Imaging the inner ear promises to be new gold standard for hearing researchers

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Credit: Canadian Light Source

Her interest in providing people who suffer from sensorineural hearing loss with a richer music-listening experience has led a young Harvard researcher to the Canadian Light Source (CLS) and to a discovery that opens the door to exciting new avenues for the study and diagnosis of human inner ear diseases.

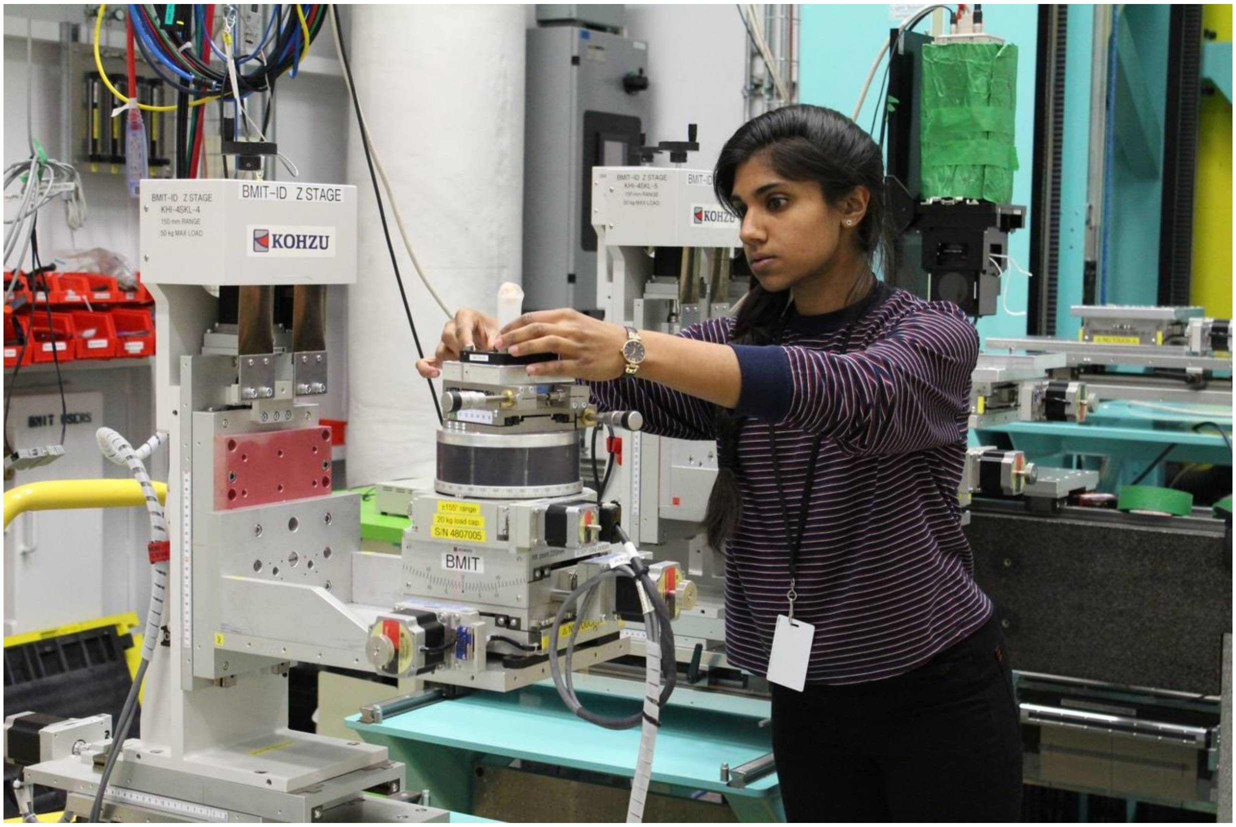
"Hearing loss is such a widespread problem and my hope is that our work will eventually help us better diagnose and treat it. People are just not aware of how sensitive the auditory system is to trauma, and how isolating and depressing it can be to lose one's ability to communicate fluidly with others," says Janani Iyer, a Ph.D. candidate in the Harvard-MIT Speech and Hearing Bioscience and Technology program.

A musician herself, Iyer came to Saskatoon to tackle the problem of how to create detailed images of the delicate structures that allow humans to hear.

"Part of what drew me to this is that, despite its prevalence, hearing loss is incredibly understudied and incredibly underfunded," she said.

Building on previous work done at the CLS, Iyer was looking for a technology "that would resolve the mosaic of cells that allow us to hear through their bony protective shell."

Iyer's work focuses on the cochlea, the part of the inner ear that looks like a snail shell. The cochlea's role is to receive sounds in the form of vibrations and convert them into nerve impulses that can be interpreted by the brain.



