MULTIDISCIPLINARY MEETINGS

New Meetings Tackle The Knowledge Conundrum

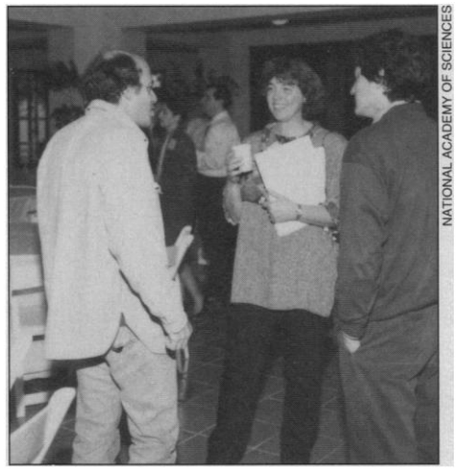
The AAAS Annual Meeting has traditionally offered scientists and nonscientists alike a broad range of topics (see page 1249). Recently, a new breed of more focused interdisciplinary meetings has sprung up to bridge the knowledge gap between different branches of science—and promote cross-fertilization of ideas.

The lights were dim and up on the big screen behind the podium was a slide showing a slice of Venusian landscape, as seen in a radar image of the planet taken by the Magellan probe of Venus. The speaker was trying to explain that this and other "ground-breaking" images of the planetary surface suggested—but didn't prove—that Venus is geologically alive, with a sharply sculpted mantle that resurfaces itself quite slowly, at least in comparison to Earth's. His audience of 100 or so were paying rapt attention when one member of the audience raised his hand to ask a quick question: "Is the cloud cover on Venus there all the time?"

What have we here? Yet another example of the scientific illiteracy of U.S. high school students? No. This audience was densely populated not only by trained scientists but by an elite group at that: a hand-picked, multidisciplinary gathering of Sloan, Packard, and MacArthur award-winners, most under 45 years of age. The best and the brightest.

Okay, so this was one of those uniquely embarrassing events that can occur at any meeting in any profession: an otherwise brilliant member of the profession shows that he is not merely out of his field but out of his depth. Wrong again. This was not a unique event. In a session the following afternoon at the very same meeting, jaws dropped when, in the course of a talk on cell growth and division, another brilliant scientist halted the speaker to ask, "What is mitosis?" And at the next session on protein structure and function, a participant blurted out, "What is a protein?"

Back to basics. Stunners like this happen every now and then at the National Academy of Sciences' (NAS) annual Frontiers of Science Symposium, which is specifically designed to guide brilliant, young scientists in one field to lectures by brilliant, young scientists in other, often remote fields. And the cause of these little surprises is something more significant than the fact that NAS president Frank Press opens each edition of the symposium with the encouraging statement: "There are no stupid questions." The deeper explanation of the phenomenon is that science has become so complex—and, hence, so fragmented—that it is no more likely for a top scientist to reveal ignorance of another discipline than it is for a youngster to display the same knowledge gap. That was a conclusion of Robert Hazen and James Trefil, both scientists at George Mason University in Fairfax, Virginia, who, about 2 years ago, made up a "Science Vocabulary Exam" based on the highly specialized curriculum of Hazen's sixth-grade daughter. They gave it informally to about 100 Ph.D. scientists, who typically scored between 20% and 30% (*Science*, 18 January 1991, p. 266). "The problem," says Hazen, "is that our educational system, even in the sixth grade, is too focused. It offers rigor in a narrow discipline, but fails to offer context."



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Mixing it up. Impromptu interactions at the academy's Frontiers meeting.

But is the need to bridge such gaps of ignorance reason enough to invite top scientists from one discipline to give up days of valuable research time, at the risk of making fools of themselves before scientists of another discipline? Of course not: There's something more significant going on. And that explains why, lately, substantial numbers of top scientists have become involved in arranging or participating in a handful of newish meetings organized around the principle that scientists of one field should be induced to mingle with scientists from other, often remote, disciplines. Besides the NAS Frontiers of Science Symposium, there is, for example, the Scientist to Scientist Colloquium in Keystone, Colorado, where the organizers, the nonprofit Keystone Center, like their NAS counterparts, refuse to reveal in advance the program of sessions so that their elite 80 or so attendees and speakers must stay for the entire meeting, rather than skipping out whenever sessions seem unconnected to their work. Another attempt of a similar nature is the even younger, but much larger, Science Innovation meeting sponsored by the AAAS. Beginning last year in San Francisco, this confab brought together hundreds of instrument types, often physical scientists and electrical engineers, to chat with a couple thousand biologists and chemists about two common interests: the latest tools driving scientific progress and the need for yet-to-be discovered tools.

