



the REGISTRY

Newsletter of the NIDCD National Temporal Bone, Hearing and Balance Pathology Resource Registry

CONTENTS

SCIENTIFIC ARTICLE:

Anatomic studies of the Human Cochlea: Implications for Cochlear Implantation 1

News & Announcements..... 5

LAB SPOTLIGHT:

Human Ear Research Laboratory — Barany Laboratory, Uppsala, Sweden..... 6

Order form for Temporal Bone Brochures 8

ॐ ॐ ॐ ॐ ॐ ॐ ॐ

The REGISTRY is published semiannually by the NIDCD National Temporal Bone, Hearing and Balance Pathology Resource Registry. The Registry was established in 1992 by the National Institute on Deafness and Other Communication Disorders (NIDCD) of the National Institutes of Health to continue and expand upon the former National Temporal Bone Banks (NTBB) Program. The Registry promotes research on hearing and balance disorders and serves as a resource for the public and the scientific community about research on the pathology of the human auditory and vestibular systems.

Anatomic Studies of the Human Cochlea: Implications for Cochlear Implantation

Elsa Erixon, Wei Liu and Helge Rask-Andersen

Department of Otorhinolaryngology and Diagnostic Radiology, University of Uppsala, Sweden

Siebenmann made corrosion casts of the human labyrinth using Woods metal and described its beautiful anatomy over one hundred years ago¹. Despite many anatomical studies of the human cochlea, there are few reports describing its anatomical variations. Such data are of value in cochlear implantation (CI). Cochlear implant electrodes on the market are designed either for a position along the inner modiolar wall (so-called peri-modiolar) or along the outer wall of scala tympani. Anatomic variations of the cochlea may influence its final position relative to the cochlea place/frequency map and final pitch discrimination. With less invasive surgical techniques and shorter electrodes, the fragile inner ear structures may also be conserved^{2,3}. Preservation of residual hearing is now a goal in all cochlear implant surgery and better knowledge about anatomical variation may limit intra-cochlear damage.

Our collection of plastic human inner ear molds contains 325 specimens (Fig.1). These molds were made from unselected human temporal bones removed at autopsy. The applied method of casting temporal bone specimens was described by Wilbrand et al.⁶ and Rask-Andersen et al.⁷. Bone specimens are macerated using potassium hydroxide, boiling, hydrogen peroxide, and trypsin. The specimens are placed in a wax form, with orifices of the



Fig. 1. Uppsala collection of 325 plastic molds of the human inner ear.

the REGISTRY

DIRECTORS

Joseph B. Nadol, Jr., M.D.
Saumil N. Merchant, M.D.
Steven D. Rauch, M.D.
Michael J. McKenna, M.D.
Joe C. Adams, Ph.D.

SCIENTIFIC ADVISORY COUNCIL

Newton J. Coker, M.D.
Howard W. Francis, M.D.
Marlan R. Hansen, M.D.
Raul Hinojosa, M.D.
Akira Ishiyama, M.D.
Herman A. Jenkins, M.D.
Elizabeth M. Keithley, Ph.D.
Robert I. Kohut, M.D.
Fred H. Linthicum, Jr., M.D.
Saumil N. Merchant, M.D.
Joseph B. Nadol, Jr., M.D.
Michael M. Paparella, M.D.
Jai H. Ryu, Ph.D.
Isamu Sando, M.D., D.M.Sc.
P. Ashley Wackym, M.D.
Charles G. Wright, Ph.D.

COORDINATOR

Nicole Pelletier

ADMINISTRATIVE STAFF

Kristen Kirk
Tammi N. King
Jon Pack

NEWSLETTER EDITORS

General: Nicole Pelletier
Medical: Saumil N. Merchant, M.D.

