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The Acoustical Society of America

ECHOES

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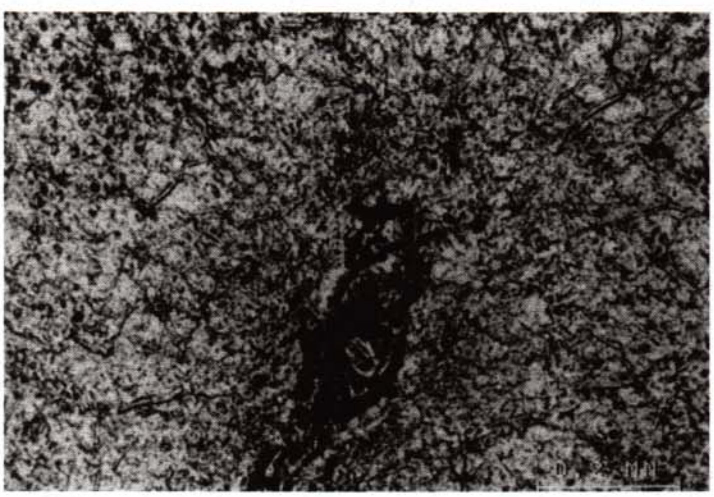
Acoustical Microscopy in Medicine and Biology

by Joie P. Jones

Since the very beginnings of biological research and the practice of Western medicine, the optical microscope has been an important tool and has served as a gold standard by which other methods are judged. Recently, however, acoustical microscopy is playing an increasingly important role in diagnostic medicine. For example, over the past decade we have been using various prototype acoustical microscope systems in my laboratory at the University of California, Irvine, as both research and clinical tools. To illustrate the potential which this technology offers as a diagnostic tool, the accompanying figure shows a scanning acoustical microscope (SAM) image taken at 600 MHz of a section of human brain with Alzheimer's disease. The plaque associated with this disease process is the large black structure in the lower center of the image. This plaque is very difficult to visualize with optical microscopy even with elaborate staining techniques. With acoustical microscopy, the plaque is immediately evident even with a fresh tissue sample that has been neither fixed nor stained. Acoustical microscopy offers a new tool to investigate Alzheimer's disease and other forms of dementia on a laboratory basis using various animal models as well as cell layers in culture media. By better understanding how the elastic properties of tissue are changed by this disease process, we may be able to better understand the fundamental mechanisms producing the disease as well as to develop techniques for evaluating Alzheimer's disease in a noninvasive way.



A scanning acoustical microscope (SAM) image taken at 600 MHz of a section of human brain with Alzheimer's plaque. The plaque is the large black structure near the center. The field of view is about 1 mm. The specimen was fresh tissue, neither fixed nor stained, 6 microns thick.

At our institution, acoustical microscopy is already playing a significant role in the clinic. My dermatology colleagues are using this technology on a regular basis to evaluate skin biopsy samples, obtaining an immediate assessment of the pathology long before standard techniques would allow. Our goal is to provide the same assessment of pathology without requiring a biopsy. A specialized ultrasound scanner applied directly to the skin could provide acoustical microscopy on an in vivo basis.

In vivo acoustical microscopy may also be possible with a catheter-based system in which a small, millimeter sized transducer is threaded via an artery or some other small passageway to the region of interest. Coupled with the development of new prototype systems better suited for laboratory work in the biological sciences, acoustical microscopy may well be entering a new phase of development in which the great potentials of this technology are finally realized.

Optical microscopy itself has a long and interesting history going back thousands of years. Clay tablets from Assyria record the use of magnifying glass spheres from meteorites to observe nature at a near microscopic level. The great library of Alexandria was known, even in 200 BC, to contain many manuscripts on optics. Based on those works which survived the great fires of 47 BC, Ptolemy formulated his major treatise on optics in 140 AD, portions of which still survive today. However, it was not until the dawn of the Renaissance and the development of experimental science that instruments which could be recognized today as microscopes became available. The first compound microscope is thought to have been

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Society Pages

To the Editor:

ARLO and JASA

In July 2000 the Acoustical Society of America launched its second archival journal, Acoustics Research Letters Online (ARLO), the international electronic letters journal of acoustics. For the prior 15 months ARLO appeared in the Journal of the Acoustical Society of America-JASA (print and online) as part of the initial testing period.

