the Johnston's Organ. The tip of each neuron is covered by an extracellular structure, called the dendritic cap (red), which helps to anchor the mechanosensitive ion channels in the appropriate location. Image: Cross-section views of a *Drosophila* antenna expressing GFP-NompA (green), a protein in the dendritic cap (red). (Left) Auto-fluorescence from the cuticle around the antennal segment outlines the antenna. (Right) The second antennal segment, which expresses GFP-NompA, was counterstained with Texas-Red-phalloidin to highlight actin (red) and ToPro to highlight nuclei (blue).





### **Capturing Clucks and Cock-a-doodle-does**

By Kateri Spinelli and Peter Gillespie, Oregon Health and Science University

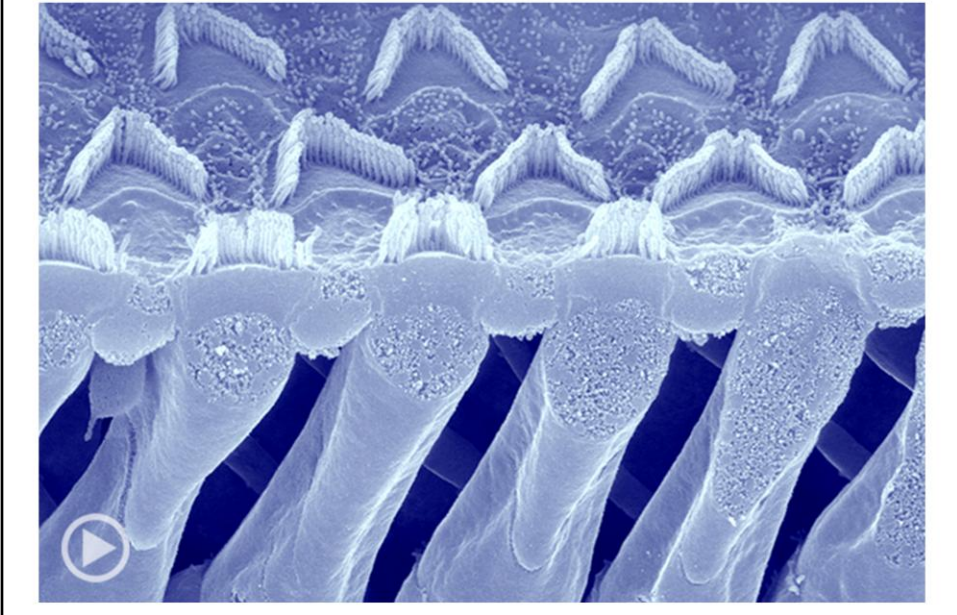
Transverse (left) and tangential (inset, lower right) views reveal the exquisite organization of the sensory epithelium that lines a chicken's inner ear.

(Left) Confocal micrograph illustrates how nuclei (blue) are densely packed in the sensory epithelium but more sparsely arranged in the basilar membrane. Hair bundle tufts are filled with actin cables (red) and anchored in the cuticular plate (yellow) at the apical surface of hair cells, which are outlined by an actin binding protein, myosin VI (green).

(Inset) A scanning electron micrograph zooms in on an array of hair bundles, each composed of characteristic "stair steps" of stereocilia.

Video Link:

[http://www.youtube.com/watch?v=MIYmeYmY0aY&feature=player\\_embedded](http://www.youtube.com/watch?v=MIYmeYmY0aY&feature=player_embedded)