NIDCD National Temporal Bone,
Hearing and Balance Pathology
Resource Registry
Massachusetts Eye and Ear Infirmary
243 Charles Street
Boston, MA 02114
(800) 822-1327 TOLL-FREE VOICE
(617) 573-3711 VOICE
(617) 573-3838 FAX
EMAIL: tbregistry@meei.harvard.edu
WEB: www.tbregistry.org

inner ear canals left open. The casting material, a polyester resin or a silicone rubber material, is poured into the wax form. The specimens are placed in a low-pressure chamber for penetration into the multiple bony channels of the macerated bones. After hardening, bone is dissolved with hydrochloric acid. The inner ear structures are freed with a fine forceps in the case of the polyester preparations or with scissors in the case of the silicone material. The silicone and polyester resin material has a shrinkage factor of 0.6 to 1%. Several studies have been made here in Uppsala using this material by Dimopoulos and Muren⁴ and Wadin⁵.

Measurement Procedure

Photographs are taken of each mold in different positions and width, length, and height of different turns is measured⁸. Relevant anatomic variations such as unusual coiling patterns and asymmetries of individual turns that may influence the introduction of a CI electrode array can be appreciated. Computer-aided planimetry is performed and a ruler is used which is connected to a computer. We use the midpoint of the long diameter of the round window as a reference and starting point for measuring the length of the cochlea. A line is drawn through the central axis of the cochlea to a distant point of the first turn. A line is drawn at right angles to this line through the axis of the cochlea, dividing each turn of the cochlea into quadrants (Fig. 2). Quadrants 1 to 4 constitute the first turn; 5 to 8, the second; and 9 to 12, the third turn. The outer wall length of each quadrant is calculated. Error of measurement was estimated to be approximately 0.08 mm.

Results and Discussion

Each human cochlea was found to be individually shaped, with large variations of the dimensions and coiling characteristics in different cochleae⁸. The estimated mean number of turns of the human cochlea was found to be 2.6 with a range from 2.2 to 2.9 (929 degrees; range, 774-1037 degrees). The number of quadrants varied from slightly

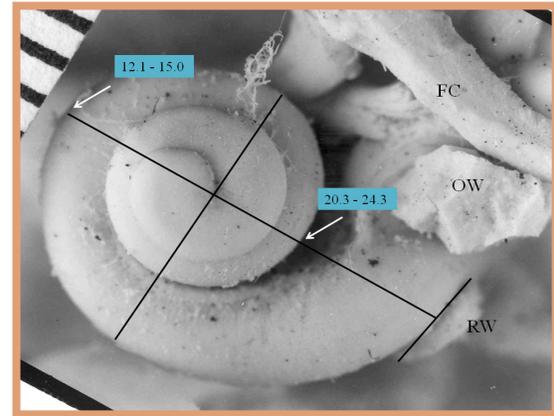


Fig. 2. Corrosion cast of a left human cochlea (axial-pyramidal view). The reference points used for estimating the length of the various turns of the cochlea are shown. RW, round window. OW, oval window. FC, facial canal.

more than 8 to 12.

The outer cochlear wall length ranged from 38.6 to 45.6 mm, with a mean length of 42.0 mm. Maximal radius of the round window (half diameter of round window) was estimated to be 1.1 mm, with a range from 0.3 to 1.6 mm. The mean length of the first turn (quadrants 1-4) was 22.6 mm, with a range from 20.3 to 24.3 mm, representing 53% of the total length (Fig. 3). The mean length of the turns are shown in the accompanying table. The mean height (diameter) of the cochlea was 3.9 mm, with a range from 3.3 to 4.8 mm. The internal diameter of the first turn varied broadly (1.6-2.6 mm). The mean width of the cochlea (first turn) was 6.8 mm with a range from 5.6 to 8.2 mm. The shape of the first turn of the cochlea seemed to be influenced by the coiling pattern. There were different positions of the central axis of the individual turns. Therefore, other authors have used different reference points⁸.