This new initiative reinforces ASA's premier position in acoustics publishing and places the Society in a leadership role in scientific publishing in general. The reason for this special position is the combination in ARLO of several advances that promise to be a model for all publishers of scientific research.

In particular, ARLO offers authors rapid peer review and publication of their letter-sized submissions (in as little as one month) with its unique online Manuscript Management System, co-developed with the American Institute of Physics. Authors are also invited to include multimedia content in their submission, which is reviewed and archived. The use of color figures is also encouraged when appropriate.

Readers of ARLO have a special benefit as well: ARLO is free to individual readers possessing Netscape or Internet Explorer browsers, guaranteeing maximum worldwide dissemination of authors' research results. Authors pay a publication fee, and libraries are asked to pay a nominal subscription fee to support the editorial process, as well as archiving, linking, search functions, and security, which are provided by the American Institute of Physics.

One of the most frequent questions about ARLO is: Should I publish a letter in JASA or ARLO? If an author wants to include color or multimedia content or is interested in rapid publication, then ARLO is an easy answer. Yet authors may feel that the newly introduced ARLO does not have the reputation of JASA or may worry that the new ARLO articles do not appear in print other than as abstracts monthly in JASA. Therefore, each author will have to weigh the pros and cons. Some authors may want to introduce recent exciting research as a Letter in ARLO, and follow up at a later time with a more comprehensive report in JASA.

Readers, authors, and reviewers, and associate editors (many of whom are also JASA associate editors) enter the ARLO system at <http://asa.aip.org/arlo>. We invite you to visit the ARLO website to review the features and benefits of ARLO. Questions should be directed to **Robert Apfel**, the Editor of ARLO, at <robert.apfel@yale.edu>.

— Robert Apfel, Editor of ARLO
— Allan Pierce, Editor of JASA and ASA Editor-in-Chief

ECHOES

Newsletter of the Acoustical Society of America

Provided as a benefit of membership to ASA members

The Acoustical Society of Amnerica was organized in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.

Echoes Editor .... Thomas Rossing

ASA Editor-in-Chief .... Allan Pierce

Assistants .... Elaine Moran, Charles Schmid

Phone inquiries: 516-576-2360. Contributions should be sent to Thomas Rossing, Physics Dept., Northern Illinois University, Dekalb, IL 60115<Rossing@physics.niu.edu>

We hear that...

- ASA Fellow **Gregory Tocci** is serving as president of the Institute of Noise Control Engineering (INCE). **Paul Donovan** is president-elect and will become president in 2001.
- **Glenn Frommer** was awarded the first INCE Award for Excellence in Noise Control Engineering. He was recognized for his work on the airport railway in Hong Kong.
- **Hyeong-seok Kim** was awarded the INCE Martin Hirschorn IAC Prize given to a graduate student studying noise control engineering in the United States who proposes a project related to an application of noise control engineering and/or acoustical conditioning of architectural spaces.
- **Stuart Bolton** was awarded the INCE Outstanding Educator Award.
- **Lisa Zurk** has been awarded a Fulbright program grant in mathematics to lecture and conduct research at the University of Helsinki, Finland. She will conduct research in electromagnetic and acoustic wave propagation and scattering in stochastic media.
- With support from ASA technical initiative funds, **Uwe Hansen** conducted a workshop in acoustics for about 25 high school and college teachers at a meeting of the Indiana Section of the American Association of Physics Teachers on April 14. Material was provided to enable workshop participants to construct an impedance head for use with a number of computer-based experiments suitable for high school physics classes.
- **Brooks Acoustics Corporation** of Vernon, CT has been awarded the 1999 Connecticut Engineers in Private Practice prize for the acoustical renovation of Crowell Concert Hall at Wesleyan University in Middletown, CT.
- A 14-page booklet "Classroom Acoustics" prepared for the ASA Technical Committee on Architectural Acoustics by **Benjamin Seep, Robin Glosemeyer, Emily Hulce, Matt Lin,** and **Pamela Aytar** will be available from ASA in September. The authors, who at the time of preparation were students in Architectural Engineering at the University of Kansas, were supervised by faculty member **Bob Coffeen**.

