The newsletter of
The Acoustical Society of America

ECHOES

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Fall 2008

ASA returns to Miami

The Acoustical Society of America returns to Miami November 10–14 for the first time since 1987. Actually this will be fifth meeting in Miami/Miami Beach, but the first one (I can remember, at any rate) at a golf resort. The Doral Golf Resort and Spa has five golf courses, with such daunting names as "blue monster" and "the great white," but the local committee, chaired by Harry DeFerrari, has created an interesting program designed to keep your mind on acoustics—and off golf—most of the time, at least.

Doral Golf and Spa Resort.

The technical program, arranged by Eric Thorsos, David Palmer, and the Technical Program Organizing Committee includes some 660 papers and 42 special sessions. An exhibit, which will feature instruments, materials, books, and services for the acoustical community, opens with a reception on Monday evening, November 10.

A tutorial lecture on "Aircraft Noise Prediction" will be given by Joe Posey of NASA Langley Research Center on Monday, November 10 at 7:00 p.m. Lecture notes will be available, as usual. A short course on Ultrasonic, Nondestructive Evaluation and Materials Characterization on Sunday (1:00 to 5:00) and Monday (8:30 to 12:30) will be taught by Dale E. Chimenti, Professor of Aerospace Engineering at Iowa State University. The number of attendees will be limited, so advance registration is advised.

Awards will be presented and the new Fellows announced at the ASA Plenary session, Wednesday afternoon. Buffet socials with cash bar will be held on Tuesday and Thursday evenings. A Fellows luncheon will be held on Thursday noon, and the Women in Acoustics luncheon will be on Wednesday. Again, advance registration is advised (and rewarded with a lower rate). The ASA Education Committee provides a way for a student to meet one-on-one with an ASA member over lunch. (Students who are interested should contact David Blackstock at dtb@mail.utexas.edu. The Women in Acoustics Committee is helping to organize on-site child care services; interested attendees can contact Andone Lavery at alavery@whoi.edu.

Many visitors will also wish to explore downtown Miami and Miami Beach. Approximately 80% of the people in the city of Miami are Hispanic, and "Little Havana" is famous as the cultural and political capital of Cuban Americans. Art museums in Miami include the Miami Art Museum, the Lowe Art Museum at Miami University, and the Museum of Contemporary Art. Science museums include the Miami Museum of Science, the Fairchild Tropical Garden, and the Parrot Jungle and Gardens. Vizcaya Museum and Gardens, once the home of James Deering and now a National Historic Landmark, is worth a visit. Miami University is in Coral Gables, a south suburb of Miami.

Besides golf, the Doral offers a spa, a fitness center, and

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ASA news

A letter from the editor

Once again, no letters to the editor. In fact we didn't receive much material at all from readers: no articles, no notes for "We hear that. . .", no photos.

This is your newsletter. I comb the journals and newspapers for articles and news about acoustics, but I'm sure that I miss a lot of interesting acoustics news, because it is such a broad and diverse subject. Please send us news about your adventures and accomplishments, news about the accomplishments of other acousticians, and most of all your letters. We want *ECHOES* to be not only a newsletter but a forum on acoustics!

New Fellows

Congratulations to the 13 new ASA Fellows introduced at Paris: Michael Akeroyd, Susanna Blackwell, Dick Botteldooren, Dani Byrd, Brian Glasberg, Larry Humes, Vera Khokhlova, Christophe Micheyl, Anthony Nash, John Osler, Subramaniam Rajan, Brad Story, and Lily Wang.

Sorry we don't have a photo available.

From the Student Council

Michael Canney

Bonjour! Welcome back from Paris! The joint meeting with our fellow acousticians across the Atlantic at Acoustics '08 was a huge success with a record turnout in student participation—over 1,000 abstracts were submitted by students. The student participation in the meeting was enormous and was a great way to meet students from all over the world who are studying acoustics. In addition, there were several opportunities for students to socialize with each other at the student luncheon set up by the conference organizers as well as by an informal student outing in Paris organized by EAA and ASA students.