An unforeseen outcome was the individual design and proportions of the human cochlea. These variations should be taken into account when performing surgery on the cochlea because they may not always be comprehended from a preoperative CT scan as performed routinely. Unusual anatomy such as tilting or misalignment of

Outer wall length (mm)	Mean	Range	SD	n
Half diameter of the RW	1.1	0.3-1.6	0.21	65
First half of first turn	13.5	12.1-15.0	0.73	67
First turn (quadrant 1-4)	22.6	20.3-24.3	0.83	65
Second turn (quadrant 5-8)	12.4	10.7-13.3	0.63	63
Third turn (quadrant 9 to 11(12))	6.1	1.5-8.2	1.40	58
Total length*	42.0	38.6-45.6	1.96	58

SD indicates standard deviation, n, number of specimens; RW, round window. *The total length of the outer wall excluding the basal half of the RW.

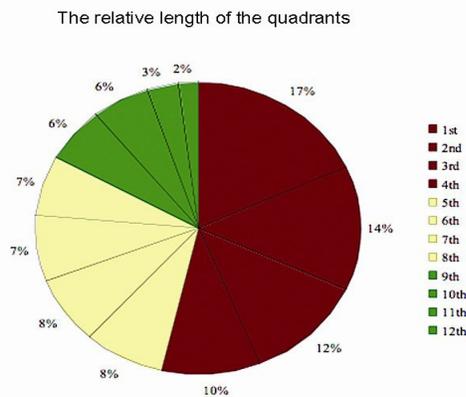
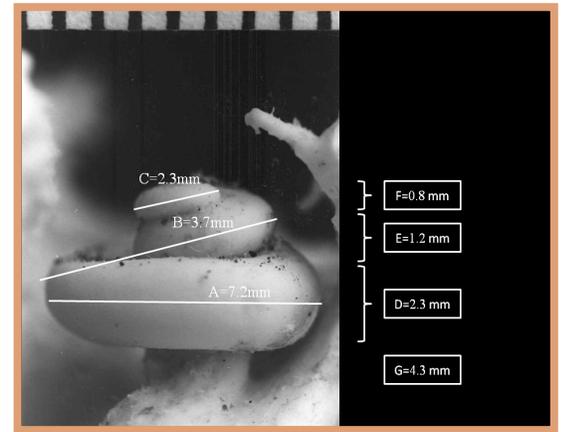


Fig. 3. Diagram showing relative lengths of various quadrants of the human cochlea.

the first and second turns may account for difficulties for the electrode to glide upward and reach the second turn (Fig. 4). The width of the various turns differed greatly between individuals, and the cochlear height varied as much as 1.5 mm, representing one-third of the total height. There was also abrupt turning of the cochlea near the carotid area. In some instances, the carotid canal impinged on the anterior cochlear wall. This condition will influence the force generated by the tip of the electrode on the lateral wall when gliding up the first turn. The estimated mean number of turns of the human cochlea is in accordance with Hardy, who measured the organ of Corti on histological sections. The number of quadrants was in accordance with Kawano et al.⁹ who investigated 6 human temporal bones and performed sectioning and computer-aided 3-dimensional (3-D) reconstructions. They found the number of turns on average to be 2.69, with a range from 2.63 to 3. Cochleae with up to 3 turns were also described by Tian et al.¹⁰

Kawano et al. estimated outer wall length to be 40.81 mm,

Fig. 4. Plastic mold of a human cochlea demonstrating the height of the second turns.



which coincides with our data, wherein we also found individual differences of up to 7 mm. We calculated the length of the bony outer wall of the human cochlea, which is longer than the estimated length of the organ of Corti. The latter corresponds to the extension of the basilar membrane, which is generally around 34 mm. Our estimated values of the width and height of the first turn are in accordance with those reported by Dimopoulos and Muren⁴. Stakhovskaya et al.¹¹ presented measurements of cochlear width ranging from 6.9 to 8.2 mm, which is slightly more than we found as well as those obtained by Escudé et al.¹².

Analyses of the molds also confirmed the short distance between the upper first turn of the cochlea and the first (labyrinthine) portion of the facial nerve canal (Fig. 5). In one specimen, there was virtually no distance between the two structures, indicating that the neural fascicles of the facial nerve were almost in direct contact with the cochlear soft tissue. This may explain the facial nerve excitation or twitching when stimulating certain electrodes in this region, especially in patients with extensive cochlear otospongiosis or Paget's disease.