Student Council Convenes in Atlanta

by Micheal Dent

The ASA Student Council, consisting of one student representative from each of the Technical Committees, met for the first time at the ASA's meeting in Atlanta. The Council has great expectations for making a lasting impression on the ASA, and a wide variety of topics were discussed to that end. Some of the most important objectives of the Student Council are to increase student membership and participation in the ASA as well as to assist students already active in the Society. The consensus of the Council is that ASA is already very student-friendly regarding conferences--offering free registration, travel subsidies, receptions for students to meet senior members of the Society, and numerous student awards. The Student Council has many ideas to increase student involvement.

In just our first meeting, the Council made plans to: add a student section to the ASA website, add a student page to the meeting programs, submit more items to Echoes, develop a career advice/job placement program and a mentoring award, plan more student activities at future conferences, and get students involved in the technical committee meetings. Look for these and other exciting improvements soon. For now, we encourage senior members to help as many students as possible to join ASA and to attend all of the conferences. Students will certainly benefit from both of these actions, as their contacts in the Acoustical Society of America will be very important for their education and careers.

The Student Council would like to congratulate the reported winners of the Best Student Paper Awards at the Atlanta conference: 1-Luiz Souza, 2-Kyle Becker, and 3-Gopu Potty (AO); 1-Elizabeth Brittan-Powell (AB); 1-Constantin Coussios, 2-Xufeng Xi, and 3-Dahilia Sokolov (BB); 1-Francois Guillot (EA); 1- Joon-Hee Beth Hwang (MU); 1-Cory Clarke and 2-Chrisopher Park (SA); 1.-Purnima Ratilal, 2-Roger Schwenke, and 3-Chris Higham (UW).

The Student Council members, their technical committee designations, and their email addresses are listed below. Feel free to contact them for further information or to submit topics of interest that the Council might want to tackle in the future.

Dorie Najolia (AA, dnajolia@sabine.acs.psu.edu), Micheal Dent (AB, mdent@psyc.umd.edu), Marc Dantzker (AO, mdantzker@ucsd.edu), Sandra Poliachik (BB, poliachi@u.washington.edu), Jeff Banks (EA, jcb242@psu.edu), Rachel Romond (MU, romond@oxy.edu), Michael Dallal (NS, michael_dallal@hotmail.com), Preston Wilson (PA, psw@bu.edu), Nandini Iyer (PP, iyer.8@osu.edu), Senthil Gopinathan (SA, svg104@psu.edu), Melissa Epstein (SC, melissae@ucla.edu), Roger Schwenke (SP, rws142@psu.edu), and Scott Frank (UW, franks2@rpi.edu).

Micheal Dent is a PhD student in Psychology at the University of Maryland in the Integrative Neuroscience program.

Society Pages

Acoustical Society Foundation: An example of giving

by Bob Frisina

The following is based on a recent gift to the Foundation, but the names and amounts are fictitious. Deborah and Ken are a professional couple in their late 60s. Deborah is a member of ASA, and Ken is an accountant. Deborah, who had invested wisely, donated stock to the Foundation currently valued at $14,0000. Still desirous of obtaining personal income from her gift, she designated it for the Foundation Pooled Income Fund. This fund pays Deborah an annual return of approximately $1000 for the rest of her life. Deborah gets an immediate charitable deduction of about $5425, and avoids capital gains tax on the appreciated amount of her donation. With a combined state and federal income tax bracket of 35%, depending on her cost basis, this deduction will produce immediate tax savings of about $1900. The Acoustical Society endowment receives $18,500 upon Deborah's death, and Deborah has helped ensure the Society's future vitality and diversity of programs.

More personalized or complicated payment schedules can be achieved by setting up a charitable remainder trust, while receiving similar benefits as donating to the Foundation's Pooled Income Fund. For more information on ways to share in the Foundation's goals and mechanisms for making donations, please contact Bob Frisina at 716-275-8130 or <asf@q.ent.rochester.edu>.

