Diverse AAAS Converges in Atlanta

DNA Goes Electric

DNA is a remarkable molecule, but researchers have long debated its talent for conducting electricity. An electron moving from bond to bond along one of DNA's helical backbones, many assumed, would follow a slow, circuitous path. That's a pity, because technologies exploiting DNA's ability to carry information and probe for other molecules would be easier to develop if DNA could also transmit electrons fast. But in Atlanta, chemist Thomas Meade of the California Institute of Technology demonstrated that it does not pay to underestimate the double helix.

Meade and his colleague Jon Kayyem found that the molecule can carry electrons efficiently after all—and believe that electrons take a straight shot down a central channel. By setting up an electron detection system at either end of this channel, they found that electrons shoot through DNA like bullets. “The rate we found was very fast,” says Meade.

Their work should open the way to exploring DNA's basic physics by testing the effect of different strand lengths or combinations of DNA bases on conduction speeds. “It's a nice model system, and it will allow them to make stronger statements about distance dependence,” says electron transfer theorist David Beratan of the University of Pittsburgh. Moreover, say Meade and his colleague, this work may point to a simple DNA-based diagnostic device.

DNA researchers have long known of the channel, which runs down the center of the ring-shaped molecules formed where the complementary bases on DNA's two strands meet. And some guessed that it might have conducting properties because the joined bases have electron bonds called π orbitals that stick up perpendicular to the ring, forming what is known as a π-stack—a high-speed path for traveling electrons. Proving the existence of the π-stack has been a dicey chore, however.

In 1993 Caltech chemist Jackie Barton's group made a stab at measuring the rate of electrons through DNA and found it to be very fast for a biological molecule, supporting the π-stack theory (Science, 12 November 1993, p. 1025). Barton slid an electron donor molecule into the helix near one end of a DNA strand and a receptor molecule million electrons per second.

That more modest speed sounds more realistic to some researchers. “I'm more comfortable with Meade's numbers,” says biophysicist José Onuchic of the University of California, San Diego. Barton, however, stands by her results: Her experiment revealed higher rates, she says, because her donor molecules injected electrons straight into the π-stack, while Meade's electrons have to wind through the ruthenium complex before reaching the start of the stack. Chemist Brian Hoffman of Northwestern University believes both techniques will make a contribution to the field: “The two sets of results will end up adding, not canceling,” he says.

Meade and Kayyem are not contenting themselves with just answering a few questions of chemistry, however. “We set out to study electron transfer in biomolecules and came across an application,” says Meade. The boosted conductivity of the π-stack, they realized, would make their system a dandy biological sensor to detect precise sequences of DNA in blood, for instance, or pathogens in watercourses. Meade and Kayyem's idea is to fabricate specific single strands of DNA with attached electron donor and receptor complexes, fix them to a substrate, and hook it into an electric circuit to measure the rate at which electrons pass through. The single strands have no π-stack, and so current through them will be slow. But if the substrate is dipped into a solution, such as blood, containing complementary strands of DNA, these would bind onto the attached strands to form DNA helices, and conduction speeds would shoot up.

In theory, that is. “They need to demonstrate a significantly different rate of electron transfer between a perfect match and a single-base mismatch,” says David Barker, vice president for scientific development at Molecular Dynamics of Sunnyvale, California, which is funding research on the sensor. Most rival DNA sensors are not very accurate at picking up single-base mismatches, so if the new scheme passes this test, it would find a good market niche. The researchers are currently working with strands of different lengths and different base pair sequences to test length and mismatch dependence. “If it's really sensitive to mismatch, then we start celebrating,” says Meade.

—Daniel Clery

Painting a Grim Funding Picture

Now that Republicans are in power in Congress, scientists can blearily ignore Democrats' insistence that basic research be linked
to specific national goals and expect a return to the good old days of no-questions-asked funding. Right? Wrong, says Representative George Brown (D–CA), former chair of the House Science Committee. In a grim speech to AAAS members on 17 February, Brown offered two reasons why the Republican agenda spells much bigger trouble for the scientific community than Democratic efforts in recent years to link basic research with applied efforts, a policy influential House Republicans promise to reverse.

First, there is the budget picture, which Brown says is far gloomier now. “The magnitude of cuts that are looming boggles the mind,” says Brown. He forecasts a 25% cut in government spending for research and development over the next 5 years to help balance the budget and pay for tax cuts. Even though there are science advocates among the Republican leadership, the congressman says these larger forces inevitably will dominate the political scene, leading to “deep and broad” cuts, especially at research universities.