An additional highlight of the meeting was the creation of a European counterpart to the ASA Student Council that will provide European students with a forum for organizing activities and resources for fellow students who are doing research in acoustics. More information should be available soon on the EAA website (http://www.european-acoustics.org). We look forward to organizing future events for students at meetings with the EAA Student Council and in helping them establish a support network for students. In addition, the 'Schola' section of the EAA website provides information about acoustics classes at various universities in Europe, in case you happen to be pondering a move across the Atlantic in the near future.

We look forward to seeing everyone in Miami in November. The Student Council will again have a students-only "Icebreaker" on the first night of the meeting as well as a student reception on Wednesday night. Informal social outings will also be organized on Monday and Wednesday nights, information about which will be available on the bulletin board at the meeting. Be sure to check out our fantastic website as well for updated information about the Student Council as well as the latest e-zine, which contains additional details about the Miami meeting (www.asastudentzone.org).

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Michael Canney is a graduate student at the University of Washington, where he performs research on medical ultrasound. He is currently the chair of the ASA student council. He can be contacted at mcanney@u.washington.edu

Gilles Daigle, Manell Zakharia, and Michael Vorländer in Paris

Pat Kuhl, Andy Meltzoff, and the Eiffel Tower

ECHOES

Newsletter of the Acoustical Society of America

Provided as a benefit of membership to ASA members

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

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ASA returns to Miami

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Miami Art Museum

Doral spa pool

David Palmer, Eric Thorsos, Harry DeFerrari

the Blue Lagoon swimming complex with waterfalls and a waterslide. A variety of restaurants, boutique shops, and barber/beauty shops will be found on site. Come one, come all and enjoy Florida sunshine along with lots of acoustics!

Technical Program Organizing Committee Meeting

High fidelity on the line: please say "aah"

Sten Ternström

If you ever tried, you will know that the "treble" tone control on your hi-fi regulates the strength of the highest frequencies, those above 5,000 Hz. Turning it up makes the sound brighter, turning it down makes it more dull. Curiously, although the sounds of the human voice have been studied for decades, researchers have hardly looked at those highest parts of the voice spectrum until now.

In male speech, the vocal folds vibrate only some 100 times per second; in female speech, about twice that. But these vibrations generate harmonic overtones, which carry acoustic energy at higher frequencies as well. The overtones, or harmonics, are fairly strong up to about 4000 Hz, or 4 kHz for short. Going above 5 kHz, they diminish rapidly, and carry only about one ten-thousandth of the total energy of the sound, or even less. Still, the high harmonics can be heard and measured as high as 16 kHz, especially in song. Speech and song also contain fricative consonant sounds such as "s", "f" and "sh". These consist of high-frequency noise rather than periodic vibrations.

Because the voice signal is so weak above 5 kHz, it has been largely ignored by researchers. Long ago, when telephony was being developed, engineers soon discovered that speech can be transmitted cost-effectively yet intelligibly using only frequencies in the range 300-3500 Hz; and consequently, the structure of voice signals in that low range has been studied intensely. But the sound quality does suffer from this constraint, and everyone knows what is meant by "telephone" sound. Indeed, after a hundred years, that nasal, tinny timbre has become iconic.

Best heard with young ears, the treble region of the voice is still regarded mostly as a subtle curiosity; and acoustically, it is admittedly rather messy. At low frequencies, below 5 kHz, things stay fairly simple, because the sound waves are much