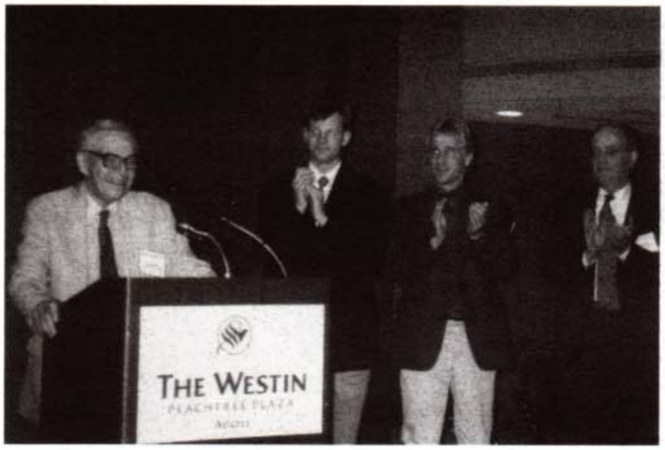
Donate/Receive back issues of JASA

The ASA office tries to match members who wish to donate their back issues of JASA with a college or university or an individual member who is interested in receiving them. Currently they have several offers to donate back issues and encourage any members who are interested in obtaining them to send the following information: your complete contact information, years of back issues desired, whether you wish these for your own use of for use by a college or university. Members wishing to add their names to the list of donors should send complete contact information and the date range of the back issues they wish to donate. Information should be sent to: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502, FAX: 516-576-2377; email: asa@aip.org.

Echoes from Atlanta

The historical city of Atlanta served as a gracious host for ASA's 139th meeting May 30- June 3. The technical program included 658 papers arranged into 72 sessions, all comfortably housed in the Westin Peachtree Plaza Hotel. The usual mix of buffet socials, receptions, and luncheons provided ample opportunity for technical discussions and social interactions among attendees. New features included a book fair and a workshop on finding a job in acoustics.

At the Awards Ceremony, the Gold Medal was presented to Murray Strasberg. The Helmholtz-Rayleigh Interdisciplinary Silver Medal went to Lawrence Crum, while the R. Bruce Lindsay Award was presented to Robin Cleveland. Preceding the awards ceremony was a business meeting at which the members voted to change the ASA bylaws to include the Immediate Past Vice President as a member of the Executive and Technical Councils.



Above left: Gold medal recipient Murray Strasberg receives standing ovation. Above right: Dean Ayers demonstrates a trombone mouthpiece that provides an unobstructed frontal view of the lips during playing.

Above left: New fellows of the Society with Vice President Mauro Pierucci and President Pat Kuhl: (left to right) Mauro Pierucci, Mendel Kleiner, James M. Hillenbrand, Peter Tyack, Charles R. Greene, F. Michael Pestorius, Judith C. Brown, Stephen E. McAdams, Lynne E. Bernstein, Robin S. Langley, Mohsen Badiey, Patricia K. Kuhl. Above right: Sten Ternström and Ingo Titze discuss the acoustics of singing.

Acoustical Microscopy

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developed by the Dutch spectacle maker Zacharias Janssen around 1590. Almost a hundred years later, following his fellow countryman's tradition, Anton van Leeuwenhoek constructed many fine instruments, some using small, near-spherical lenses. He was also a superb observer, who sketched capillaries, red blood cells, and sperm cells as seen through his microscope. Van Leeuwenhoek was probably the first to observe bacteria and protozoa under the microscope. During this same time period, Robert Hooke, working in England, made detailed microscopic observations of both biological and non-biological materials. The details of his research with the microscope were published in the beautifully illustrated book *Micrographia*, published in 1665.

The 18th and 19th centuries saw further developments in optical microscopy technology, producing instruments almost identical to those used today. By the 19th century, it was clearly recognized that the wavelength of visible light represented a real limitation to the resolution capabilities of optical microscopy, and, as would have been expected, all attempts to overcome these fundamental limitations failed. The problem was finally resolved in the 1920's by the French physicist, Louis de Broglie who, in his Ph.D. thesis, suggested that if electromagnetic radiation could behave as if composed of particles, then subatomic particles should also display wave-like properties. This theoretical framework was put into practice less than a decade later by the development of the electron microscope which, taking advantage of the wave-like nature of electrons, produced images of structures with resolutions hundreds of thousands of times greater than light microscopy.

