Characterizing Auditory Neurons in the Cochlea

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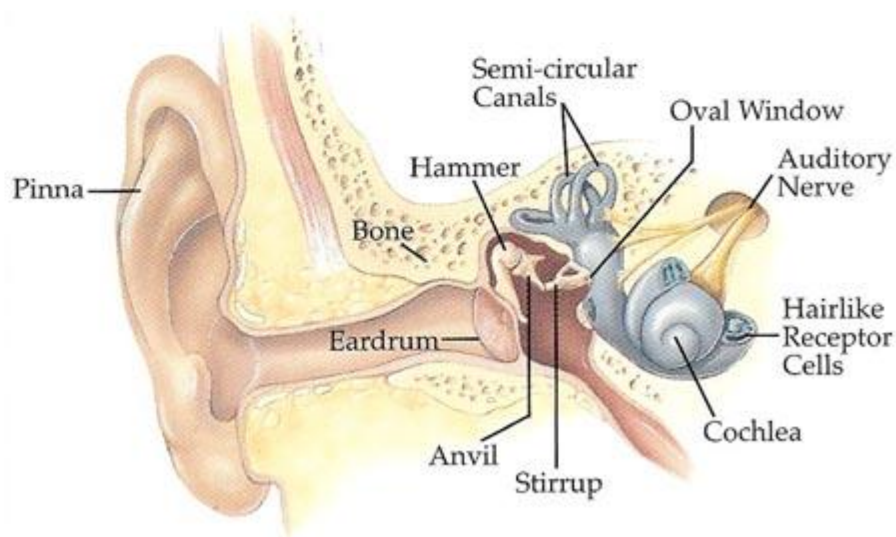
Background:

Hailing from San Jose, California, Saya Yusa is a senior at the University of Southern California, majoring in Biological Sciences. Saya aspires to attend medical school after possibly taking a year off to gain experience in the field of health policy, as she believes a proper understanding of health policy is required for effective practice of medicine. Her interest in providing healthcare to disadvantaged communities has driven her to participate in the Alternative Spring Break program, where she traveled to Baltimore to combat health disparities. During this trip, she volunteered within the Baltimore Medical System learning to confront the issues associated with health disparities. This experience motivated her to become even more involved with the organization, and she is now in charge of coordinating the Alternative Spring Break for the 2013 trip to Baltimore. She is also part of Global Medical Brigades, delivering health care and medicine to those in need. Outside of the realm of medicine, Saya is part of the Asian Pacific Islander California Action Network, where she works in public policy trying to install programs benefiting the community.

Since January 2012, Saya has been working under the instruction of Radha Kalluri of the otolaryngology department, a branch of medicine that focuses on the diagnosis and treatment of disorders of the head and neck, and plans to stay there until she graduates. Initially, the opportunity to get hands on experience drove her to the position, and she is now in charge of her own project. This position allowed her the independence to lead her own experiment, and it has provided her with a plethora of challenges and responsibility. She also was interested in the subject of neurology, which is closely related. After months of mastering the lab techniques required for the experiment, her experiment is now in the stages of collecting data in hopes of proving her hypothesis.

The inner ear, the cochlea:

Saya's research focuses on the cochlea and the neurons responsible for transmitting sound to the brain. The cochlea is a portion of the inner ear. As sound enters the ear, it first enters the outer portion, which collects sound energy and directs it to the eardrum, causing it to vibrate. The vibrations from the eardrum set the ossicles into motion. The ossicles are three bones: the malleus (hammer), incus (anvil) and stapes (stirrup). Amplification of sound is perpetuated by these bones. The sound waves enter into the cochlea located in the inner ear, which is filled with fluid that moves in response to the vibrations from the ossicles. As the fluid moves, the tectroial membrane pushes down on cilia located on hair cells. This results in a change in the hair cells, which convert that motion to electrical signals that are communicated via neurotransmitters to thousands of nerve cells. Transformation of the vibrations into electrical impulses allows the signal travel to the brain and causes the brain to transform these signals into sound.



Connecting hearing loss to neurons in the cochlea:
Saya is attempting to prove her hypothesis that the different characteristics of high intensity sound neurons are already differentiated at birth. These low and high intensity sound neurons are responsible for transferring signals to the brain, resulting in hearing.
High intensity sound neurons are associated with loud sounds and low intensity neurons are associated with quiet sounds. Characterization of neurons is important because high intensity neurons are known to die faster, causing deafness. Further understanding of these neurons could result in prevention of their death which could be an important step in trying to prevent hearing loss.