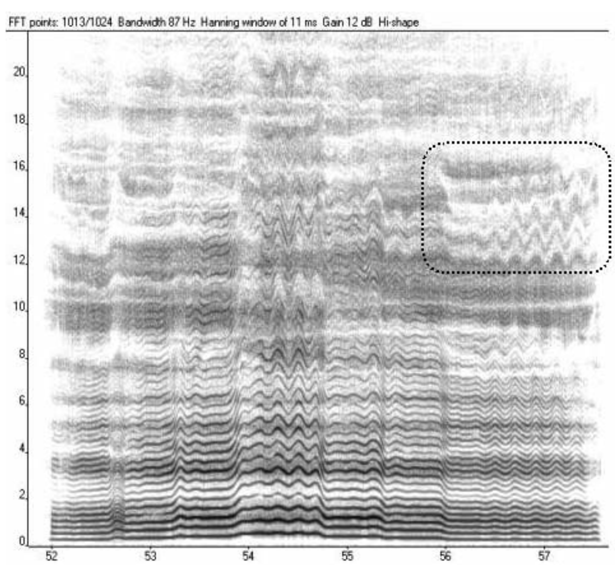

Fig. 1. Wide-band spectrogram of an arpeggio by an operatic soprano. Note band of energy at 9-13 kHz. Enclosed area exhibits resonance frequencies (not partials!) that are being modulated by the vibrato. Horizontal time in seconds, vertical frequency in kHz.

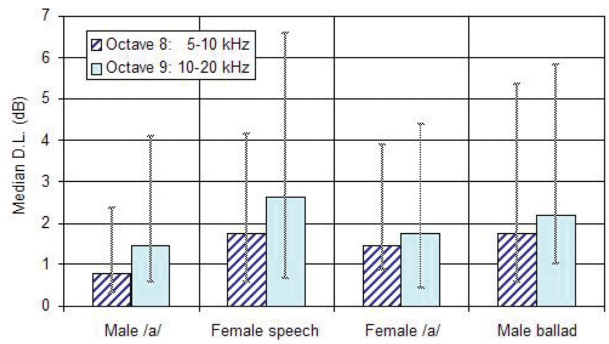

Fig. 2. Difference limens for octave band boost in speech signals. 10 male non-naïve listeners. Columns show median values, bars show quartiles. Three-alternative forced choice test, 1 up – 1 down, adapting amount of boost.

longer than any dimension of the vocal tract. This means that the relatively slow pressure changes in the air travel neatly and only lengthwise from the vocal folds to the lips. The wave propagation inside the vocal tract can be decently described using the textbook math for, say, a round pipe which diameter varies along its length. But the higher the frequency, the shorter the sound waves. Above 5 kHz, the waves become short enough that the sounds can start resonating sideways inside the mouth: between the cheeks, tongue, teeth and palate.

These so-called cross-modes make things much more complicated. The vocal tract conducts high-frequency sounds as if it were a tiny but elaborate cave with intricate acoustics, rather than just a pipe with a few resonances. To make things worse, this little room changes shape continuously as we speak. And the slightest displacement of tongue, larynx or jaw can make a huge difference to details in the high part of the sound spectrum. Perhaps this does not matter very much – our sense of hearing shrewdly concentrates on the low frequencies below 5 kHz, while resolving much less spectral detail at high frequencies (which, incidentally, has been exploited for compression of audio signals).

So what's the big deal? Can't we just go on ignoring these high frequencies? Well, as recently as in the year 2000, a new "wide-band" standard for telephony was defined, up to 7 kHz. That is not perfect, but it is a big improvement on the old "telephone sound." Hopefully, your cellphone calls will sound much better in a few years, and internet telephony already does. Audio engineers, music producers and broadcasters invariably crank up the treble for the vocals, because doing so is said to increase "crispness," "intimacy," and "openness." According to this fairly recent aesthetic, especially in popular music, live voices now sound almost a bit dull and faded—because, sitting in the fifteenth row, we are not close-up—like the microphone, and auditorium acoustics tend to penalize the highest frequencies. Medical experts who attend to our voices now know that well-functioning vocal folds generally produce stronger high frequencies. Signs are also that micro-fluctuations at high frequencies could be important for making natu-