An electrode runs considerably higher up into the cochlea if placed near the modiolus than along the outer wall because of the relatively large diameter of the first turn and small dimensions of the modiolus in the second and third turns. Rosenthal's canal is well defined only in the first turn of the cochlea. Thus, neurons innervating hair cells in the basal turn coincide fairly well with the location of corresponding hair cells, whereas more apically, neurons merge into a less well-defined canal with less obvious and precise place/frequency alignment. Neurons innervating hair cells in the third turn are located more basally (Ariyasu et al.¹³). It is valuable to estimate the mean outer wall length of the first turn for patients undergoing CI surgery with combined acoustic and electric hearing¹⁴.



Fig 5. Corrosion cast of a left human inner ear showing the extension of one turn. Arrow shows distance between the labyrinthine portion of the facial nerve canal and the upper basal part of the cochlea. Sometimes this distance is very small which can explain electric stimulation of the facial nerve in some patients with CI.

An electrode around 21mm will extend one turn if placed laterally. The variable dimensions suggest that place/frequency maps will vary considerably between individuals, especially in the apical portion that is spatially compressed relative to the base¹⁵. Maximum insertion depth angle as defined by Xu et al.¹⁶ may be a better reference for the position of CI electrodes because it will not be influenced by the distance of the array to the modiolus.

The large variations in cochlear anatomy may question the use of a standard electrode with a fixed shape and favor the idea of using individual- or custom-shaped electrodes. When performing CI surgery for combined acoustic and electric hearing, it is necessary to consider the multiple anatomic variations. Despite attempts to preserve hearing after CI, a small group of patients appear to lose their residual hearing and become dependent on their implant. Although shallow insertion reduces the risk of damage to apical cochlear structures, a deep insertion of the array may improve CI performance in case residual hearing is lost. A radiological method to preoperatively predict the required insertion depth to achieve a 360-degree insertion is therefore of value^{14,17}. Although not all factors leading to hearing loss after electrode insertion are known to date, the extensive anatomic variations of this fascinating construction most likely play one important role.

Address for correspondence:

Rask-Andersen Helge M.D, Ph.D.