At the same time the electron microscope was being developed, Sokolov, in the Soviet Union, proposed the basic concept of acoustical microscopy. Although he knew that acoustical instruments could not achieve the resolution of electron microscopy, he suggested that the acoustical or elastic properties of materials might prove interesting to image. Such a suggestion seems particularly appropriate when applied to the imaging of tissue. Indeed, the optical properties of soft tissue vary by only 0.5%; thus, the only way to extract useful information from an optical microscope image of tissue is to prepare the tissue specimen with appropriate stains designed to bring out features associated with specific pathological or biochemical processes. The acoustical properties of soft tissue, on the other hand, vary by some two orders of magnitude thereby providing an extremely sensitive probe with which to image soft tissue structures. In principle then, acoustical microscopy , by imaging the mechanical or elastic properties, should provide an important new tool for evaluating tissue structure and disease process.

The system proposed by Sokolov was to operate in the low GHz frequency range so as to have wavelengths (and therefore resolution) equivalent to visible light. The proposed system was to read out the localized electric charge developed on a piezoelectric crystal in response to an acoustical input. For various technical reasons, such systems are difficult to construct at high frequencies, and today this concept is universally limited to low frequency ultrasonic imaging.

Serious attempts to develop an acoustical microscope had to wait until after the early 1960's and the development of very-high frequency ultrasonic transducers. With this technology in hand, two groups in the U. S. developed two very different acoustical microscopy systems in the early 1970's. At the Zenith Laboratory in Chicago, Adrian Korpel and Larry Kessler developed a system in which the acoustical wave traveled through the sample and deformed a plastic membrane which, when scanned with a laser beam, yielded an image. This general type of system has become known as a Scanning Laser Acoustical Microscope (or SLAM). Such systems available today are generally easy and fast to use, are capable of producing images in real time, but are limited to frequencies below a few 100 Mhz.

Almost in parallel with the developments at Zenith, Quate and Lemons at Stanford built a direct scanning system which did not require a laser. This general type of system has become known as a Scanning Acoustical Microscope (or SAM). Such systems available today are generally more difficult to use than SLAM, do not produce real-time images, but can operate at much higher frequencies, well into the GHz range.

Some of the first applications with both SLAM and SAM were in biomedicine. Such applications have continued to play a major role, but have not made the impact once anticipated even though there are strong physical arguments as to why acoustical microscopy should be superior to optical microscopy in the evaluation of tissue. Optical microscopy can, in general, only visualize tissue structures that have been stained. Such staining techniques can be quite involved and elaborate and can take several days to implement; thus, with optical microscopy it is virtually impossible to scan fresh or living tissue. Acoustical microscopy, on the other hand, has great inherent sensitivity and requires no staining to bring out the features of interest. Thus, acoustical methods permit us, in principle, to scan fresh and even living tissues.

Although many similarities do exist between the optical and the acoustical images, many of the important differences (such as the differences between the optical and elastic properties of tissue) are not well known or fully appreciated. Part of the problem centers on the fact that many of the subtle features noted in the acoustical image are not understood or have not yet been correlated with a particular biological process. It is difficult to create a new gold standard when the new technology is significantly more sensitive revealing details as yet uncorrelated with other processes. In spite of these difficulties and its short history, acoustical microscopy is playing an increasingly important role in diagnostic medicine and biomedical research, representing yet one more example of acoustics in the service of humanity.

Joie P. Jones is professor of radiological sciences at the University of California, Irvine. His research interests include the applications of ultrasound technology to medicine and biology and the relationships between science, technology, and society, including the relationships between Eastern and Western medicine.

Acoustics in the News

● The July 16 *New York Times* (Connecticut section) includes a story on noise in restaurants. "Noise in a restaurant is like secondhand smoke," one noise expert commented. "A person who didn't create it still suffers from it. The people who suffer most are the workers because they are subject to it all day long." Various techniques are used to reduce noise in restaurants: tablecloths, thick fabric upholstery on the chairs, carpeting with padding. Bennett Brooks, chair of the ASA Technical Committee on Noise commented "Sound control is not rocket science. Any restaurateur who is aware of a noise problem, and is willing to address it, can do something, but too often they just let it go."