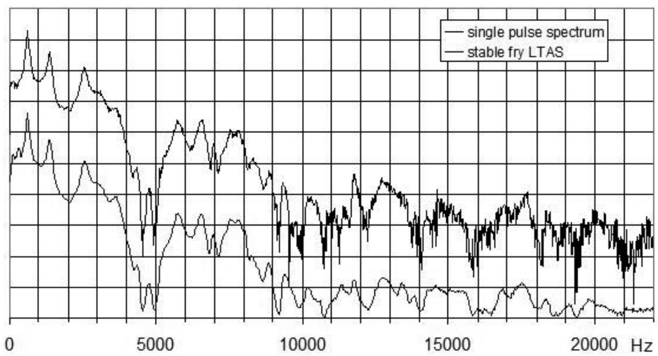

Fig. 3. Spectrum of a single ingressive pulse (upper curve), and LTAS of 2 s of ingressive fry phonation (lower). Male nonsinger subject, vowel /ɛ:/. Vertical scale is 10 dB/div. Note the dual zero of the piriform fossa at 4.5 and 4.9 kHz; and the fairly large amount of energy at 5-9 kHz.

ral-sounding synthesis of voices. So, it is high time to describe the treble part of the voice signal in greater detail.

This study is a sort of reconnaissance mission into a fairly unknown territory, and it is the first in a new three-year project dedicated to the treble region of the voice. Eight people, mostly singers, were recorded as they did different speech-like and song-like tasks with their voices, and various aspects of the high frequency range of vowel sounds were analyzed. Reassuringly, it was found that the acoustics of the vocal tract behave as expected from room acoustics, in that the resonances in the vocal tract at higher frequencies become very profuse, and very sensitive to small shape changes. The relative amount of energy at 5-10 kHz and 10-20 kHz for different vowel sounds was measured, and some gross features of the high spectrum were described. Among these features were a pronounced dip at 4-5 kHz; a cluster of resonances at 5-10 kHz, and a lesser trough at 10-13 kHz. In a few loud sung tones, harmonics were observed all the way up to 20 kHz. Listening tests showed that very small level changes of less than one decibel in the high region can be discernible for long sung vowels, which may have a fair amount of high-frequency harmonics. In running speech, the fricative consonants dominate at high frequencies, and the rapid modulations mean that small changes of the treble control are harder to hear.

These findings will show the way into more detailed studies on the high-frequency region of voice signals in speech and song. Once such studies have unfolded, the results will find applications in speech communication, voice health care, and the performing arts. So, the next time you play your favorite singer, or an audio book, try turning down the treble for a while. Chances are you'll soon want to turn it up again.

Sten Ternström is a professor in the Department of Speech, Music and Hearing in the School of Computer Science and Communication at the Kungliga Tekniska Högskolan (Royal Institute of Technology) in Stockholm. His research is on the acoustics of singing and especially choir singing. This article is based on paper 3aMUa7 at Acoustics08 in Paris.

Best student paper/young presenter awards (Paris)

Animal Bioacoustics
First (lecture): Yossi Yovel (Eberhard-Karis-Universitat, Tugingen)
First (poster): Joseph Jackson (University of Bristol)

Acoustical Oceanography
First (poster): Paul Roberts (University of California, San Diego)
Second (poster): Aleksandra Kruss (IOPAN, Poland)
First (lecture): Meghan Ballard (Pennsylvania State University)
Second lecture): David Barclay (University of California, San Diego)

Architectural Acoustics
First: Anne Guthrie (Rensselaer Polytechnic Institute)
Second: Yun Jing (Rensselaer Polytechnic Institute)

Biomedical/Biresponse
First: Moire Smith (Cambridge University)
Second: Todd Hay (University of Texas)
Third: Dorothêe Bossks (Univeresité Pierre et Marie Curie)

Engineering Acoustics
First: Thierry Le Van Suu (Université du Maine)
Second: Cyril Meynier (Vermon SA)

Musical Acoustics
First: Chen Jier-Ming (University of New South Wales)
Second: Ed Berdahl (Stanford University)

Noise
Sarah Gourlie (University of Texas at Austin)
Brice Lafon (Renault, Malmaison, France)
Sarah Payne (University of Manchester)

Psychological and Physiological Acoustics
First: Marion Cousineau (Université Paris Descartes)
Second: Jayaganesh Swaminathan (Purdue University)