Department of Otolaryngology – Head and Neck Surgery

Dept of ORL, Uppsala University Hospital, 751 85 Sweden

Email: helge.rask-andersen@akademiska.se

References

1. Siebenmann F. Die Korrosionsanatomie des knöchernen Labyrinthes des menschlichen Ohres. Wiesbaden, Germany: C. F. Bergmann, 1890.
2. von Ilberg C, Kiefer J, Tillein J, Pfennigdorff T, Hartmann R, Stürzebecher E, Klinke R. Electricacoustic stimulation of the auditory system. New technology for severe hearing loss. *ORL J Otorhinolaryngol Relat Spec* 1999;61:334–340.
3. Kiefer J, Tillein J, von Ilberg C, Pfennigdorff T, Stürzebecher E, Klinke R, Gstoettner W. Fundamental aspects and first results of the clinical application of combined electric and acoustic stimulation of the auditory system. In: Kubo, Takahashi Y, Iwaki T, editors. *Cochlear Implants: An Update*. The Hague, Kugler: 2002, p. 569-576.
4. Dimopoulos P, Muren C. Anatomic variations of the cochlea and relations to other temporal bone structures. *Acta Radiologica* 1990;31:439-444.
5. Wadin K. Radioanatomy of the high jugular fossa and the labyrinthine portion of the facial canal. A radioanatomic and clinical investigation. *Acta Radiol Suppl* 1988;372:29-52.
6. Wilbrand HF, Rask-Andersen H, Gilstring D. The vestibular aqueduct and the para-vestibular canal. An anatomic and roentgenologic investigation. *Acta Radiologica Diagnosis* 1974;15:337-355.
7. Rask-Andersen H, Stahle J, Wilbrand H. Human cochlear aqueduct and its accessory canals. *Annals Otol Rhinol and Laryngol* 1977. Suppl 42, vol. 86, no.5, part 2.
8. Erixon E, Hogstorp H, Wadin K, Rask-Andersen H. Variational anatomy of the human cochlea: implications for cochlear implantation. *Otol Neurotol* 2009;30:14-22.
9. Kawano A, Seldon HL, Clark GM. Computer-aided three-dimensional reconstruction in human cochlear maps: measurement of the lengths of organ of Corti, outer wall, inner wall, and Rosenthal's canal. *Ann Otol Rhinol Laryngol* 1996;105:701-709.
10. Tian Q, Linthicum FH Jr, Fayad JN. Human cochleae with three turns: an unreported malformation. *Laryngoscope* 2006;116:800-803.
11. Stakhovskaya O, Sridhar D, Bonham BH, Leake PA. Frequency map for the human cochlear spiral ganglion: implications for cochlear implants. *J Assoc Res Otolaryngol* 2007;8:220-233.
12. Escudé B, James C, Deguine O, Cochard N, Eter E, Fraysse B. The size of the cochlea and predictions of insertion depth angles for cochlear implant electrodes. *Audiol Neurotol* 2006;11:27-33.
13. Ariyasu L, Galey F, Hilsinger R, et al. Computer-generated three dimensional reconstruction of the cochlea. *Otolaryngol Head Neck Surg* 1989;100:87-91.
14. Adunka O, Unkelbach MH, Mack MG, Radloff A, Gstoettner W. Predicting basal cochlear length for electric-acoustic stimulation. *Arch Otolaryngol Head Neck Surg* 2005;131:488-492.
15. Başkent D, Shannon RV. Interactions between cochlear implant electrode insertion depth and frequency-place mapping. *J Acoust Soc Am*. 2005;117:1405-1416.
16. Xu J, Xu SA, Cohen LT, Clark GM. Cochlear view: postoperative radiography for cochlear implantation. *Am J Otol* 2000;21:49-56.
17. Gstoettner WK, Helbig S, Maier N, Kiefer J, Radloff A, Adunka OF. Ipsilateral electric acoustic stimulation of the auditory system: results of long-term hearing preservation. *Audiol Neurotol* 2006;11:49-56.

MEETINGS

THE REGISTRY IS PLANNING TO
EXHIBIT AT:



OTOPATHOLOGY MINI-TRAVEL FELLOWSHIP PROGRAM

The NIDCD National Temporal Bone Registry is pleased to announce the availability of mini-travel fellowships. The fellowships provide travel funds for research technicians and young investigators to visit a temporal bone laboratory for a brief educational visit, lasting approximately one week. *The emphasis is on the training of research assistants, technicians and junior faculty.* The fellowships are available to:

- 1) U.S. hospital departments who aspire to start a new temporal bone laboratory
- 2) Inactive U.S. temporal bone laboratories that wish to reactivate their collections or
- 3) Active U.S. temporal bone laboratories that wish to learn new research techniques

Up to two fellowship awards will be made each year (\$1,000 per fellowship). The funds may be used to defray travel and lodging expenses. Applications will be decided on merit. Interested applicants should submit the following:

- 1) A 1-2 page outline of the educational or training aspect of the proposed fellowship
- 2) Applicant's curriculum vitae
- 3) Letter of support from temporal bone laboratory director or department chairman
- 4) Letter from the host temporal bone laboratory, indicating willingness to receive the traveling fellow

Applications should be sent to:

Saumil N. Merchant, M.D.
NIDCD National Temporal Bone Registry
Massachusetts Eye and Ear Infirmary
243 Charles Street
Boston, MA 02114