● "The Cosmos was Alive with the Sound of Matter" is the title of a news story in the *Los Angeles Times*, May 11. "When the universe speaks, astronomers listen. When it sings, they swoon." What the writer K. C. Cole is referring to is the analysis of the cosmic background by Caltech's Andrew Lange and colleagues. Peaks and valleys paint a visual picture of the sound the newborn universe made "when it was still wet behind the ears, a mere 300,000 years after its birth in a big bang. Light and matter fluid sloshed in and out of gravity wells, compressing the liquid in some places and spreading it out in others, setting up "sound waves" that might be called the "oldest music in the universe." When the universe cooled off, the sound stopped, as the universe congealed.

● A team of engineers at Lucent Technology, headed by James West, is developing a two-way communication system that will function in the high noise levels found in auto racing cars, according to a story in the May 24 *National Post*. Lucent and Jordan Grand Prix of Silverstone, U.K. signed a three-year agreement to improve car-to-pit communications. Asking a member of the U. S. National Inventors Hall of Fame to undertake such a task, the article suggests, is like "hiring Albert Einstein to design a better frisbee." West's challenge is to create a two-way system that will let both driver and pit manager hear each other perfectly.

● A new understanding of speech and hearing in people may result from listening to songbirds, according to a story in the April 13 *San Francisco Chronicle*. Some of the deepest mysteries of speech, memory, and movement are starting to reveal themselves in birdsong. By piecing together how the common zebra finch learns its intricate tune, for example, scientists gain insight into how the brain records complex patterns, checks for mistakes, and corrects errors throughout life. "There's a feedback circuit in these birds, and the same kind of system could be used in humans to evaluate speech and skilled motor behaviors," according to Michael Brainard, a songbird resercher at the University of California at San Francisco (UCSF). Although female zebra finches don't sing at all, the male learns a tune early in life and refines it through constant practice, the song ultimately serving as a signal of lineage as well as suitability for mating. The UCSF scientists found that the basal ganglia in the finch's brain sends an instructive signal to another brain region where the bird's characteristic tune is maintained in memory.

● Use of an Internet application that allows anyone connected to the web to share music files stored on the hard disk of their own computer has become so heavy that some universities want to ban the software for fear that it will saturate their academic Internet connections. According to a news note in the 13 April *Nature*, scientists are now thinking of adopting the principles behind the so-called Napster technology to solve problems in distributed computing.

Lincoln Stein, a bioinformaticist at the Cold Spring Harbor Laboratories in New York was struck by the parallels with his own work on writing software for a distributed sequence annotation system for the human genome. Annotation, which involves predicting which sequence stretches are genes and what their function might be, is done through a few central databases. A better solution, Stein argues, might be to allow biologists worldwide to annotate the human genome sequence interactively using diverse computational methods and Napster-like technology could be the answer.

● *Business Week* (June 26) picked up on a paper by Evan Unger at the Atlanta ASA meeting on the use of exploding bubbles to clear out blood clots. To break up blood clots, Unger used ordinary ultrasound contrast agents. These micron-size bubbles are injected into the bloodstream to enhance ultrasound images of the heart, but Unger used higher-power ultrasound to cause the bubbles to burst, tearing apart a nearby clot.

● Another Atlanta ASA paper on acoustic methods for gas leak detection formed the basis of a story in *The Times* (London), June 22. Photoacoustics, originally discovered by Alexander Graham Bell in the 19th century, has been adopted by engineers at the University of Michigan to detect very small leaks. The part to be tested is filled with sulphur hexafluoride, an inert and non-toxic tracer gas, and is then scanned with a laser beam. When the beam passes over a tiny cloud of leaking gas it rapidly heats it, causing it to expand and generate a pulse of sound.

● David Pitt of the *Associated Press* wrote a story on the Georgia Tech acoustical landmine detection technique, also described at the Atlanta meeting, which appeared in several newspapers. Sound-wave techniques work because the mines, with air pockets, flexible cases and trigger mechanisms, reflect sound differently than other buried objects, whereas metal detectors fail because they detect every metal can, scrap, and shell casing, resulting in a high false-alarm rate.