Speech Communication
First: Carolyn McGettigan (University College London)
Second: Thomas Hueber (ESPCI-Telecom Paris)

Structural Acoustics and Vibration
First: René Christensen (Oticon, Denmark)
Second (tie): Daniele Moreau (University of Adelaide), Kerem Ege (Ecole Polytecnique, France)

Underwater Acoustics
First: Zachary J. Waters (Boston University)
Second: Jon La Follett (Washington State University)

Scanning the Journals

Thomas D. Rossing

• In an essay entitled "Raising the roof" in the 12 June issue of *Nature*, acoustician Michael Barron explores how "physics, psychology and fashion have influenced **concert hall acoustics**." The science of concert hall acoustics is founded on our understanding of the physical behavior of sound and how our ears interpret it. Much remains to be discovered about how our ears and brains process sound reflections. Understanding this has been complicated, for example, by our remarkable ability to localize a sound, even when the sound arriving directly from the source represents a small proportion of the total sound we receive, perhaps only 5% at the back of a concert hall. The downside of this localization is that our hearing suppresses awareness of sound reflections.

The current consensus is that there are four subjective dimensions for concert hall listening: *clarity, reverberance, acoustic intimacy*, and *loudness*. A range of measures has been developed that allows concert hall designs to be tested before building starts, using computer programs or acoustic scale models. As a result, acoustic disasters are now much less likely. Since the mid-1980s two forms have predominated for symphony concert spaces: the rectangular shoe-box hall and the terraced hall. Some acoustic designers have offered variable acoustics, which has met with mixed enthusiasm.

• Some destructive earthquakes, which produce sound waves, seem to rupture at faster than the local speed of sound through the crust. This supershear rupture produces in the ground a **seismic shock wave** similar to the sonic boom produced by a supersonic airplane. According to a paper in the 6 June issue of *Science*, the aftershocks of these tremors are also different. Instead of clustering on the fault plane they cluster on secondary structures. The lack of aftershocks on the fault plane shows that friction along the fault plane itself is relatively uniform. Supershear rupture was predicted more than 30 years ago, but the realization that it may be common during earthquakes has come only in the past few years.

• The most direct evidence for a solid inner core deep in the Earth would be the observation of shear-mode body waves that traverse it, but these phases are extremely difficult to observe. According to a paper in the 14 August issue of *Nature*, however, observation of so-called PKJKP waves point to inner-core **shear-wave anisotropy and texture**. A simple model of an inner core composed of hexagonal close-packed iron with its c axis aligned perpendicular to the rotation axis yields anisotropy that is compatible with both the observed shear-wave anisotropy and the well-established 3 per cent compressional-wave anisotropy.

• Low intensity **pulsed ultrasound** is used in the clinical treatment of fractures and other osseous defects. A paper in the August issue of *Ultrasonics* reviews the clinical evidence and associated biological mechanism for fracture healing. Level I clinical studies demonstrate the ability of 1.5 MHz ultrasound pulsed at 1 kHz, 20% duty cycle, 30 mW/cm^2 to accelerate the healing time in fractures by up to 40%. Low intensity pulsed ultrasound has been demonstrated to accelerate *in vivo* all stages of the fracture repair process, such as inflammation, soft callus formation, and hard callus formation.

• A **laser beam microphone coupled with computerized tomography** to reconstruct and visualize phase in a complex sound field is the subject of an acoustical letter in the July issue of *Acoustical Science and Technology*. The laser beam microphone depends on light diffraction. When the probing laser beam crosses a sound wave, diffracted light waves are generated and propagate through a Fourier optical system where they are detected. The computer tomography (CT) method can reconstruct a cross-sectional image using projected data from many directions. The laser beam microphone offers the advantage of not distorting the sound field as an ordinary microphone would.

