



the REGISTRY

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

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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.

DOWNLOADABLE 3-D VIRTUAL MODELS OF THE HUMAN TEMPORAL BONE

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Introduction

The human temporal bone contains a large number of complex structures within a small space. It can be challenging for students in the basic science or medical disciplines to learn this complex anatomy. Traditional methods of study comprise 2-dimensional histologic sections and surgical dissections of actual temporal bones. Computer-based 3-dimensional (3-D) virtual models have the potential to become valuable tools for teaching and learning this anatomy. Several investigators have developed 3-D wire-frame (1-3) or surface models of the human and animal ear using histological (4-9), radiological (10, 11) or microscopic (12, 13) images. Although quite useful, many of these models contain a limited set of anatomical structures and they do not readily depict the spatial orientation of the structures within the bony confines and air spaces of the temporal bone. Some of these models are also limited in their capacity for user interaction.

We have developed three virtual models of the human temporal bone, and made them available as downloadable freeware for teaching and educational purposes (14-16). These models include: 1) *Temporal Bone model*: developed from archival histologic sections of a 14 year old male, this model depicts the major-



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News and Announcements



**Deafness
Research
Foundation**



The international conference, "Cell Replacement in the Inner Ear" will be held June 13-15, 2008 at the Bethesda Hyatt under the sponsorship of the NIDCD, University of Washington, and the Deafness Research Foundation.

The meeting is open to all scientists interested in the area of regeneration biology of the inner ear. There are five sections: Systems Regeneration, Stem Cell Biology, Cell Cycle Regulation, Regulation of Cellular Specification and Differentiation, and Translational Issues. Each section will have opening addresses from a systems biologist and an auditory scientist. Keynote speakers from other disciplines include Nelson Fausto, Alejandro Alvarado-Sanchez, Mahendra Rao, and Tom Reh.

Conference information and registration are available on the DRF website: www.drf.org

Inquiries to Andrea Kardonsky: akardonsky@drf.org



**Hearing Loss
Association
of America**

Convention 2008 • June 12-15 Grand Sierra Resort & Casino Reno, Nevada

The Hearing Loss Association of America Convention is a highly interactive and accessible event for all people who are affected by hearing loss. The program includes dynamic speakers, dozens of instructive workshops, and an informative research symposium. Plus, our Exhibit Hall hosts an array of hearing loss related products, services and information.

Hearing Loss Association of America Convention 2008 will offer a wide variety of educational workshops, general sessions, and special events as well as opportunities to meet other people with hearing loss, healthcare and rehabilitation professionals, educators and vendors. Attendees can enjoy hands-on testing of hearing assistive devices and telecommunication products in the Exhibit Hall.

*To learn more, visit:
www.hearingloss.org/convention*

ity of the structures of the external, middle and inner ears along with the mastoid air spaces. 2) *Round Window model*: a more detailed subset of model #1, this depicts the detailed anatomy of the round window membrane and adjacent structures of the cochlea. 3) *Visible Ear*: developed from a library of digital images from an 85-year old female, this model contains the entire human temporal bone and surrounding structures of the skull base.

Material And Methods

1) *Temporal Bone model*. The specimen had been fixed in formalin, decalcified using 5% trichloroacetic acid, embedded in celloidin and serially sectioned in the axial plane at a thickness of 20 microns. Every fifth section was stained with hematoxylin and eosin. One hundred and forty-one stained sections were digitized and imported into a general purpose 3-D rendering analysis software package called Amira (version 3.1). The sections were aligned and anatomic structures of interest were segmented. Each anatomical structure was assigned a certain color according to certain rules of convention that we adopted. For example, nerves were given different shades of yellow, arteries- red, veins- blue, etc. Polygonal surface models were generated of the segmented anatomic structures. These surface models underwent further refinement to smooth their contours and remove artifactual distortions introduced by the histologic processing.

2) *Round Window model*. This model is a subset of model #1. A total of 201 sections which contained the round window and surrounding cochlear structures in the hook region were used to create the model. Each and every section in this anatomical region was stained and digitized. Anatomical structures of interest were segmented and surface models were created.