● An art exhibit in the Museum of Modern Art in Oxford, UK combines sound and vision to make a special impact on the viewer, according to a news report in *Nature*, March 23. Created by Carsten Nicolai and Ann Lislegaard, the exhibit includes such things as a large white wall illuminated by a bright white light whose intensity is proportional to that of a recorded sound. Another exhibit includes a raised wooden floor with eight large embedded speakers all sounding at slightly different low frequencies. Two large flasks on the floor are illuminated at an angle by a spotlight, so that refracted light sets up a pattern on the floor which varies as the audible frequencies shift.

Scanning the Journals

Thomas D. Rossing

● Sound is as old as the universe, according to an article in the July issue of *Scientific American*. During the first few seconds following the big bang, when the universe was a broiling plasma, random fluctuations caused regions of greater and lesser density to form. In regions of greater density, gravity sucked in material, whereupon the pressure imported by photons pushed that material apart again, causing the plasma to oscillate between compression and rarefaction. As the universe aged, coherent oscillations developed on ever greater scales, filling the heavens with a deepening roar. But when the plasma cooled and condensed into hydrogen, the universe went silent. Remanents of these plasma fluctuations, which show up as temperature variations in the cosmic background radiation, have recently been observed by two balloon-borne telescopes, Maxima and Boomerang. Boomerang flew above Antarctica, while Maxima was lofted above Texas.

● By analyzing the babbling sounds and first words of infants, B.F. MacNeilage and B. L. Davis (*Science* 288, 527, 21 April) found four sound patterns that suggest how the spoken forms of words originate. Peering inside particular languages, they found that physical, or phonetic, effects may be more pervasive than linguists have previously supposed. For example, infants usually begin to alternately lower and raise the jaw while vocalizing at about 7 to 10 months of age. With passive bunching of the tongue tip, this activity yields syllable sequences such as "yaya" or, if the tongue is flat, "wawa." If the substance of speech influences its form, additional phonostatistical analyses may provide information about the motor bases of speech and the structure of established languages.

● Essential nonlinearities in hearing are discussed in a paper with that title in the 29 May *Physical Review Letters*. The authors, most of them at the Rockefeller University, show that tuning to a Hopf bifurcation can account for three well-documented essential nonlinearities of the ear: compression of dynamic range, sharper cochlear tuning for softer sounds, and generation of combination tones. The great advantage of the regenerative tuning strategy is that it requires a minimal number of active elements. Because the tuner and the amplifier are one and the same, this mechanism is evolutionarily accessible. Evidence that the hair cells operate near a Hopf bifurcation is also reviewed.

● For at least a hundred years, the view of functional localization in the brain held that if we could splice the nerve so that the excitation of the ear fed the brain center concerned with seeing and vice versa, we would "hear lightning and see thunder." Results reported in two papers in the 20 April issue of *Nature* suggest otherwise. Neuroscientists at MIT rewired the nerves of ferrets and found that the different characteristics of inputs to the visual (and auditory) system actually create a new visual (or auditory) cortex, and hence its appropriate source-specific sensory and perceptual qualities. The ferrets were given the option of receiving a reward from a spout to their right following a light, or to their left after a sound stimulus. After visual stimulation of their rewired cortex, the animals always behaved as though they had been stimulated by light.

● People who can't understand words are better at picking up lies about emotions, according to a paper in the 11 May issue of *Nature*. Aphasics were found to be significantly better at detecting lies about emotion, suggesting that loss of language skills may be associated with a superior ability to detect the truth.

● The outer and inner hair cells of the mammalian cochlea perform different functions. The cylindrical outer hair cells alter their length and stiffness in response to changes in membrane potential. These mechanical changes are assumed to produce amplification of vibrations in the cochlea that are transduced by inner hair cells. According to a paper in the 11 May issue of *Nature*, researchers at Northwestern University have identified an abundant complementary DNA from a gene, designated Prestin, which is expressed in outer hair cells. This gene could make cultured kidney cells "jump" like an outer hair cell, so the authors conclude that prestin is the motor protein of the outer hair cell.