• A model to describe the low frequency dynamic and **acoustic response of a submarine hull** subject to a harmonic propeller shaft excitation is presented in the August issue of *Acoustics Australia*. The submarine is modeled as a fluid-loaded ring stiffened cylindrical shell with internal bulkheads and end caps. The bulkheads are modeled as circular plates and the end closures as truncated conical shells. Results are presented in terms of frequency responses at each end of the cylindrical hull and of the maximum far field radiated sound pressure. Results are also presented for the deformation shapes and corresponding directivity patterns for the first three axisymmetric modes.

• **Compressional-wave velocities in the Earth** are governed by the response of the constituent mineral assemblage to perturbations in pressure and stress according to a letter in the 21 August issue of *Nature*. The effective bulk modulus is significantly lowered if the pressure of the seismic wave drives a volume reducing phase transformation. The authors present synchrotron-based experimental data that demonstrate softening of the bulk modulus within a two-phase loop of olivine-ringwoodite (ringwoodite is a high-pressure polymorph of olivine, which is one of the commonest minerals on Earth). The time-resolved transformation between olivine and ringwoodite was defined by the x-ray diffraction pattern after a change in pressure or temperature altered the equilibrium proportions of the two phases. The data imply that phase transitions reduce P-wave velocities in the Earth's mantle.

• Corrections to the plane-wave approximation in **rapidly-flaring** horns is the subject of a paper in the May/June issue of *Acta Acustica/Acustica*. The input impedance of a horn with a slowly-varying cross section can be calculated by solving the Webster equation assuming plane waves, but this fails for horns with large flares where transverse flow effectively increases the local inertance. A simple formula is proposed, which is useful for any horn shape to calculate approximately the additional inertance.

• An article in the 16 August issue of *New Scientist* discuss-

Scanning the Journals

es the role of *FOXP2* in **human language** as well as in bird song. "*FOXP2* may have some deeply conserved role in neural circuits involved in learning and producing complex patterns of movement," commented one researcher. "Language defects may be where problems with motor coordination show up most clearly in humans, since articulation is the most complex set of movements we make in our daily life." *FOXP2* is a transcription factor, which activates some genes while suppressing others, identifying its targets, particularly in the human brain.

• "**Science in the petabyte** era" is a theme of the 4 September issue of *Nature*. Features and opinion pieces on one of the most daunting challenges facing modern science, how to cope with the flood of data now being generated. A petabyte, 10^{15} bytes, is the currency of big data. The mad, inconceivable growth of computer performance and data storage, from kilo to mega to giga to tera to peta, is changing science, knowledge, surveillance, freedom, literacy, the arts—anything that can be represented as data, an editorial points out. In doing so, it puts endless strain on the people and machines that store the exponentially growing wealth of data involved. Every watt that is put into retrieving data and calculating with them comes out in heat, whether on a desktop or in a data center. At one large data center, two floors are devoted to cooling. The large hadron collider (LHC) at CERN is expected to store about 15 petabytes of data per year.

• Increasing the **absorption coefficient** at the back wall of a classroom can increase the speech intelligibility metric U_{50} to the largest extent according to a paper in the November issue of *Applied Acoustics*. A speech intelligibility metric, U_{50}, at different receiver positions in a classroom of 10 m × 8 m × 6 m was obtained by numerical simulations based on the mirror image model, with and without the uniform surface absorption coefficient. A numerical case study was conducted in a typical classroom of 10 m × 10 m × 3.5 m, and the speech intelligibility was assessed through a third-order polynomial

• An **array of holes in a solid plate** can reduce the sound transmission at certain wavelengths according to a paper in *Physical Review Letters* 101, 084302 (August 2008). Dubbed "extraordinary acoustic screening" (EAS), the effect could be used to design acoustic shields that block sound while allowing air and light to pass through. The effect was first noticed with ultrasonic waves in a tank of water. The attenuation, which is greater than predicted by the mass law, is greatest when the spacing between the holes is about the same as the wavelength of sound.