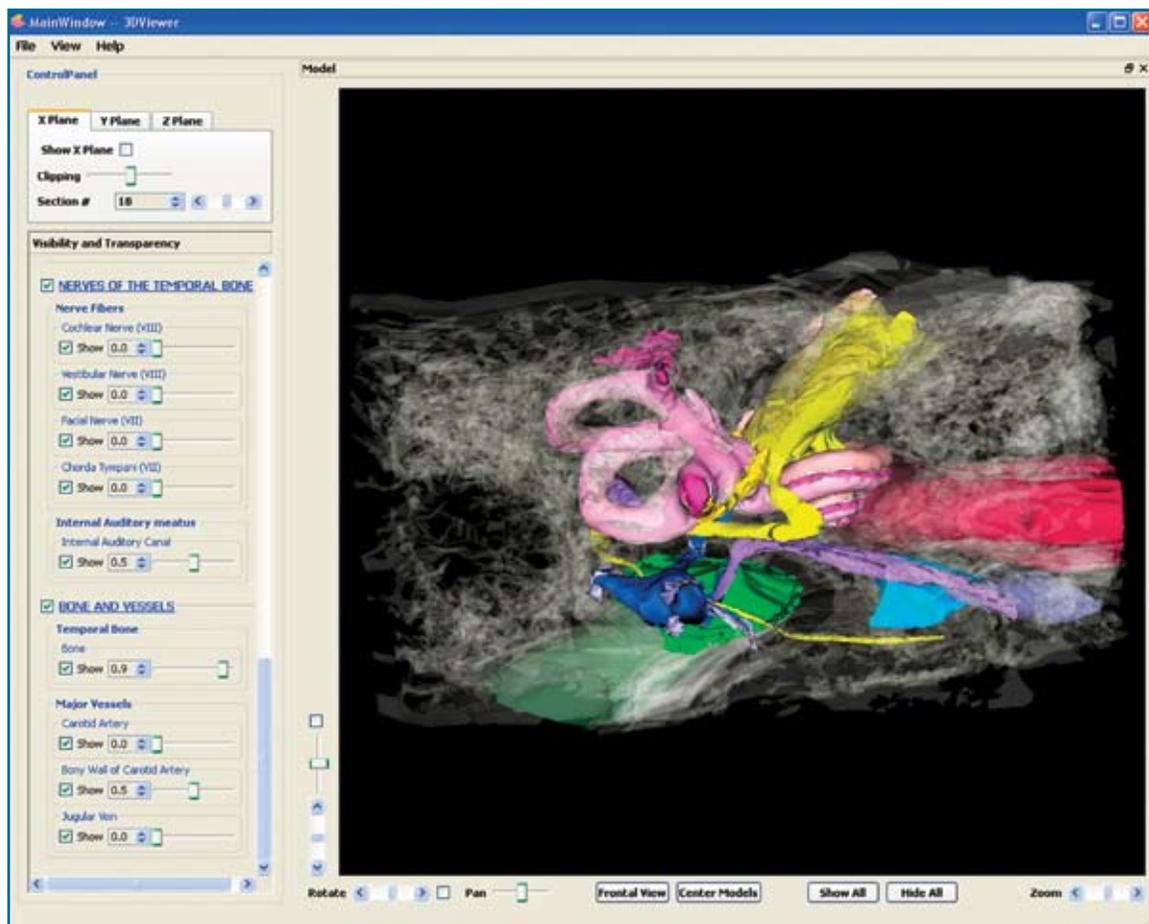


Fig. 1. A screen shot of the Temporal Bone model displayed in the 3-D Surface Viewer. A subset of anatomical structures are visible through bone that has been rendered semitransparent.

3) *The Visible Ear*. The Visible Ear is a digital freeware image library based on images obtained from an 85-year old female with no previous history of ear disease (17). The images were obtained from a fresh, frozen specimen that was serially cryosectioned at 25 micron thickness. Digital images of the block surface were recorded at intervals of 50 to 100 microns. A total of 605 images were used to generate our 3-D model of the Visible Ear. Surface polygonal models were developed of structures of interest, in a manner similar to the process used for models 1 and 2.