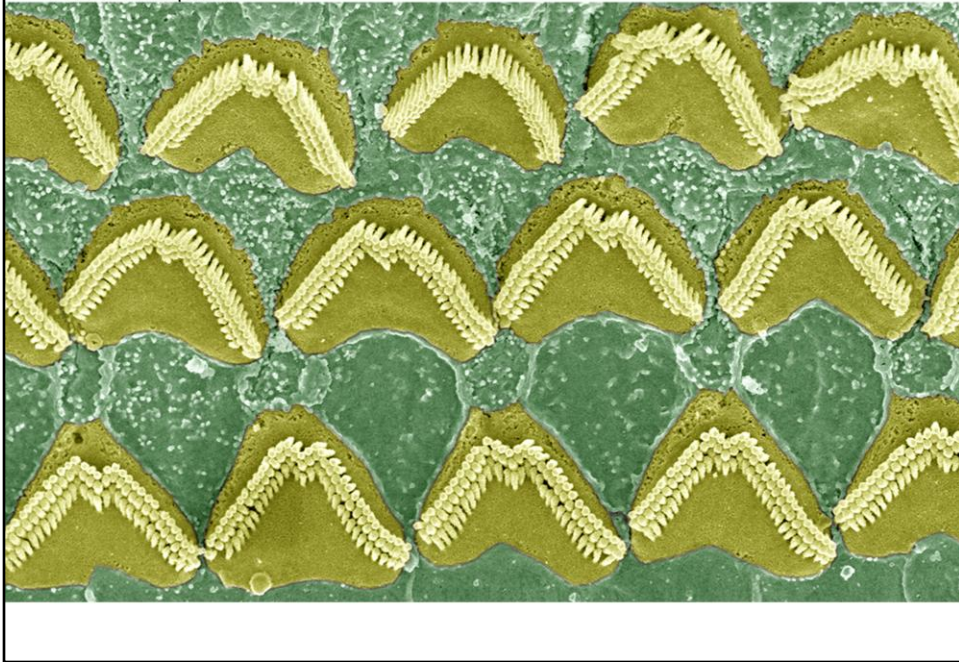
## Sound Sensitivity

By Federico Kalinec and Bechara Kachar, NIDCD/NIH

To perceive low intensity sounds, outer hair cells amplify vibrations by changing their shape in response to electrical stimulation. This ability, termed electromotility, is mediated by a transmembrane protein, prestin, that contracts in response to voltage changes. Together with the active motility of hair bundles, outer hair cell electromotility enables frequency selective amplification.

Image and Movie: Here the mammalian organ of Corti is imaged by scanning electron microscopy, showing hair bundles and outer hair cells. An isolated outer hair cell exhibits electromotility because of changes in intracellular potential controlled by the patch-clamp amplifier. The potential of the cell is held at -70 mV, and square depolarizing pulses of 60 mV amplitude are delivered at the rate of one per second (stimulation mark is on the bottom left of the frame). Depolarization produces contraction; hyperpolarization produces elongation. (See also Kalinec et al. 2002, Proc. Natl. Acad. Sci. USA 89:8671–8675 and Frolenkov GI et al., 1998, Mol Biol Cell. Aug;9(8):1961–8.).

Photo Description:

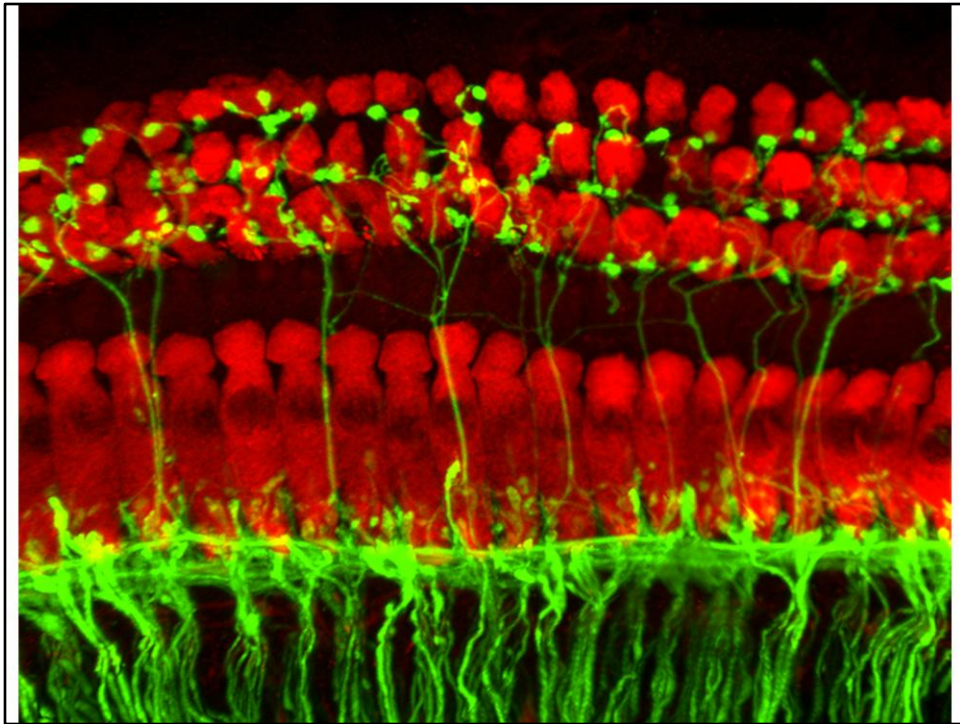


### **Planar Polarized Patterns**

By M'hamed Grati and Bechara Kachar NIDCD/NIH

Sensory hair cells and supporting cells form a well-defined planar polarized mosaic along the entire length of the sensory epithelium that lines the cochlea. The highly uniform orientation of the V or W-shaped stereocilia bundles is critical for effective mechanotransduction.

Image: Scanning electron micrograph of the surface of the mouse organ of Corti.



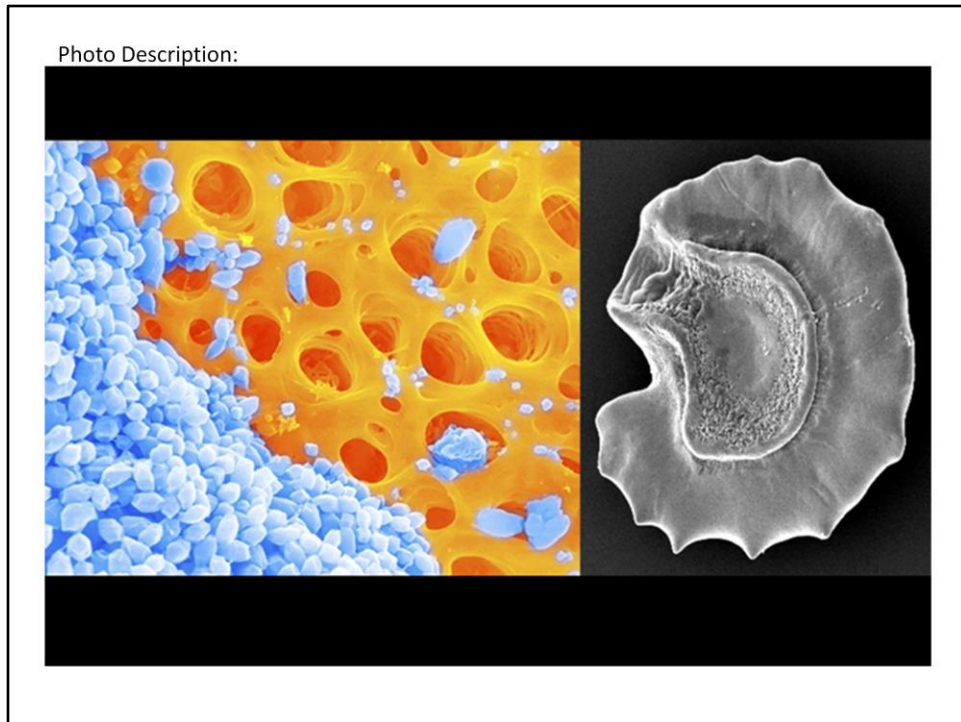
### **Sounding Out Synapses**

By Sonja Pyott, University of North Carolina, Wilmington

The brain receives information from the inner ear, converting the perception of sound into the sensation of hearing. Multiple nerve fibers (green) synapse on a single inner hair cell, relaying information about sound to the brain. Multiple outer hair cells are innervated by a single nerve fiber, receiving information from the brain via efferent synapses.