LAB SPOTLIGHT

Human Ear Research Laboratory – Barany Laboratory

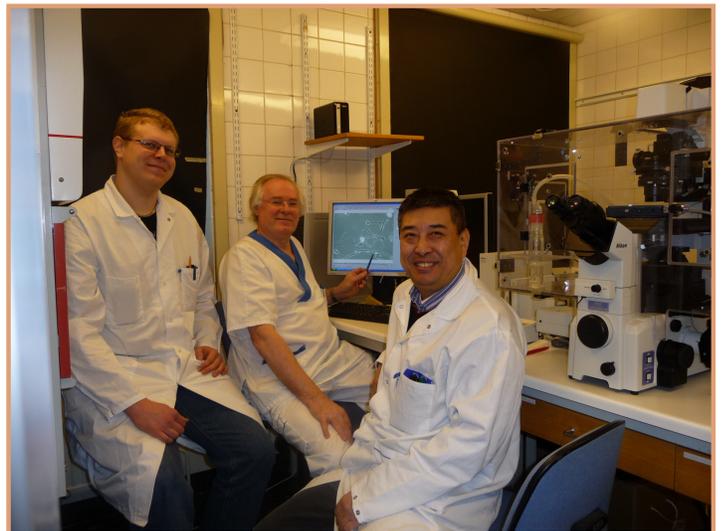
Department of Otolaryngology – Head and Neck Surgery
Uppsala University Hospital
Uppsala, Sweden

by Helge Rask-Andersen MD, PhD

Nobel Prize winner Robert Barany was the first Professor at the Dept. of Otorhinolaryngology (ORL) in Uppsala (1926-1936). He was awarded the prize in 1914 for his discovery of the caloric response, but due to the First World War he collected it in 1915 in Stockholm, and chose thereafter to stay in Uppsala. He was an ingenious scientist who combined clinical observation with physiological thinking. His work laid the foundation for future vestibular research in Uppsala that included Olof Nylen, Arne Sjöberg and Jan Stahle. Olof Nylen designed the first microscope for use in ear surgery.

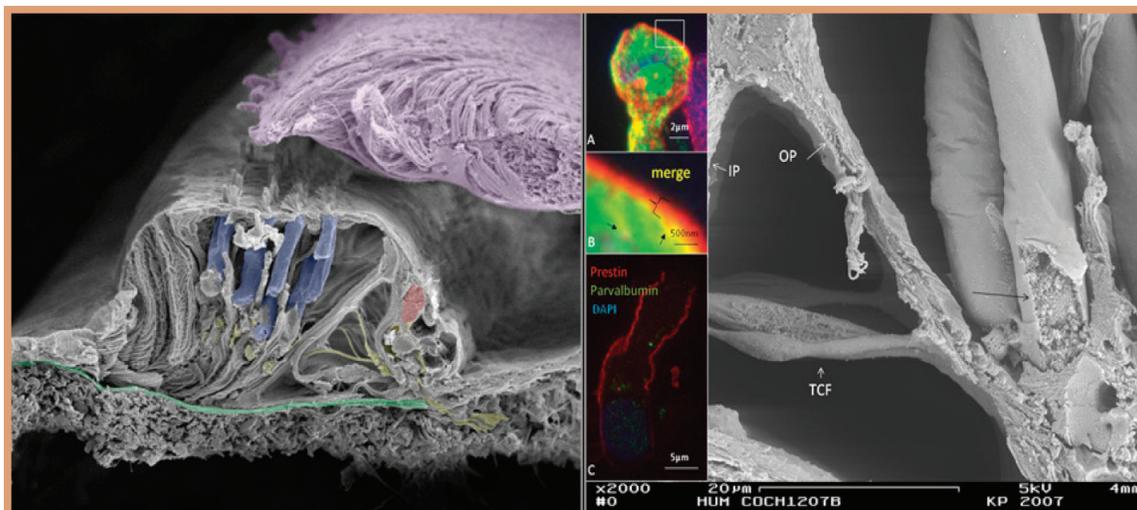
It was under Professor Hans Engström (1968-1979) that Uppsala Clinic started to perform cellular inner ear research. Engström was an outstanding electron microscopist. He came from Karolinska Institute where he had worked under the famous anatomist Fritiof Sjöstrand; a pioneer in electron microscopy (Afzelius Björn. Sjöstrand FS. Memories, the development of Scandinavian electron microscopy. *J Submicr Cytol Pathol.* 2001;33:363-417). During its golden age (1951-1955) he developed a technique to cut thin sections using razor blades (Schick!) that were polished with a particular diamond powder using a glass plate inspected with epimicroscopy. Hans Engström was the first in the field of inner ear electron microscopy and was joined by Jan Wersäll, later chairman of the Dept. of ORL at Karolinska Hospital in Stockholm. Hans Engström brought his daughter Berit Engström into the field (today, a medical audiologist); also an excellent electron microscopist. Their beautiful studies of the organ of Corti are still classic.