3-D Surface Viewer. Amira provides a user friendly and powerful software package for creating and representing 3-D models. However, it is relatively expensive which renders it impractical for wide distribution for teaching purposes. Users would be able to better appreciate the anatomy and 3-D spatial relationships if they could freely manipulate the models on their own computers without space, time or cost constraints. Due to these considerations, we developed a stand alone, downloadable, cross-platform software package, the 3-D Surface Viewer (Figs. 1, 2 and 3). The Viewer is compatible with Windows XP/2000, Mac OSX and Linux Red Hat 9 operating systems. Our 3-D virtual models have been incorporated into the 3-D surface viewer and can be downloaded at no cost from our website at:

<https://research.meei.harvard.edu/otopathology/3dmodels>

Results

The Temporal Bone model contains 26 individual anatomical structures which are hierarchically organized into 5 groups on the basis of anatomy: the external ear group, the middle ear group, the inner ear group, the nerves and bone with great vessels. The anatomical structures displayed in the Round Window model include the scala

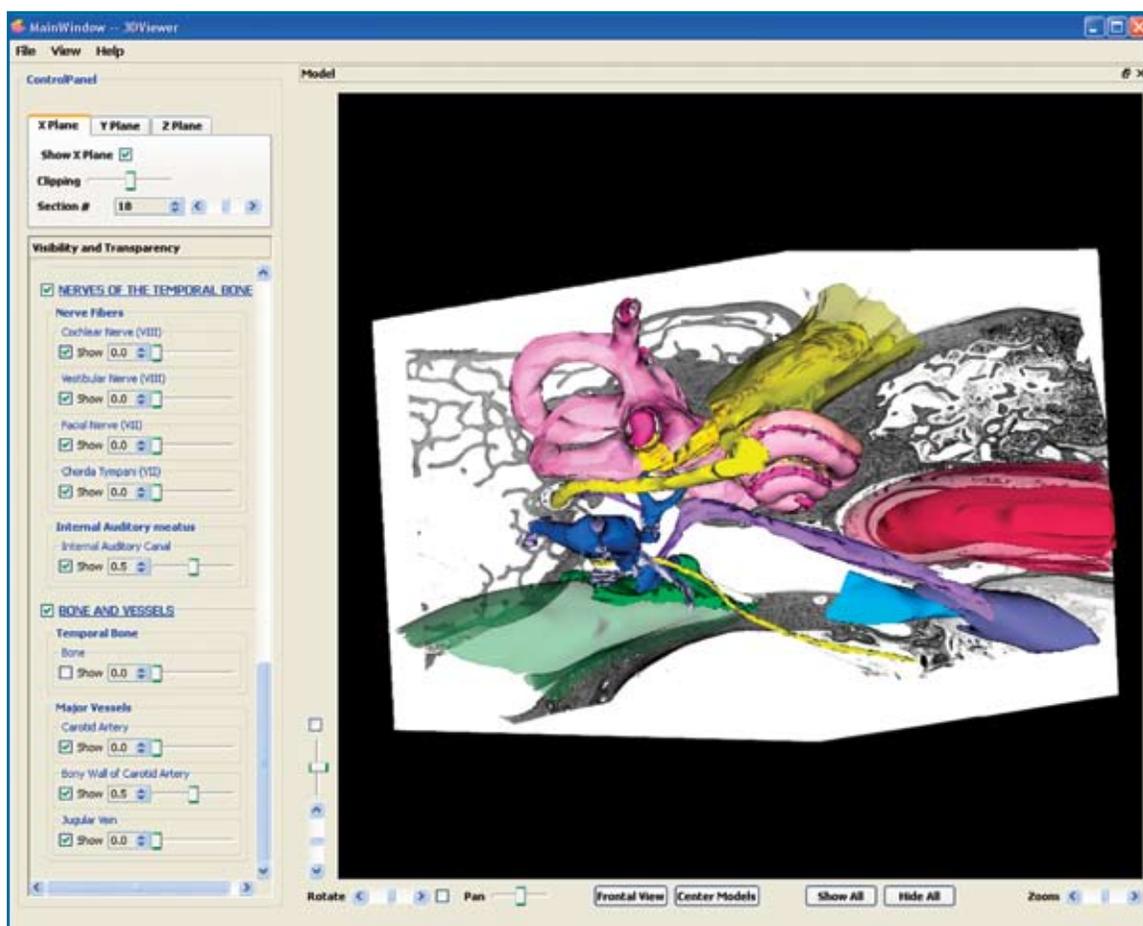


Fig. 2.