The common denominator in these efforts is that organizers and attendees alike are realizing, more and more, that scientific progress often comes out of multidisciplinary activity and unexpected alliances. What is most valuable about such meetings, says incoming NAS president Bruce Alberts, is the chance to meet people with different specialties. "From personal contacts come all sorts of opportunties," he says. "Together, people can do things they can't do as individuals."

What's more, "it is the people who have breadth who often come up with the important findings," adds Philip S. Abelson, former long-time editor of *Science*. He cites as an example the late Nobel physicist Luis Alvarez, who first proposed that the sudden decline of dinosaurs might be associated with a collision of an extraterrestrial object with Earth. Alvarez and his colleagues made the connection that iridium, a common element in asteroids and comets, but rare on Earth, is found in especially high concentrations in the thin layer of sediments associated with the boundary of the Cretaceous and Tertiary eras, the time when dinosaurs disappeared. Another example is found in the work of Francis Crick, who received his initial training in physics, and James Watson, a graduate in zoology: They coupled their talents to use x-ray diffraction techniques to determine the structure of DNA. "Some of the greatest achievements in science come from work at the boundaries of disciplines," says Hazen, "and you can't work there unless you have familiarity with various areas."

That opportunities for such advances might arise not merely in chance encounters or in large, multidisciplinary teams, but even at meetings, can be illustrated from another event that took place at the Frontiers meeting held last fall, as usual at the academy's Beckman Center in Irvine, California. There, Rutgers University mathematician Ingrid Daubechies was giving a talk on wavelets, a new technique for culling the significant points from mountains of data. She discussed

how wavelet analysis can be used to, for example, ease the processing of speech signals and photographic information. But before the conference was out both Claire Max, an astrophysicist at the Lawrence Livermore Laboratory, and Richard Friesner, a theoretical chemist at Columbia, had begun to look into ways for using wavelets to speed their own computations. Friesner, for example, is considering use of this new mathematical technique to solve equations that describe the electrostatic interactions of proteins with water. "Wavelets are too powerful a tool for analysis to be left just to the mathematicians," says academy president Press. Yet, he notes, because wavelet analysis is a new, technical discipline, where discussions are confined largely to mathematical journals, most researchers can learn about them only from chance encounters with mathematicians and their literature, or by coming to Frontiers-type meetings. "Networking does work," adds Press.

Innovative interactions. Indeed, it was in hopes of fostering such cross-fertilization of ideas under AAAS auspices that the organizers of the Science Innovations meeting scheduled sessions on biomedical imaging, plant molecular biology, and laser-based chemical analysis, among others, that were designed to capture the interests of a broad audience. The idea was that such a gathering would draw some of the best scientists who, says Abelson, "are somehow capable of taking in new information, storing and processing it and, with a bit of intuition, weaving things together in a novel way."

Yet, even when the interactions of scientists in unrelated disciplines don't produce a Eureka during the very course of a meeting, seeds may be planted that yield fruitful interactions long after the meeting. Indeed, Whitehead Institute geneticist Eric Lander, who chaired last summer's Scientist to Scientist colloquium, says that provoking collaborations among scientists of disparate interests need not be the primary goal for such meetings. Rather, it should be enough to establish a setting where scientists can get to know and respect each other's work. "The professional demands of doing good science, focusing in on a problem, are often in con-

Measures of Success at the Frontiers

On the surface, the national academy's "Frontiers of Science" symposium is fairly routine: two and one-half days of all-star speakers on subjects such as ozone holes, structural biology, and high-energy physics, broken up by coffee (poorly brewed) and a banquet (lean but elegant). But as with all classy gatherings, it is the attention to detail that elevates it above the rest. After 4 years of operations, the Frontiers organizing committee has fine-tuned its operations to get scientists who don't know each other, and may not share the same vernacular, to discuss science that could be, and should be, of mutual interest.

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Beckman beckons. The academy's new conference center in Irvine, California, provides an added attraction.