To test her hypothesis, Saya examines the cochlea of rats. The cochlea is removed by dissection from the rest of the body so it can be examined with protein staining. This is done under IACUC protocol to treat the rats in the most ethical way possible. Three groups of rats are tested: p2, p3, and p4. These represent the numbers of days after the prenatal date. At this point, the rats cannot hear, thus marking the ideal dates to test the cochlea. If the neurons are already differentiated at this point in their life, it means that they are not affected by environmental factors. After removing the cochlea, immunohistochemistry and labeling is used to visualize proteins, which are then seen under a confocal microscope. From protein size, Saya is able to distinguish if the neurons are already differentiated. CtBP2 and GluR2/3 are the specific proteins being analyzed by evaluating their location and size. GluR4 is also stained for further identification.

The size and location of CtBP2, GluR2/3 and GluR4 are used to identify if the neurons are differentiated, as low intensity neurons and high intensity neurons have different protein characteristics (figure 2).

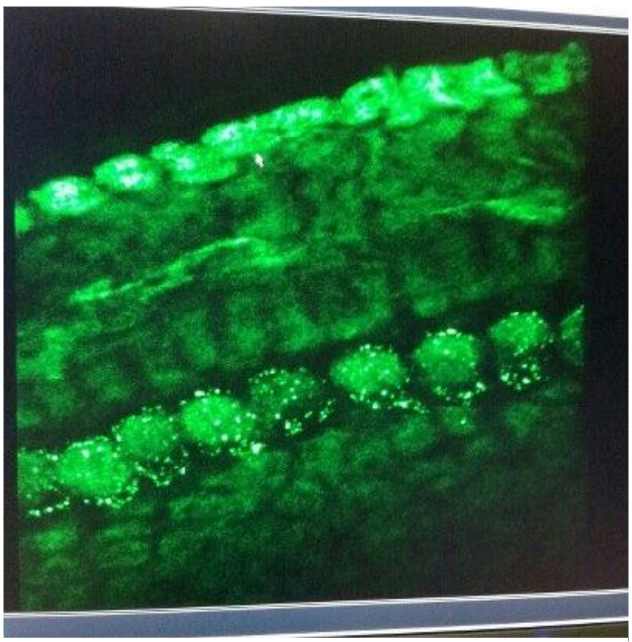


Figure 1: Confocal microscope slide showing protein staining in cochlea analyzed by Saya

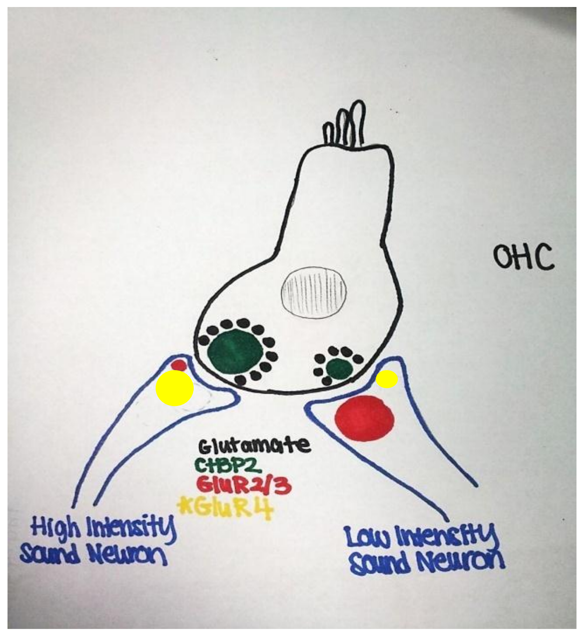


Figure 2: Diagram of sound neurons, showing distinct protein characteristics when differentiated

Conclusion:

Saya's research can be applied to humans to see how low intensity and high intensity sound neurons function and what causes their death. Prevention of their death could also be a potential research topic in the future in order to delay or eliminate hearing loss.
Overexposure to intense sound can cause temporary or permanent hearing loss. Sharon Kujawa and M. Charles Liberman (2009) previously showed that acoustic overexposures causing moderate threshold elevation leave cochlear sensory cells undamaged, but can cause serious loss of afferent nerve terminals and delayed degeneration of the cochlear nerve. Dr. Kujawa and Dr.

Liberman’s study suggest that noise-induced damage to the ear has progressive, widespread consequences.

Primary neurodegeneration results in difficulty hearing in noisy environments, and could contribute to tinnitus, hyperacusis, and other anomalies associated with inner ear damage. Differentiation of these sound neurons could potentially lead to a groundbreaking way of preventing damage from happening and a full understanding of the functions of each neuron. This is a very relevant issue facing us today as over 48 million people in the US alone suffer from hearing loss. Saya’s work could contribute the elimination of this problem.

Work Cited:

Kujawa SG, Liberman MC (2009) Adding insult to injury: cochlear nerve degeneration after “temporary” noise-induced hearing loss. J Neuroscience 29: 14077–14085.