



Hair Cells: Review, Regeneration and Protection

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Background

Inner and outer hair cells are highly specialised sensory (afferent) transducers residing within the Organ of Corti of each cochlea. Each Organ of Corti contains 10,000 to 12,000 outer hair cells (OHCs) and 3,000 to 4,000 inner hair cells (IHCs). IHCs are myelinated and are the “true” auditory receptors (NIH, 2005). Each IHC has its own auditory nerve fibre. Stereocilia converts IHC fluid-based energy into bioelectrical energy which is sent to the brain. OHCs are not myelinated and up to 20 OHCs may share a single auditory nerve fibre. OHCs amplify incoming sounds and provide “exquisite sensitivity” to increase frequency resolution in humans (see Henderson et al, 1994). OHCs are more susceptible to damage from noise exposure, acoustic trauma, ototoxic drugs and other insults and OHC damage is associated with elevated hearing thresholds, such as noise induced and presbycusis hearing loss. IHC damage is often associated with word recognition problems, secondary to degradation of the neural signal. In humans, when an IHC or OHC is damaged or dies, it is gone forever and the resultant hearing loss is permanent.

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Hair Cell Growth in Non-humans

Taleb, Faulkner and Cunningham (2006) reported that deletion of the retinoblastoma gene in very young mice allowed growth of an increased number of fully differentiated and functional inner ear hair cells. Taleb and Cunningham (2006) reported proliferative regeneration (cell division from which a daughter cell becomes a hair cell) and non-mitotic conversion (cell changes without cell division) as two mechanisms which facilitate hair cell regeneration in lab animals. Researchers at the Virginia Merrill Bloedel Hearing Research Center (VMBHRC, 2006) in Seattle, discovered auditory and vestibular hair cell regeneration in mature birds.

Protecting Hair Cells

Prevention of hair cell loss (through noise protection) is arguably the best defense against noise-induced hearing loss (NIHL). Insult to the ear via noise exposure releases free radicals in the inner ear, which damages hair cells (see CAOHC, 2003). However, glutathione (GSH, an antioxidant antagonistic to free radicals) appears to limit hair cell damage secondary to noise exposure in guinea pigs (Ohinata et al, 2000, also Ya-

masoba et al, 1998). Henderson et al (1997) reported that GSH was elevated in animals who underwent noise conditioning training and had achieved “acquired resistance to noise”. The researchers suggested that antioxidants are important in the prevention of NIHL and that pharmacological intervention may enhance prevention of NIHL. Researchers supported by NIDCD (2005) found that when antioxidants, aspirin and vitamin E were given to guinea pigs for up to three days following noise exposure, hearing loss, free radicals and hair cell damage were reduced.

Another fascinating avenue under exploration is the development of an antioxidant compound, taken orally, to prevent noise-induced hearing loss. The “Hearing Pill” has been explored by the United States Marine Corp (Boswell, 2004) and others. The primary compound within the pill is an amino acid (N-acetylcysteine) which facilitates the synthesis of antioxidants. It is too early to report conclusive results, but the Hearing Pill may prove to be a useful defense against noise induced hearing loss (Shafer, 2005).

Conclusion

As laboratories and scientists focus their energies on hair cell regeneration and hair cell protection, significant progress in non-humans has been demonstrated. At this time, the only proven option for humans is avoidance of, and protection from, prolonged and significant noise exposure. In the next few decades, there is an excellent opportunity for advances in pharmacological and biological sciences to potentially impact the preservation and regeneration of human hearing.

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References and Recommendations

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