Can you hear me now?

Test, test, one, two, three. Can you hear me now? Well you couldn't if you would not have my sisters and me. Let me introduce myself first. I'm an inner hair cell (IHC). I live with my sisters in your inner ear, a snail-like structure (Cochlea) in the temporal bone of your head. Better to say in a small part of that structure, the so-called Organ of Corti, the midsection of a three-level building which constitutes the whole inner ear. The top floor is called Scala vestibuli, the mid floor, where our office, the aforementioned Organ of Corti, lies, is called Scala media and the ground floor is named Scala tympani.

Architecturally speaking, our house is pretty weird, since top and ground floor are connected to each other and everything is flooded, even our floor. Physiologically speaking that's brilliant since sound travels much, much faster in fluids than in air. So when a sound is transmitted into the inner ear, the fluids and consequently the whole Organ of Corti start to move and a travelling wave forms. This wave shakes our carpet, the basilar membrane, on which we hair cells stand. But why is it called travelling wave? Remember I told you about the coiled structure of the inner ear? Let's pretend we'd unroll it. We would still have the three-level structure but nicely laid out. We, the inner hair cells stand in a single row next to each other spanning the whole distance from the basis (the bulgier part of the inner ear) to the apex (the tip). What I haven't told you before; we also have other sisters, the outer hair cells (OHCs), which outnumber us three-to-one. They span in three rows from basis to apex, too. And here's the trick: we all react best to different frequencies! Those of us who are placed at the basis swing in tune to high frequencies whereas those at the apex dance when they hear low frequencies. And the outer hair cells dance literally! They have a protein called prestin, which enables them to contract and amplify the motion of the basilar membrane. So the wave travels along the basilar membrane till it reaches its peak of amplitude in the place where the corresponding tuned outer hair cells reside. Thus these hair cells get shaken up pretty well and the motion of the fluid around them deflects their stereocilia, a hair-like structure on top of every hair cell (now you know where we got our name) and notably due to the deflection, they begin to dance and make us, the inner hear cells sway intensively with them.

But how do we tell your brain there is an incoming sound? That's the business of us inner hair cells. The deflection of our stereocilia opens ion channels in our cell membrane. Positively charged ions enter, our negative membrane potential diminishes and we depolarize. The change in potential is a trigger for us to release the neurotransmitter Glutamate, which binds to receptors in the spiral ganglion cells. This generates a postsynaptic potential at the contact point of a given cell and nerve cell, which is called synapse, that then is transformed to an action potential and send via the auditory nerve to the brainstem.

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Because we inner hair cells are so important we get an exclusive treatment by the spiral ganglion cells from the auditory nerve. Each one of them makes contact just with one of us, whereas we ourselves send our information to lot of them. The outer hair cells don't have that status. They make contact with only one cell, which of them connects with lots of the outer hair cells.

But because the OHCs play an important role in the gain and tuning of the signal we send to the brainstem and their fragile nature, handle them with care! Too much noise and poof! - they're gone. Then, all you hear is faint and fuzzy. Sounds awful, doesn't it?

Of course, there is help for those in need. Hearing aids are nowadays a quite common solution for people with damaged hair cells. Various models are available which can be worn behind the ear or directly in the ear canal but the basic working principle is always the same. Because they need higher volume for perception the incoming sound needs to be amplified. Every hearing aid consists of one or two microphones to record sound (two are better for spatial recognition), an amplifier and a speaker. They are constructed to suppress background noise and increase the desired frequencies, which are of course mostly those in the range of human voice.

If me and my sisters in the inner ear are already too much damaged to achieve good enough listening comprehension with a hearing aid, a Cochlear Implant (CI) may be the last choice. It consists of two parts, the outer part encompassing a microphone, speech processor and a transmitter. The implantable parts are a receiver and stimulator, which convert the signal into electrical impulses send to the electrodes which are directly inserted into the Cochlea (the snail-like structure I live in, you remember?). These electrodes then directly stimulate the acoustic nerve without the need of us.

Since we are one of the few cells in your body that don't regenerate once they're gone, the symptomatic approach of hearing aids or cochlear Implantation is the best shot so far to restore hearing. Of course the success depends on many other factors as age, time span between onset of deafness and implantation and so on. Causal therapies for hearing restoration like being able to regenerate us artificially unfortunately don't exist yet but since hearing disorders are such a common disease many laboratories (also in my favourite town of Wuerzburg) are working on solutions in this field.

I hope you understood my little excurse into the science of hearing, regarding the content as well as acoustically ;-).