Image: A projection of confocal micrograph slices through the intact cochlear epithelium shows hair cells (red) labeled with an antibody for hair cell-specific myosin. Myelinated afferent and efferent fibers contacting inner and outer hair cells express YFP (green). Each hair cell is approximately 10  $\mu\text{m}$  wide.



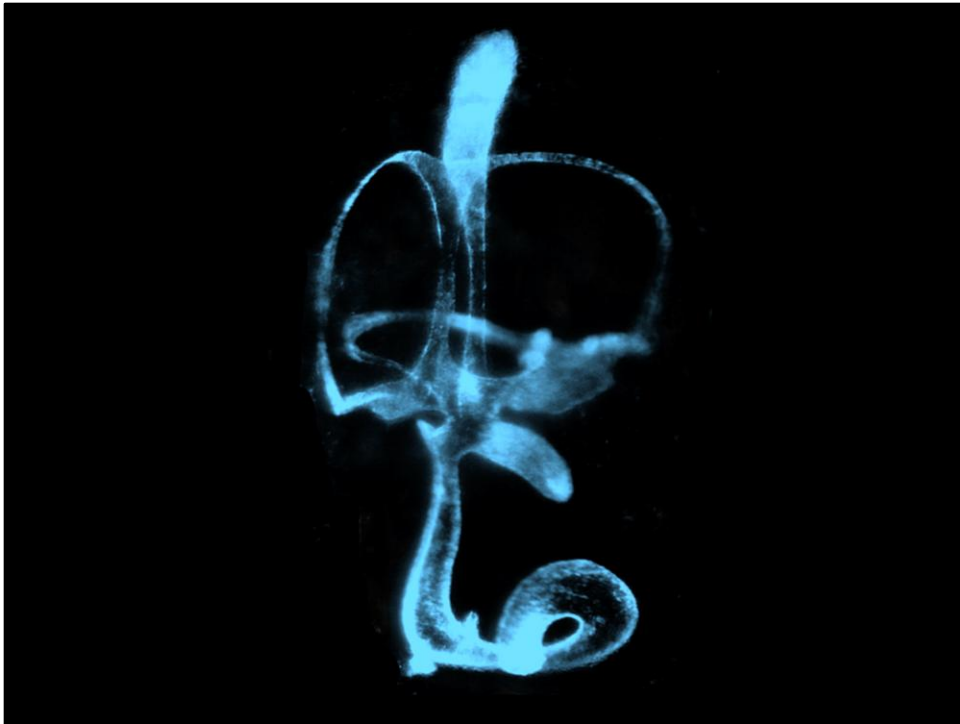


### Rockin' the Inner Ear

By Inna Belyantseva and Bechara Kachar, NIDCD/NIH and Leila Abbas and Tanya Whitfield, University of Sheffield, MRC

The inner ear doesn't just sense sound waves, it also helps us balance and orient ourselves in space (e.g., the vestibular senses). Otoconia (left) and Otoliths (right), are calcium carbonate-containing structures that sit on top of the sensory epithelia in the vestibular parts of the ear. These "ear rocks" are linked to the sensory epithelium by the otolithic membrane (gold), and this connection enables vestibular hair cells to sense gravity and acceleration. Malformation of these "ear rocks" or disruption of their connections to the sensory epithelium are associated with several forms of vestibular disorders including a common condition known as benign positional vertigo.