A key to success is offering opportunities for talk, and plenty of it, over breakfast, at breaks, and at late-night hospitality suites, all in nonstressful situations. The untutored of the day's discussions are not hesitant to approach the bigwigs, knowing full well that, tomorrow, the tables may be turned. This relaxed atmosphere does not, however, bar the subtle manipulation of settings, such as arranging seating at dinners. The academy's attractive, West Coast venue at the Beckman Center on the campus of the University of California, Irvine, overlooking the Pacific, can also be a lure for the 100 or so scientists lucky enough to be invited. "It is hard to turn down an opportunity to get the broad view of science, from top researchers, in a short period," says University of Minnesota, Minneapolis, materials scientist Lorraine Falter Francis, who temporarily discarded her subarctic gear to enjoy a bit of Southern California's Mediterranean climate.

Indeed, William Spindel, who spearheads the program, says its success can be judged by the high rate of acceptance of invitations, even though very few find something on the program of obvious relevance to their own work. "The scientists vote with their feet and, if invited, they're delighted to come," he says. What's more, in an era when a scientist's stature is often inversely related to the time spent at a meeting, most who come stick around for the final session.

The symposium was started, says academy president Frank Press, as part of the national academy's ongoing effort "to seek ways to improve American science and the way people work together." This is not restricted, he stresses, to interactions in the lab. For sure, the Frontiers program has fostered both the cross-fertilization of ideas and some collaborations. For example, following a first meeting at Irvine, synthetic chemist Mark E. Davis of Caltech started a project with Don Eigler of IBM in San Jose to build nanometer-sized structures that could function as atomic switches.

But probably more rewarding for this group of young researchers is the opportunity to discuss those issues that rarely appear on formal scientific agendas; the contrasting cultures between those disciplines where experimental opportunities are rich, such as biology, and those, such as astronomy, where they are more limited; different strategies for supporting and finding jobs for students; and the challenges of working in a scientific group that routinely demands cooperation among dozens, or hundreds, of scientists. Davis, for example, was particularly intrigued "to learn how the high-energy physics community organizes itself to influence the government to support its expensive facilities." Such wide-ranging discussions, says Press, lead to the networking the academy wants to encourage and, most important, to the training of the future policy makers of science.

But is this enough to merit more Frontiers-type meetings? It is too soon to conclude whether such endeavors produce scientists with better all-around smarts but, already, the academy has some early signs that their hunches about the scientific leadership of tomorrow are proving correct. University of Colorado biochemist Thomas Cech, who was a speaker at the first Frontiers symposium in 1989, won a Nobel Prize in Chemistry later that year; two other speakers, Vaughan Jones of the University of California, Berkeley, and Edward Witten of Princeton University, went on to win the prestigious Fields Medal in mathematics; and Robert Tjian of the University of California, Berkeley, won the national academy's Award in Molecular Biology in 1991.

–A.S.M.

flict with what is needed for the total scientific community, a broader outlook," says Lander. "We don't train each other." More broadly trained scientists, he says, "are needed for the development of good science policy."

Marcia McNutt, a Massachusetts Institute of Technology earth scientist and an organizer of this year's Frontiers Symposium, agrees, noting that, "We weren't raised in a broad enough culture to make judgments about science in the broadest sense." She acknowledges that society can't afford to do everything proposed by scientists, and, currently, most scientists are unwilling or unable to make judgments about priorities. As a result, McNutt says, "politicians often make the decisions for us. Frontiers-type symposia might allow us to raise a new generation of scientists who are better trained to establish priorities."

But could it be that the vast preponderance of hours devoted to these kinds of interactions—not to mention the travel dollars spent for activity that may not further one's research—are wasted in the grand scheme of things? Are these meetings simply chic events, opportunities to socialize in elegant settings and, perhaps, establish some groundwork for election to the academy? Are the views of Alberts, Hazen, McNutt, and the like simple hype? Just how much do molecular biologists need to know about the surface of Venus anyway?

Many of those invited to the Frontiers or the Keystone meetings hesitated before agreeing to come, uncertain whether it was worth the time. "Most people were suspicious, including myself," says Princeton University physicist David Gross, who attended a Keystone meeting. "But it was an extraordinary meeting with some spectacular talks. We heard about science from the top practitioners, who made an extraordinary effort to explain their fields."