A screen shot of the Temporal Bone model displayed in the 3-D Surface Viewer with an image of a histological section mapped into a set of surface contours.

vestibuli, scala media, scala tympani, ductus reuniens, basilar membrane, round window membrane, cochlear aqueduct, osseous spiral lamina, spiral ligament, inferior cochlear vein and surrounding bone. The 3-D model of the Visible Ear contains 26 anatomical structures organized in six groups: skin, soft tissue and bone, middle ear, inner ear, cranial nerves, major blood vessels and the cranial cavity.

For all three models, users can rotate and zoom the models in real time using simple controls of the mouse or widgets provided on the screen. The visibility of each individual anatomical structure can be controlled and its degree of transparency can be adjusted. The 2-D raw histologic images can be superimposed onto the 3-D models. Users can also navigate through the series of histologic images. The raw stack of images can be re-sectioned in three different orthogonal planes and users can step through the images in different sections. Users also have the option of viewing the models on their own computers in stereo mode. The latter requires (standard) cyan and red 3-D glasses. Also included with each model is a view of a complete skull. The skull and the model are synchronized such that both are always displayed in the same anatomical orientation. Thus, a user can determine the anatomical orientation of each model (or a portion thereof) by comparison to the orientation of the skull.

Discussion

The various models have complementary strengths and weaknesses. The Temporal Bone model has relatively high resolution. For example, within the inner ear, individual structures that are depicted include the three scalae, perilymphatic and endolymphatic spaces within the vestibular system, vestibular sense organs, basilar membrane and round window. However, the model does not contain all portions of the temporal bone. For example, the tegmen is missing along with a part of the superior semicircular canal. While the raw histologic images