Inner ear research continued under Jan Stahle's chairmanship. He devoted his clinical career to problems around Meniere's disease. Under his and Herrman Wilbrand's (Professor in Otoradiology) guidance, the idea was developed to create a collection of human inner ear molds and dissections. The initiative was to delineate the miniscule structures of the human inner ear such as the vestibular and cochlear aqueducts and to observe their role in Meniere's disease. These small canals were also associated with accessory canals housing blood vessels that were believed to play important roles for the turnover of inner ear fluid. Herrman Wilbrand had a deep interest in temporal bone anatomy and its radiological appearance and used polytomography before the era of modern CT. Our collaboration resulted in radio-anatomic correlations and new techniques to cast human inner ears using methacrylate and silicone with a low shrinkage factor. A collection was built with 325 corrosion casts performed by several collaborators at the Dept of Radiology. These casts are now at the Medical-History Museum and Dept. of ORL, and used for research and teaching. Little did we then understand the remarkable evolution of ORL with cochlear implants and auditory brainstem implants, and other bionic systems. Our collection can be used to understand the individual biological variations important for inner ear surgeons. Today, our research focuses on cell culture, structural analyses and proteomics of the human ear. We rely on animal data, as well as fresh human tissue obtained at surgery; the latter is scarce, which limits the investigations.



Left to right: Fredrik Edin, Prof. Helge Rask-Andersen and Prof. Wei Liu

Recent studies have revealed (and perhaps a bit surprising) differences in molecular expression between animal and human material, which motivates some caution in generally extrapolating animal data to human. This seems particularly relevant for the auditory nervous system.



Scanning electron micrograph (SEM) of human cochlea and prestin immunolocalization. Specimen was directly fixed for SEM after removal at surgery. Surgery by Anders Kinnefors, Dept. ORL Uppsala. Microdissection by author. Labeling and SEM performed by author with Professor Kristian Pfaller, Innsbruck. Photoshop colorization (left image) by Rudolf Glueckert, Innsbruck. Inner hair cell (right image) and confocal microscopy (middle) by Professor Wei Liu, Dept. ORL Uppsala. *(Surgical specimen was obtained during transotic skull base surgery for life-threatening petro-clival meningioma where inner ear was removed instead of drilled away. Ethical and informed consents were obtained from the patient and study was performed in accordance with the Helsinki declaration).*

Selected Publications from Uppsala Human Ear Research Laboratory Dept ORL, Uppsala University Hospital, Uppsala, Sweden