● The cochlea not only vibrates in response to sound but it also pumps energy into its own vibrations to beef them up, a news story in the 16 June issue of *Science* reminds us. Such "active feedback" gives the mammalian ear its exquisite sensitivity and its ability to distinguish pitch. However no one is sure just how the inner ear pumps up the volume. Auditory researchers have known for decades that hair cells turn vibrations into electrical signals, and recent advances raise the prospect of countering hearing loss by replacing dead or damaged hair cells. But the cells also appear to amplify the vibrations, and researchers have two different ideas about how they do it. Roughly speaking, it's a question of pistons versus trapdoors.

The basilar membrane is carpeted by hair cells, and some of these, known as outer hair cells, contract and elongate when zapped with electrical signals. Some researchers believe this pistonlike pumping amplifies the motion of the membrane, and this piston picture got a big boost when neurobiologists reported that they had isolated the protein prestin that gives the outer hair cells their unique ability to contract (see previous item). Every hair cell, however, wears a crown of stiff fibers called stereocilia, which tip to one side as vibrations in the basilar membrane push it against the tectorial membrane. In response, trapdoorlike ion channels open in the stereocilia and let in potassium and calcium ions. This is the mechanism that converts vibrations into the chemical signals that fire nerves. Some researchers think it also amplifies the vibrations. The calcium ions bind to the channels, snapping them shut, and some believe this pulls the stereocilia in the opposite direction, causing them to amplify the motion of the basilar membrane.

● The seas are alive with the sound of music, according to an article in the 8 April issue of *New Scientist*. Lowering a hydrophone into the water near the edge of the Great Barrier

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Scanning the Journals

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Reef off the coast of Queensland (Australia), Rob McCauley and Doug Cato picked up a loud roar, the massed voices of a multitude of fish. They found that a fish choir in full swing can raise the noise level by as much as 35 dB. The fish choruses are heard mainly at night, when many marine animals depend upon sound to communicate and navigate. The researchers were able to identify some of the sounds as coming from certain species.

● How cicadas interpret acoustic signals is the title of an article in the 18 May issue of *Nature*. While the vertebrate ear can analyze the frequency components of sound with high resolution, most insect ears can separate only broad-frequency bands, resulting in a categorical perception of sound. However the cicada has a capacity for fine-frequency resolution, which could explain the evolution of frequency-modulated communication signals in cicadas. Although most insects that hear have only a few auditory receptors (2 to 200), cicadas have up to 2100 auditory receptors in each ear. Interneurons apparently provide the cicada with a much lower threshold for intraspecific communication signals than would be predicted from recordings of the summed activity of auditory receptors, the authors conclude.

● The December issue of *Acoustics Australia* features articles on ultrasound, including "Ultrasonic domestic gas meter," "Three-dimensional medical ultrasound," "Ultrasound calibration at the National Measurement Laboratory," and "Ultrasonic guided waves for inspection of bonded panels." These papers, according to the editors, address the "middle ground" of ultrasonic sensing and nondestructive testing, where the fact that ordinary solids and liquids are moderately transparent to ultrasound provides the background upon which the techniques are built, while the fact that transmission properties are significantly modified by changes in density, elasticity, or structure allows such changes to be detected and imaged.

● Algorithms for predicting the articulation loss of consonants are discussed in a paper in the June *Journal of the Audio Engineering Society*. The simplest algorithm, known as the architectural form of the Peutz equation, is discussed and rederived. It is shown that the other Peutz algorithms, which use measured values of room acoustical quantities for estimating AL_{cons}, are based on Fletcher's articulation index concept, which is a quantitative measure of a communication system for transmitting the speech sounds. In smaller rooms with a diffuse sound field and ideal exponential decays, STI (speech transmission index) and U50 (useful-to-detrimental sound ratio) are highly correlated with each other, whereas AL_{cons} is not uniquely correlated with either of these speech metrics.

● A simple physical model of trumpet-like systems for real-time synthesis is described in a paper by Christophe Vergez and Xavier Rodet in *Acta Acustica*, Jan/Feb. Using the Hopf theorem (a powerful method for studying periodic solutions of a certain class of nonlinear autonomous systems), it is proved that the system has a unique stable periodic orbit in the vicinity of the equilibrium point. The consequence of various improvements to the basic model are analyzed.

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SUITE 1NO1
2 HUNTINGTON QUADRANGLE
MELVILLE, NEW YORK 11747-4502