Acoustics in the News

• A milestone has been reached in the search for a deafness cure, according to a story in the 27 August issue of *New Scientist*. A neurobiologist who is profoundly hard of hearing has developed an experimental gene therapy that generates the type of cells that are damaged or missing in deaf mice. Mice embryos were injected with a key developmental gene called Atoh 1 that led to the production of hair cells. Although no human subject committee would allow injecting a fetus with a foreign gene, the understanding gained from the ability to tweak the developing mouse cochleae might eventually allow researchers to figure how to treat deafness with drugs, the researchers point out.

• A tiny 3-D ultrasound probe can guide catheter procedures, according to a story in the online e! *Science* News of 28 August. An ultrasound probe small enough to ride along at the tip of a catheter can provide physicians with real-time images of soft tissue with the risks associated with x-ray catheter guidance. The device works like an insect's compound eye, blending images from 108 miniature transducers working together. The scientists plan to begin tests of the new system in animals within the year.

• Is it true that "the hotter the night, the louder the crickets"? Not on an individual basis, according to a story in the August 26 issue of *The New York Times*. If it's hot and there is less overall noise at that time, then the cricket chirping may seem louder. Also there will be more males chirping at the same time because of higher temperatures, and if they sing in unison, then the overall sound will be louder. Cricket metabolism and chirping speed vary with ambient temperature, with the chirps coming faster at higher temperatures. A formula called Dolbear's Law (after A. E. Dolbear, who reported his studies in 1897) provides a rough temperature gauge: count the number of chirps by a snowy tree cricket in 13 to 15 seconds and add 40 for the temperature in Fahrenheit. The formula doesn't work with the house cricket or field cricket, however.

• According to a story in the August 30 issue of *Science News*, anthropologists have found that eight hearing-related genes show signs of having evolved systematically in human populations over the past 40,000 years. Some alterations on these genes took root as recently as 2000 to 3000 years ago. Seven genes produce proteins that make stereocilia and the membrane that coats them. The eighth gene assists in building middle ear structures that transmit sound to the inner ear. It appears that evolution has increasingly promoted genes that mediate the ability to hear speech sounds. However, genes that have been implicated in aging-related hearing loss showed no evidence of systematic change in the past 40,000 years.

• Too quiet? Blindfolded subjects who listened to recordings of cars approaching at five miles per hour could locate the familiar hum of a Honda Accord's internal-combustion

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engine 36 feet away, according to a note in the August issue of *Scientific American*. But they failed to identify a Toyota Prius running electric mode until it came within 11 feet, affording them less than two seconds to react before the vehicle reached their position. At least one company is planning to market a device that projects a warning device for pedestrians when the Prius is running at low speed but shuts off when the car accelerates beyond about 20 miles per hour and creates a normal amount of wind and tire noise.

• The Federal Communications Commission (FCC) is proposing a ban on certain types of wireless microphones, according to a story in the August 22 issue of the *Washington Post*. Consumer groups alleged in a complaint last month that users of the ubiquitous microphones, including Broadway actors, mega-church pastors and karaoke DJs are unwittingly violating FCC rules that require licenses for the devices, which largely operate in the same radio spectrum as broadcast television stations. Most owners of the microphones are unaware that FCC rules require them to obtain a license. The FCC rarely enforces the licensing requirements on the microphones because there have been so few complaints.

Channels 52 through 69 in the UHF television band, currently used by broadcasters, will be vacated as they convert to digital broadcasting. The government sold the section of airwaves for $19 billion in the FCC's most successful auction is history. The concern is that microphones operating in that range may cause interference for the new licensees. It is estimated that more than 1 million wireless microphones operate in that range.

• Historically black colleges and universities (HBCUs) play a key role in producing future scientists and engineers, according to a recent National Science Foundation report. In 2006, 33 percent of the African-American students who earned science or engineering doctorates came from HBCUs, as compared with 25 percent in the early 1990s, according to the report. The top five U.S.-wide baccalaureate-origin institutions for African-American S&E doctorates during the period 1997-2006 were: Howard University, 224; Spelman College, 150; Hampton University, 135; Florida A&M, 100; and Morehouse College, 99.

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