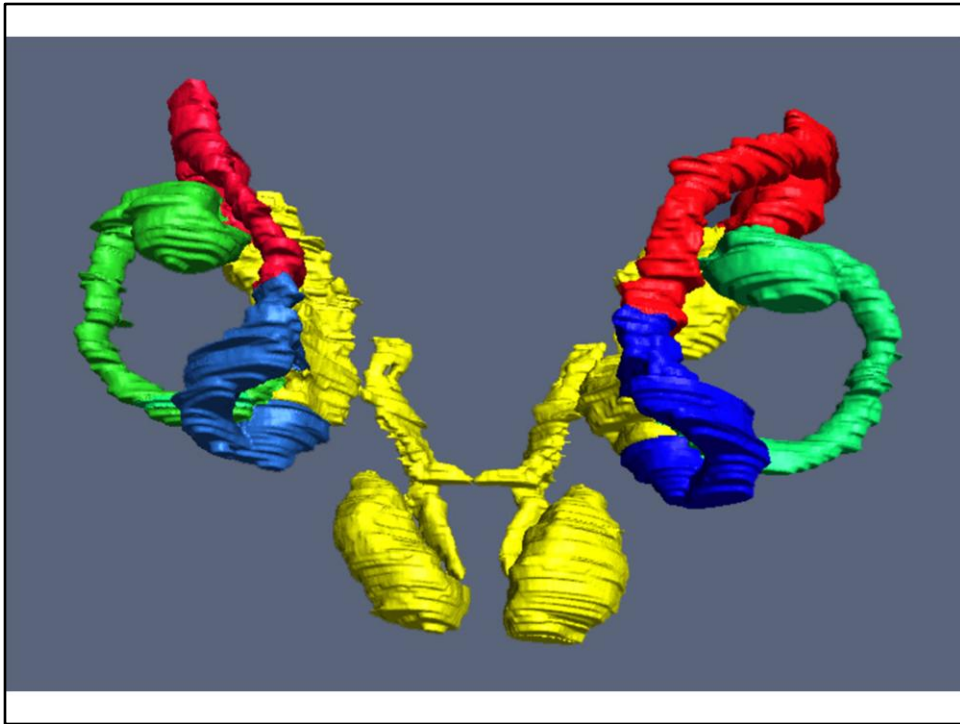
Image: (Left) Part of the apparatus in the inner that helps us balance is called the utricular macula from the mouse inner ear. On one side of the macula, the otoconia (blue) were removed to reveal the supporting otoconial membrane (gold). (Right) Scanning electron micrograph of the otolith that overlays the lagenar sensory patch inside the zebrafish inner ear.



### **Inner Ear Takes Shape**

By Martin Basch and Andy Groves, Baylor College of Medicine

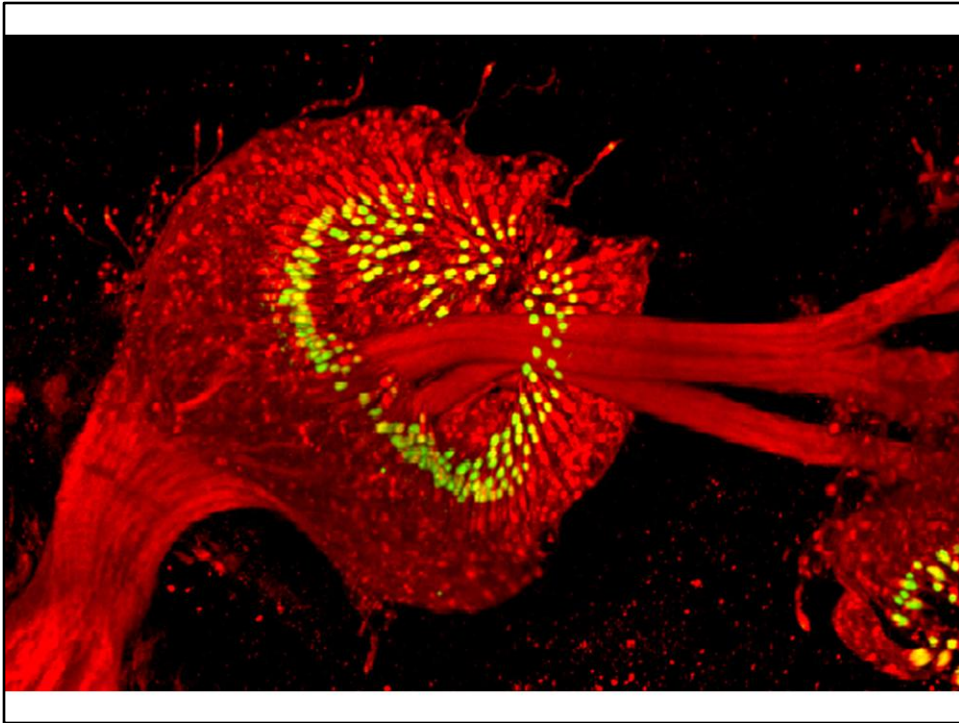
The inner ear is a complex structure that mediates both hearing and the vestibular senses. The spiral cochlea is responsible for detecting sound and the attached semicircular canals mediate balance and orientation. Here, the structure of a mouse's inner ear is revealed (age E13.5). It was first cleared in alcohol and methyl salicylate and then filled with white paint (falsed colored blue).