Second, scientific research is likely to run head-on into the conservative Republican social and political agenda, and the collision could endanger funding still further, according to Brown. Fetal and genetic research are obvious examples, but much of the scientific agenda is also at risk, says Brown. “Environmental research discovers environmental problems that might lead to regulation. Global warming would be a good example. And biological research may lead to the discovery of additional endangered species,” he says. That means Republican lawmakers could meet funding requests with concern and skepticism. “And, unlike public television, you don’t have Big Bird to help defend yourselves before Congress,” Brown adds.

This political threat, coupled with budget pressures, means scientists will have to lobby harder for their funding, something Brown criticizes academics for having been reluctant to do in the past. He blasted academia for not using the political muscle latent in the extensive U.S. university system—a system that employs nearly 2.5 million people, more than the auto, textile, and aircraft industries combined. And by not trying scientific research tightly to national priorities, Brown warns that scientists leave themselves open to the charge that their work is a luxury the country can no longer afford.

In the past, scientists at the National Science Foundation and the National Institutes of Health have countered that such strategies only increase applied research efforts at the expense of basic research. And in Atlanta, scientists again reacted coolly to Brown’s alarm. Richard Zare, a chemistry professor at Stanford University, said government had such a poor record of directing research into specific areas that could benefit industry—the approach rejected by Republicans—that it wasn’t worth defending. And Ernest Moniz, chair of the physics department at the Massachusetts Institute of Technology, said Brown’s doom-and-gloom scenario seemed overblown. “This is more of a readjustment than a revolution,” he noted.

While scientists debated the accuracy of the Democratic congressman’s predictions, there was silence from the one group that might be able to provide more concrete answers. No Republican lawmakers or congressional staff turned up at the Atlanta conference. AAAS organizers say that new House Science Committee chair Robert Walker (R–PA) and his staff declined invitations. House Speaker Newt Gingrich—a dues-paying AAAS member—offered to do a videotaped speech, but organizers preferred a live appearance. The closest they got was spotting the speaker at the Atlanta airport during the meeting—his home district is right next door to the city.

—Andrew Lawler

Putting Methane Worries on Ice

A decade ago the late Roger Revelle came up with a prediction that sparked a hot debate among climatologists. Some 640 million metric tons of methane gas, he estimated, trickled out of icy ocean sediments into the atmosphere each year, feeding a buildup of greenhouse gases that—like extra coals shoved onto a fire—could drive average global temperatures higher. But new measurements presented in Atlanta—apparently (USGS) estimates that about 13 trillion tons of methane are trapped in oceanic gas hydrate deposits, says Keith Kvenvolden, an organic geochemist at USGS in Menlo Park, California. Oil companies, which used to view hydrate as a sludgy nuisance, are now looking for ways to exploit these abundant deposits as an energy source (Science, 28 June 1991, p. 1790).

Revelle, however, had thought hydrates were even more abundant. He had assumed gas hydrate could form anywhere beneath the ocean floor, because two conditions necessary for its formation—high pressure and low temperature—were present whether one looked in shallows or in the ocean abyss. In the late 1980s, however, geochemists began paring down Revelle’s estimates after studies suggested that gas hydrates formed only in organic sediments near shore, where bacteria in the sediments produce the methane. Until recently, the best guesses for releases of oceanic methane worldwide had shrunk to less than 5 million metric tons of methane per year.

Now comes Kvenvolden with a more direct measurement—and an estimate that is even lower. During the past 2 years, Kvenvolden has measured methane levels in the Beaufort Sea off the coast of northern Alaska, which is thought to harbor some of the more volatile hydrate deposits. His team, which published data from its 1993 Arctic field season in Geophysical Research Letters (19 November 1993, p. 2459) and presented additional data from last year’s field season in Atlanta, sampled methane concentrations in the Beaufort Sea’s water columns. It appeared to be the kind formed by sediment-dwelling bacteria, because it is richer in light isotopes of carbon than is geothermally produced methane, although Kvenvolden admits there is still some room for doubt.

What was very clear was the tiny amount of the gas in the water samples: less than 20 parts per million. If that rate is similar worldwide, Kvenvolden says, then gas hydrates are releasing no more than 130,000 metric tons of methane per year. That’s barely a hiccup compared to the estimated 720 million metric tons belched annually by terrestrial sources such as cows, rice paddies, and coal mining. “The stuff Kvenvolden’s doing is right on the money,” says Charles Paull, a marine geologist at the University of North Carolina, Chapel Hill. “His data are very relevant for putting into better perspective some of the estimates of methane’s impact on global warming.”

The key to a more solid conclusion will be
Painting a Grim Funding Picture
Andrew Lawler

Science 267 (5202), 1270-1271.
DOI: 10.1126/science.267.5202.1270-a

http://science.sciencemag.org/content/267/5202/1270.2.citation

http://www.sciencemag.org/help/reprints-and-permissions

Use of this article is subject to the Terms of Service