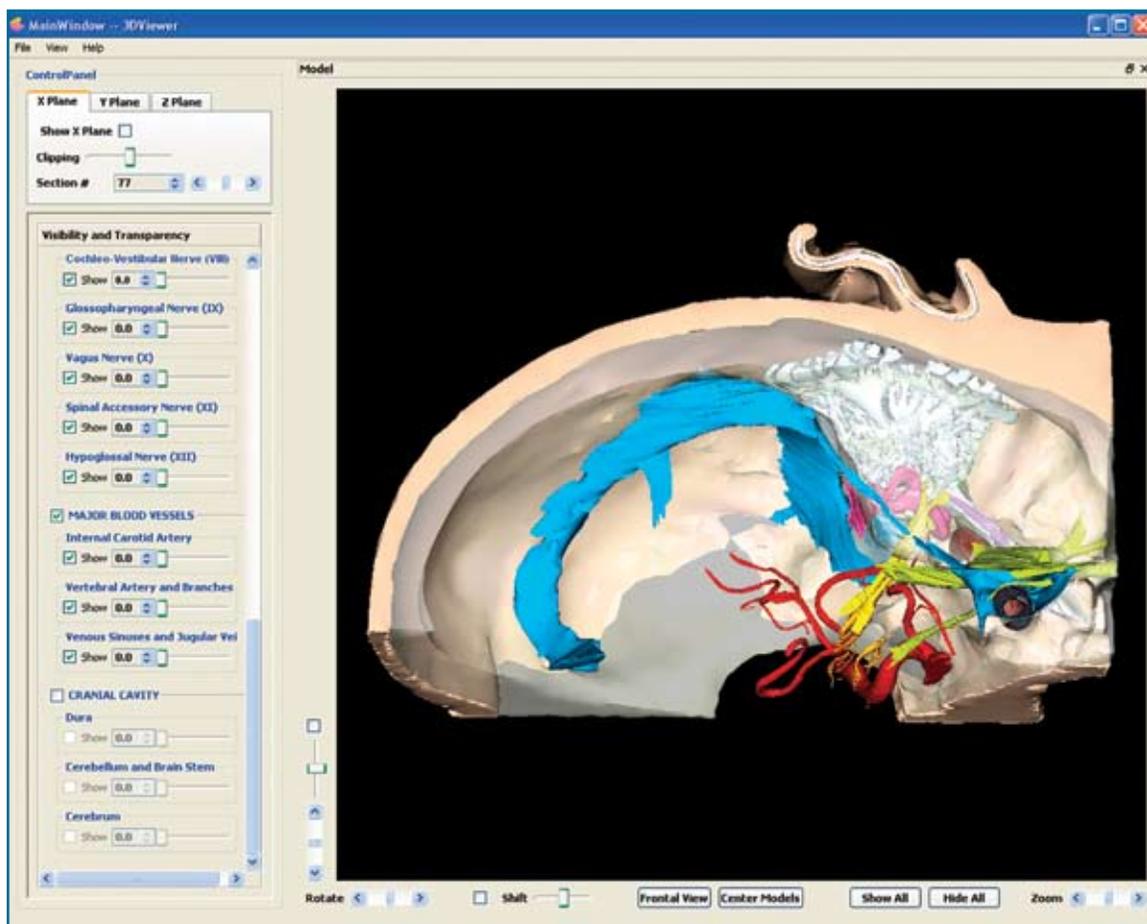


Fig. 3. A screen shot of the Visible Ear displayed in the 3-D Surface Viewer. The dura and central nervous system structures have been turned off and the bone has been set to be 50% transparent.

are of very high quality in the axial plane (the plane in which histologic sectioning was originally done), the reformatted images in the two other orthogonal planes are of inferior quality because of anatomical distortions introduced during the histologic processing.

The Round Window model focuses on a small area of the cochlear anatomy related to the round window and adjoining structures. It is of value in understanding the complex relationships between these structures which will help an otosurgeon in procedures related to this region; for example, where to perform a cochleostomy with minimum damage to important structures such as the basilar membrane, spiral ligament, etc.

The Visible Ear model depicts the entire temporal bone and delivers information about the middle, inner and outer ears in their surgically relevant surroundings of the skull base. The use of photographic images taken from the surface of the tissue block prevents possible distortions that can occur during mounting of individual histologic sections. Therefore, the raw images in the X, Y and Z planes are of high fidelity and free from distortion. One limitation of the Visible Ear is the level of detail that can be ascertained since the 3-D reconstructions were made from surface photographic images. For example, it is difficult to segment small structures within the labyrinth such as the basilar membrane or the ductus reuniens.

We hope that our models will serve as teaching tools in both basic science and clinical disciplines by

providing realistic, interactive and anatomically accurate information with 3-D visualization.

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3-D Virtual Model Download



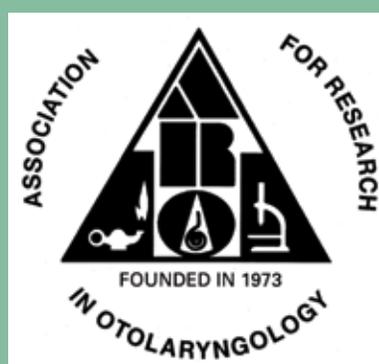
To download the 3-D Virtual Models at no cost, visit our website at:

<https://research.meei.harvard.edu/otopathology/3dmodels>

Look for the Registry's Exhibit at These Upcoming Meetings



The Registry will be exhibiting at the upcoming AAO-HNSF Annual Meeting and OTO Expo in Chicago, IL, September 21-24, 2008
www.entnet.org



The Registry will be exhibiting at the upcoming ARO MidWinter Meeting in Phoenix, AZ February 16-21, 2008
www.aro.org

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News From NIDCD



Save the Date:

The National Institute on Deafness and Other Communication Disorders (NIDCD) plans to hold a research symposium on October 23, 2008, as part of its 20th anniversary celebration. The symposium will be held on the National Institutes of Health (NIH) campus in Bethesda, MD.

Did you know?

The NIDCD Information Clearinghouse has many publications available to patients and physicians on various topics related to hearing and balance. The list of publications is available on their website:

www.nidcd.nih.gov



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Free Brochures for Your Office or Clinic About Temporal Bone Research and Donation

That Others May Hear is a short brochure which describes briefly 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.

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Enrollment Packets _____ 25 50 100

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

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