### **Ears Reconstructed**

By Katherine Hammond, Bill Chaudhry, and Tanya Whitfield, University of Sheffield, MRC

Similar to mammals, fish also rely on their ears for a sense of balance and orientation. The zebrafish inner ear detects rotational movement with three semicircular canals (anterior [red]; posterior [blue]; and lateral [green]). The other sensory chambers (yellow)—the utricle, saccule and lagena—detect gravity, acceleration and sound. This 3D model provides a dorsal view of both ears of an adult zebrafish.



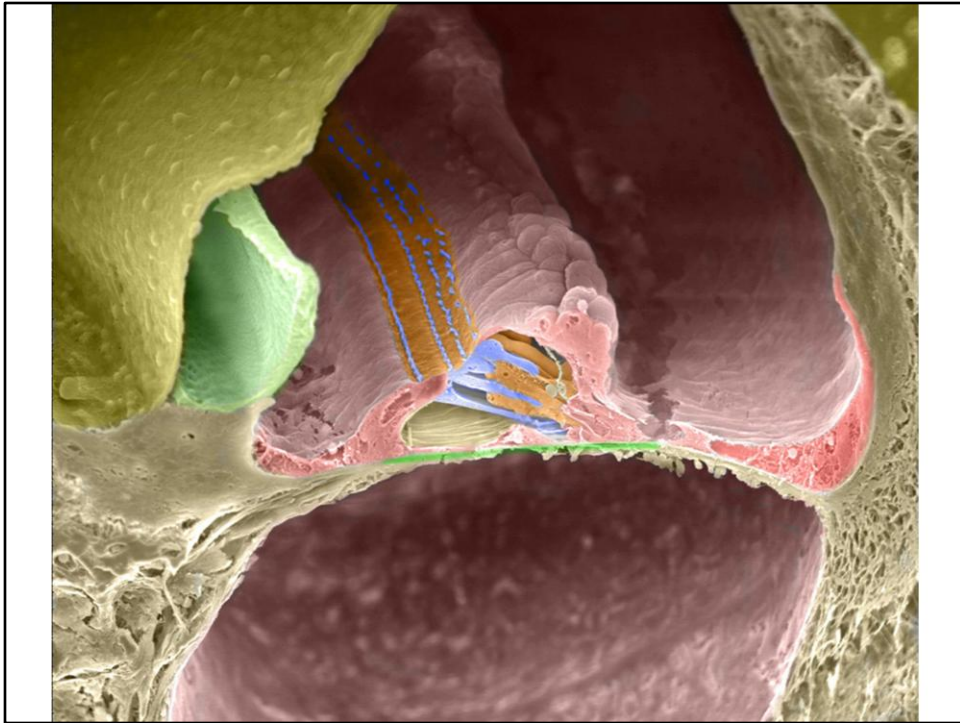
### **Neurons Know Noise**

By Tongchao Li, Hugo Bellen, and Andy Groves, Baylor College of Medicine

The *Drosophila* auditory organ (Johnston's organ) is located in the second antennal segment of the fly. It contains several hundred mechanosensory neurons with specialized dendrites arranged in sensory units known as scolopidia. The antennal nerve receives input from both the Johnston's organ and olfactory neurons. Here the axons of the olfactory neurons pass through a ring of scolopidia.

