

New report bolsters theory on the ear's inner amplifier

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Two competing theories exist to explain how the human ear amplifies sound. Now, using ear hair cells from a bullfrog, scientists at Rockefeller provide evidence to bolster the theory they proposed in 1998.

Seven years ago, A. James Hudspeth, head of Rockefeller's Laboratory of Sensory Neuroscience, proposed a new theory for the workings of the inner ear. In research published last week in the online Early Edition of the Proceedings of the National Academy of Sciences, Hudspeth bolsters his theory by showing that tiny clusters of hairs on the cells of bullfrog ears generate precise amounts of force as they oscillate.

The human ear is a complex organ, made even more mysterious by the fact that — since its inner workings are so tiny and so inaccessible — it's nearly impossible for researchers to watch it in action. Only within the last 20 years have scientists even been able to confirm that it has its own built-in amplifier: the cochlea, a coiled tube in the inner ear. Inside the cochlea lies the basilar membrane, which is carpeted with thousands of tiny hair cells that vibrate in response to sound waves, magnifying noises.

Precisely how the hair cells do this, however, is debatable, and two competing theories exist. One proposes that the hair cells pump like pistons in response to vibration, strengthening the motion of the basilar membrane and creating the amplification effect. Hudspeth's theory, on the other hand, suggests that the hair cells themselves actively enhance the sound.

Each of these cells has a hair bundle, which consists of as many as 300 hair-like fibers, projecting from its tip. When the fibers — called stereocilia — bend in response to sound, the resulting tension unlocks ion channels, which open like little trap doors and allow potassium and calcium ions to flow into the cell. Hudspeth's theory suggests that once calcium enters the stereocilia, the trapdoor snaps shut again and the resulting force is what causes amplification.

In a quiet environment, hair cells spontaneously vibrate and emit sound — an action that indicates that something in the ear is, indeed, acting as an amplifier. Hudspeth, who is the F.M. Kirby Professor and also an investigator at the Howard Hughes Medical Institute, and his team examined individual hair bundles as they did this, using cells from a bullfrog that had been rigged to act as if they were still inside the frog. They then took “snapshot” measurements of the directional force acting on the bundles as they oscillated, and found that these measurements were consistent with Hudspeth's ion channel theory: The bundles showed distinct changes immediately before the ion channel opened, and immediately after it closed.

The researchers believe that this result may apply to mammalian hair cells, too. And the more scientists know about how the ear amplifies sound, the better they'll be able to understand what happens when people lose their hearing.

Source: Rockefeller University

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