Interdisciplinary Talkfest Prompts Flurry of Questions

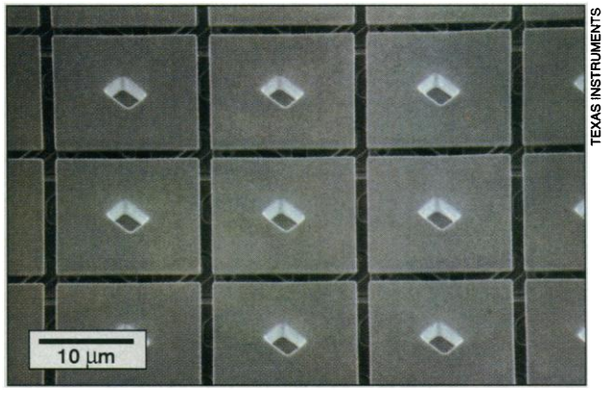
IRVINE, CALIFORNIA—Bring together 100 of the best and brightest young (under age 45) scientists for 3 days to listen to talks from the cutting edge of a variety of disciplines, and what do you get? An endless barrage of questions, as participants try to slake their intellectual thirst in fields far removed from their own. That, at least, was the dominant feature of this year's Frontiers of Science symposium,* an annual thinkfest sponsored by the National Academy of Sciences (NAS), held here earlier this month. And it was exactly the kind of atmosphere the academy hoped to foster when it sent out invitations for this unusual scientific gathering.

This year's meeting centered on eight sessions that hoisted formidable questions themselves. How old is the universe? What constitutes a language? What is emotion? How did life begin? How small a machine can humans make? And that's just for starters. "It was the best general-purpose meeting I've been to in my life," says Steven Rudich, a theoretical computer scientist at Carnegie Mellon University who specializes in complexity theory. "It's just like going to Athens and being at the center of the world. You had all these people there in the prime of their lives who are working on different stuff take a few days out and talk to each other."

This fit closely with what NAS President Bruce Alberts, who attended the symposium, had hoped people would take from the meeting. "It's a wonderful invention, this symposium," said Alberts. "We're making connections between what we hope will be the future leaders of American science."

Although past Frontiers of Science gatherings have spawned some collaborations, it is the cross-pollination of ideas during the sessions that is the meeting's raison d'être. Take the first session on micromachining, in which electrical engineers described motors, televisions, and motion sensors that are now being built on a micrometer scale (a human hair is about 50 to 100 micrometers thick). In a discussion at the end of the talks, the audience began peppering the engineers with questions and ideas about applying the microlessons of biological systems. Why not model a miniature motor after flagella, exquisite micromotors that propel cells around the body? How about linking silicon devices to cells?

This meeting could have quickly devolved into a bunch of scientists spouting off their fantastical visions about things they know little about—but it didn't, mainly because many of the presenters raised questions that require the input of scientists from many disciplines. In "The Missing Sink: Whither Anthropogenic CO_2?" Ralph Keeling of the Scripps Institution of Oceanography cited work from ecologists, oceanographers, chemists, biologists, geologists, and atmospheric scientists. Keeling raised the conundrum that although CO_2 in the atmosphere has been steadily increasing since the 1700s, many researchers believe the rate of increase should be even higher. Models predict that more CO_2 is added to the atmosphere by fossil fuel emissions and humans harvesting forests and converting them into farmlands than is observed in the atmosphere. Where, then, is the "missing sink" of CO_2?



Mirror, mirror on a chip. Texas Instruments researchers described projection device with 307,000 micromirrors.

Keeling offered startling suggestions—at least to most scientists in this audience, to judge by their questions. The high nitrogen content in acid rain, for example, might lead to increases in plant photosynthesis. "Acid rain is a fertilizer for plants," said Keeling. This, in turn, leads plants to store more carbon. Keeling explained how global warming caused by rising CO_2 levels might also increase carbon storage in plants by liberating nitrogen in the soil. "It's not obvious that temperature change is bad," said Keeling. To which a man in the audience called out, "Will this make the East Coast like Irvine?"

If Keeling's suggestions took some by surprise, the audience was downright incredulous about a session describing mathematical models on the evolution of languages. By doing an elaborate comparative analysis of words from 12 Indo-European languages, Donald Ringe, Ann Taylor, and Tandy Warnow from the University of Pennsylvania have arrived at new evolutionary trees. The significance of the roots of Old Church Slavonic, however, took a back seat to a side note about nonobvious roots of some familiar words. The Spanish "mucho," for example, has a different root from that of the English "much." "You're telling us that 'mucho' and 'much' are not the same?" asked one leery listener. "Yes," said Ringe. The listener rolled his eyes. "And we can prove it," Ringe said, noting that "much" traces back to the Greek *megas* (big), and "mucho" is derived from the Latin *melio* (better).

For the most part, the sessions didn't prove much of anything—except that science is a glorious, eye-popping enterprise that can provide plenty of surprises even for those deeply involved in it. Among the facts that raised eyebrows—and some questions: There are approximately the same number of neurons in the brain—10^{11}—as there are stars in the universe. You can now purchase the world's first all-digital projection display, which operates by twisting 307,200 mirrors, each 17 micrometers by 17 micrometers. You can physically react to fear in about 4 milliseconds, but consciousness doesn't turn on the feeling of fear for about 12 milliseconds. And the amount of plant material in the San Francisco Bay and the rivers that feed into it has been reduced by 80% since the 1980s, when an Asian clam that feeds on plants made its way to the bay (probably via a ship's ballast water).

This last point is particularly disturbing to Carla D'Antonio, an ecologist at the University of California, Berkeley, who studies how nonindigenous species of plants can overtake the natives. D'Antonio contended in her talk that "biological invaders are really a significant threat to the biological diversity of the planet." Not everyone bought that argument. "Calling them 'invaders' is biased," charged one listener. "Why don't you call them 'immigrants'?"

Still, no one could quarrel with the final dilemma D'Antonio posed. "What do we want the world to look like in another 50 to 100 years?" she asked. Now that's a good question. And it would not be outlandish to think that the young scientists at this meeting will have a disproportionate influence over what the world will in fact look like a century from now.

–Jon Cohen

* National Academy of Sciences' Seventh Annual Symposium on Frontiers of Science, Arnold and Mabel Beckman Center, Irvine, California, 2–4 November.