Yet others argue that, if all you're really going to get out of these experiences is a broader education, there are other, and cheaper, ways to get it: from *Scientific American*, say, or from the weekly Research News offerings and Perspective in *Science*, and the News and Views section in *Nature*. Indeed, isn't that the raison d'etre for "horizontal" publications anyway? What's more, Hazen argues, the scientific community itself has produced some stellar authors, such as Stephen Jay Gould and Richard Feynman, and if scientists couldn't find the time or money to attend multidisciplinary meetings, they would benefit from putting time aside to enjoy their books, which are aimed at general audiences.

But there's a hitch. The plain truth, says Press, is that "most scientists have little time to read outside their fields." Says Friesner, "I could read more to gain breadth, but that is an inefficient use of my time. I find out what is new and incisive by talking to people at meetings and to my friends." So, in the end, meetings may offer an especially good opportunity for scientists to broaden their own education.

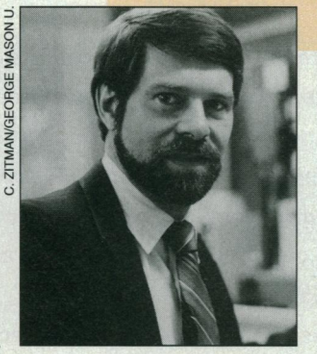
THE KEYSTONE CENTER

Keystone stars. The Scientist-to-Scientist Colloquium features top speakers. Last year's included *(from left to right)* Ronald Cape, Robert Craig, Jonas Salk, Eric Lander, and David Baltimore.

In fact, the drive to reverse the ever-increasing pressure to specialize in science—to move toward interdisciplinary studies—has become so powerful that it has even pushed the organizers of some traditionally specialized meetings to program subjects that were once thought alien. A few years ago, for example, a Gordon Conference on Diffraction Physics, which often surveys the latest advances in the use of x-rays to study individual atoms or small clusters, had a talk by a protein crystallographer on how a particular set of x-ray diffraction techniques can be used to determine complex viral structures containing thousands of atoms.

"Our educational system offers rigor in a narrow discipline, but fails to offer context."

–Robert Hazen



C. ZITMAN/GEORGE MASON U.

The trend can also be seen in both the biotech industry and, ever so slowly, in academia. In the former, chemists and instrumentation gurus are not only increasingly being brought in to create interdisciplinary teams but lab heads invite scientists from other disciplines, like math, to give lectures on a regular basis. At Monsanto, for example, the so-called Technical Community of Monsanto invites outside speakers such as Cornell chemist and Nobelist Roald Hoffmann, who spoke on "molecular beauty." Such talks can be broadcast from the company's headquarters in St. Louis, to its Life Sciences Research Center in nearby Chesterfield, Missouri, and to its pharmaceutical subsidiary, Searle, outside Chicago, using video conferencing. And at Genentech, in South San Francisco, there are two or three seminars daily, presented by job candidates, scientists up for promotion, and visitors. "They were not organized with the explicit purpose of broadening our staff, but they do serve that function," says protein chemist Andy Jones.

New perspective. In the slow-to-change world of academia, efforts like molecular biologist Leroy Hood's novel Department of Molecular Biotechnology at the University of Washington in Seattle, provides as good an example as any of efforts to cut across traditional departments in a university setting. This new department is recruiting synthetic, analytical, and physical chemists, applied mathematicians and physicists, computer scientists and engineers, not to mention biologists of various persuasions, to help crack open the crucial systems and networks that direct living systems. Few researchers, however, are lucky enough to have sugar-daddies, in the guise of computer genius and boyish billionaire Bill Gates, to fund such endeavors.

Again and again, the goal is to help scientists become better generalists. Why? As in the case of Max and Friesner, the immediate take-home prize can be concrete and significant. But even if it isn't, scientists who have participated in the broad range of experiences that drag them away from their everyday concerns insist that it may be extremely valuable. Hazen, for example, says that scientists have evolved their own society somewhat akin to an ancient priesthood. "We are the priests who go through rituals, have our own language, and design labs as our temples," he says. If that is true, attendance at a Frontiers-type meeting might just have the effect of drawing researchers out of their cloistered existence and into a heightened stage of enlightenment. Iowa State University surface scientist Patricia Thiel describes her first experience at Irvine with a more secular twist. "Science is like a secret society with its own code and language. Sometimes you get lucky and meet someone who explains it all."

–Anne Simon Moffat