Image: A confocal reconstruction of the second antennal segment reveals neuronal connections within Johnston's organ. HRP staining highlights neurons (red) and immunostaining with an antibody to the Eyes Shut protein (green) highlights an extracellular structure surrounding the dendrites.



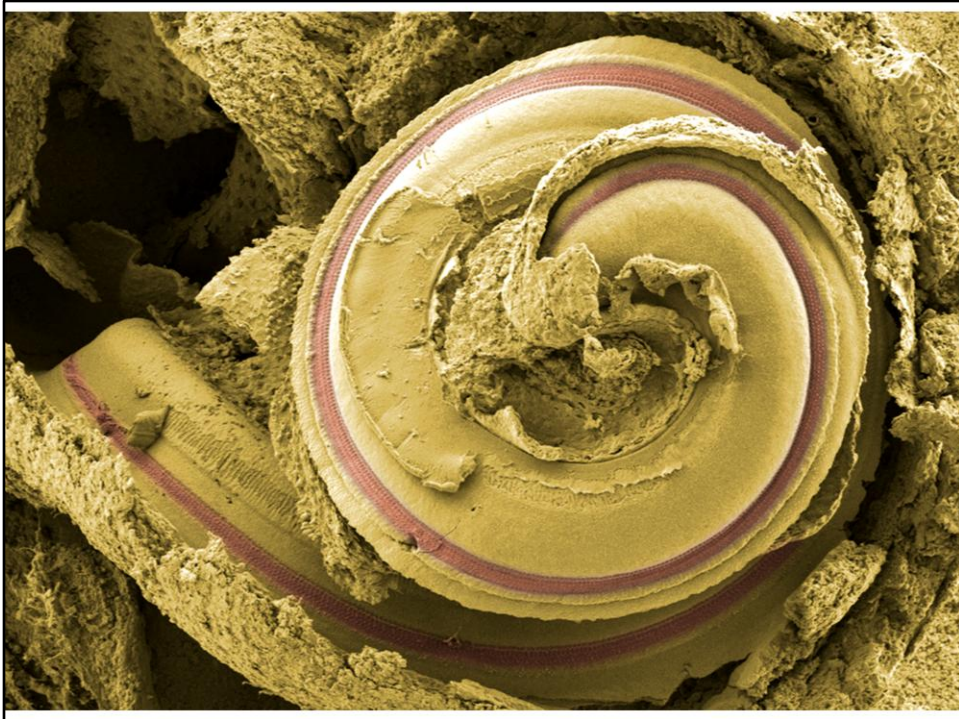


## Cochlear Canals

By Bechara Kachar, NIDCD/NIH

The mammalian hearing organ is built of mechanosensory hair cells (blue), supporting cells (pink), and highly specialized extracellular matrix structures (ECM, green). These components are housed within a fluid-filled spiral labyrinth known as the cochlea. Although all hair cells in the cochlea have similar organization and the same basic function, the broad range of sensitivity and exquisite frequency selectivity of each hair cell depends on its micromechanical properties and its relationship to the local architecture. The main inner ear ECM specializations are the tectorial and basilar membranes (green), which are above or below the sensory epithelium, respectively.

Image: A scanning electron micrograph of a cross-section through the cochlea, false colored to reveal the distinct functional units of the mammalian organ for hearing.



### **Spiraling Around Sound**

By M'hamed Grati and Bechara Kachar, NIDCD/NIH

The cochlea is a spiral-shaped tunnel in the bony labyrinth of the inner ear. Its principal component is a strip of sensory tissue (red) called the organ of Corti. The organ of Corti is lined with rows of auditory hair cells. Hair bundles that project from the hair cells are deflected in response to sound-induced vibrations in the basilar membrane. This bending opens mechanically gated ion channels, initiating the conversation of the sound-induced mechanical stimulus into an electrical transmission.