1. Barany R. Untersuchungen iiber den vom Vestibularapparat des Ohres reflektorisch ausgelosten rhythmischen Nystagmus und seine Begleiterscheinungen. Monatsschr Ohrenheilkd 1906;40:193-297.
2. Barany R. Nobel-Vortrag. Nord Tidskr Oto-rhino-laryngol. 1916;74:157-74.
3. Stahle J. Electronystagmography in the caloric test. Acta SOC Med Upsal. 1956;61:307-32.
4. Stahle J. Robert Barany-ingenuous scientist and farseeing physician. In: Graham MD, Kemink JL, eds. The vestibular system. Neurophysiologic and clinical research. New York: Raven Press, 1987:17-25.
5. Carl-Olof Nylen. The Otomicroscope and Microsurgery 1921-1971. Acta Otolaryngol. 1972;73:453-454.
6. Nylen CO. An oto-microscope. Acta Otolaryngol. 1923;5:414-417.
7. Nylen CO. The new oto-laryngological department of the University Hospital, Uppsala, Sweden. Acta Otolaryngol. 1950; Suppl 87:1-16.
8. Stahle J. Endolymphatic hydrops-fiftieth anniversary. Acta Otolaryngol. 1989;468:11-16.
9. Angelborg C, Hulterantz E, Ågerup B: The cochlear blood flow. Acta Otolaryngol. 1977;83:92-97.
10. Rask-Andersen H, Stahle J. Immunodefence of the inner ear? Lymphocyte-macrophage interaction in the endolymphatic sac. Acta Otolaryngol. 1980;89:283-94.
11. Engström,H, Ades HW, Hawkins JE, Jr. Structure and Functions of the Sensory Hairs of the Inner Ear. J Acoust Soc Am. 1962;34:1356-1363.
12. Rask-Andersen H, Boström M, Gerdin B, Kinnefors A, Nyberg G, Engstrand T, Miller JM, Lindholm D. Regeneration of human auditory nerve; in vitro/ in video demonstration of neural progenitor cells in adult human and guinea pig spiral ganglion. Hear Res. 2005;203:180-91.
13. Hirt B, Penkova ZH, Eckard A, Liu W, Rask-Andersen H, Müller, Löwenheim H. The subcellular distribution of aquaporin 5 in the cochlea reveals a water shunt at the perilymph-endolymph barrier. Neuroscience. 2010;168:957-970.
14. Boström M, Khalifa S, Boström M, Liu, W, Friberg U, Rask-Andersen H. Effects of neurotrophic factors on growth and glia cell alignment of cultured adult spiral ganglion cells. Audiol Neurotol 2010;15:175-186.
15. Liu W, Boström M, Kinnefors A, Rask-Andersen H. Unique expression of connexins in the human cochlea. Hear Res. 2009;250:55-62.
16. Stjærnschantz J, Wentzel P, Rask-Andersen H. Localization of prostanoid receptors and cyclo-oxygenase enzymes in guinea pig and human cochlea. Hear Res. 2004;197:65-73.
17. Knutsson J, von Unge M, Rask-Andersen H. Localization of progenitor/stem cell in the human tympanic membrane. Audiol Neurotol. 2010;16:263-269.
18. H. Rask-Andersen, A. Kinnefors, R.-B. Illing. On a novel type of neuron with proposed mechanoreceptor function in the human round window membrane; an immunohistochemical study. Rev Laryngol Otol Rhinol. 1999;120:203-207.



**NIDCD National Temporal Bone, Hearing & Balance
Pathology Resource Registry**
Massachusetts Eye and Ear Infirmary
243 Charles Street
Boston, MA 02114-3096

NON-PROFIT ORG
U.S. POSTAGE
PAID
BOSTON, MA
PERMIT NO. 53825

Address Service Requested

FREE BROCHURES FOR YOUR OFFICE OR CLINIC ABOUT TEMPORAL BONE RESEARCH AND DONATION

That Others May Hear is a short brochure that briefly describes the functions of the Registry, and answers commonly asked questions regarding the temporal bone donation process. (Dimensions: 9" x 4")

The Gift of Hearing and Balance: Learning about Temporal Bone Donation is a 16-page, full-color booklet which describes in more detail the benefits of temporal bone research. It also answers commonly asked questions regarding the temporal bone donation process. (Dimensions: 7" x 10")

If you are willing to display either or both of these brochures, please complete the form below and return it to the Registry by mail or fax. The brochures will be sent to you **free of charge**. Please circle the amount requested for each brochure or write in amount not listed.

That Others May Hear _____ **25 50 100**

The Gift of Hearing and Balance _____ **25 50 100**

NAME: _____

ADDRESS: _____

ADDRESS: _____

CITY, STATE, ZIP: _____

TELEPHONE: _____

Mail or fax this form to the Registry at: **NIDCD National Temporal Bone, Hearing and Balance Pathology Resource Registry**,
Massachusetts Eye and Ear Infirmary, 243 Charles Street, Boston, MA 02114

Toll-free phone: (800) 822-1327, Fax: (617) 573-3838, Email: tbregistry@meei.harvard.edu