Jan Iyer, a PhD student at Harvard University, places a specimen on the sample stage of the beamline. Credit: Canadian Light Source

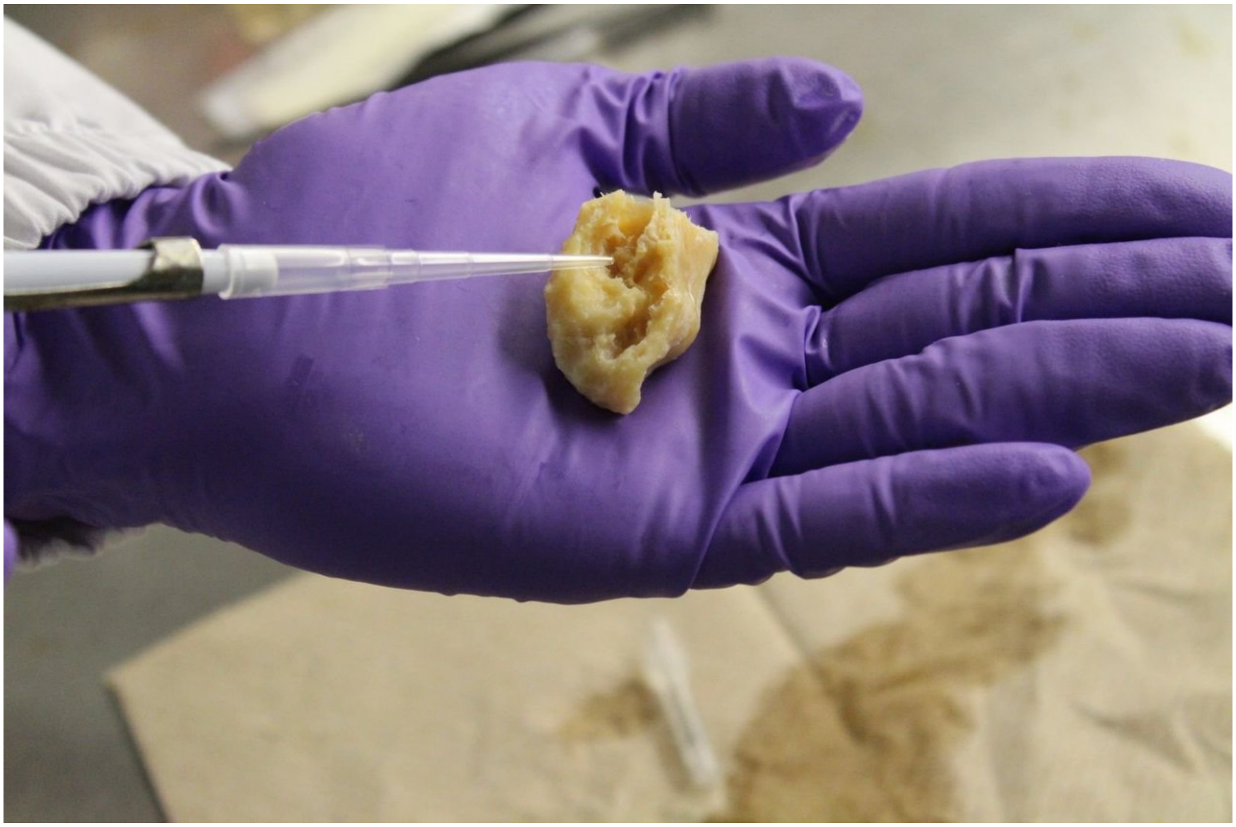
Sensorineural hearing loss, which is caused by damage to sensory cells and nerve fibers in the cochlea, is incredibly prevalent, verging on what Iyer terms an epidemic. About 466 million people, including 34 million children, around the world suffer from it, and there is no cure.

The challenge with understanding the structure and function of the cochlea, and what can go wrong, is its inaccessibility—the tiny organ, only millimeters in size, is very fragile, is located close to the brain and is nestled in the temporal region of the skull, containing the densest bone in the human body.

For the past 125 years, the best way to visualize the pathologies that cause sensorineural hearing loss in humans was through post-mortem examination of thin slices of the cochlea (animal models serve as the only alternative). Even modern imaging technologies, including CT scans and MRIs, are insufficient because they cannot penetrate the bone adequately.

At the CLS, Iyer and her colleagues are showing that synchrotron light produces the kind of high-quality images needed to distinguish between healthy and damaged sensory cells and nerve fibers without having to remove the cochlea from the temporal bone. Their results were published in the August edition of the journal *Biomedical Optics Express*.

"The method of imaging and analysis described here has the potential to revolutionize and accelerate the study and diagnosis of human inner ear pathologies, as it promises to replace traditional histologic sectioning and staining as the gold standard method for human organ of Corti evaluation and disease diagnosis," wrote Iyer in the research paper.



Inside this specimen of human temporal bone is the cochlea still intact. The imaging techniques Iyer uses will produce images inside the bone without damaging it or the cochlea. Credit: Canadian Light Source

The level of radiation needed for her CLS study is far too high to use in living humans "but our goal is always ultimately to help people, and we are highly optimistic about the future potential of this work."

Iyer said creating a version of the synchrotron imaging technology that can be used in a clinical setting is years away, but is promising. In the meantime, she believes a better understanding of what happens within the inner ear in patients with inner ear diseases such as sensorineural hearing loss, tinnitus, and Ménière's disease is key to raising awareness about the risks of exposure to loud sounds, and to incorporating safety precautions within public policy.

"The cochlea's structures are extremely fragile and easily damaged—listening to extremely loud music through headphones or speakers is horrible for your hearing," she said, adding that hearing loss could also be caused by certain drugs administered to treat other conditions (e.g. aminoglycoside antibiotics or certain diuretics) or genetic mutations.

"Being able to see with cellular-level resolution what specifically is causing a patient to lose their hearing will certainly help us provide personalized diagnosis and therapy recommendations."

Iyer continues her research and plans to return to the CLS to refine the process of imaging the inner ear through bone.

More information: Janani S. Iyer et al. Visualizing the 3D cytoarchitecture of the human cochlea in an intact temporal bone using synchrotron radiation phase contrast imaging, *Biomedical Optics Express* (2018). DOI: 10.1364/BOE.9.003757

Provided by Canadian Light Source

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