PROFILE: BRIAN O'NEILL

Trying to Lasso Climate Uncertainty

An expert on climate and population looks for a way to help society avoid a "Wile E. Coyote" catastrophe

LAXENBURG, AUSTRIA—A few weeks ago, Brian O'Neill hunkered down around a table with a dozen other climate scientists in Cape Town, South Africa, to talk about the future of the planet. It was no idle speculation: Whatever they agreed upon—they knew in advance—would have clout. They were hammering out the final draft of a chapter on research methods for the massive "Fourth Assessment" of the Intergovernmental Panel on Climate Change (IPCC). The product of 3 years of consensus-building among several hundred researchers from around the world, the IPCC report is the scientific bedrock on which policymakers will negotiate everything from carbon taxes to long-term greenhouse gas targets.

But for all its authority, the IPCC exercise left O'Neill with a nagging concern: What were they leaving out? "It's important that we climate scientists speak with a single voice," he said in an interview back in his office, high up in the attic of a former Habsburg palace outside Vienna. But "the extreme scenarios that tend to fall out of the IPCC process may be exactly the ones we should most worry about," he says.

O'Neill, a climate scientist at the International Institute for Applied Systems Analysis (IIASA) here, is frustrated to see uncertainties in research used as a reason to delay action. At age 41, he is one of the youngest scientists in the IPCC network trying to reformulate climate-change projections that can cope better with uncertainty by accounting for "future learning." O'Neill hopes the strategy will make it clear that, even with gaps in understanding, it pays to act now.

His work is gaining notice. Although an American, O'Neill has scooped up one of the coveted European Young Investigator Awards (EURYI), a $1.5 million grant meant in part to keep Europe's most promising scientists at home.* "He is one of the brightest young scientists out there, and we're all watching to see what he does," says Simon Levin, an ecologist at Princeton University.

* See article on sciencecareers.org (sciencecareers.sciencemag.org/career_development/previous_issues/articles/2006_10_13/an_ambitious_effort_to_plug_europe_s_research_gap).

A winding path

O'Neill's job is to predict the future, but his own career path has been unpredictable. With 3 years' training in engineering and a degree in journalism, he became passionately involved in the 1980s in efforts to prevent ozone depletion, working for Greenpeace in California. After collecting a Ph.D. in earth-system sciences from New York University, he did research stints at Brown University and the Environmental Defense Fund in New York City.

In 2002, he moved to IIASA, a center for multidisciplinary research founded in 1972. Here, O'Neill has built up a new program focusing on population and climate change. The treatment of demographics in most climate-change analyses, he says, is "simplistic at best." With the EURYI money, he's assembled a team of a half-dozen demographers, economists, statisticians, and physical scientists to sharpen the models.

Futurist. Brian O'Neill and his group think big improvements are needed in estimates of China's role in climate change.

CREDIT: PROVIDED BY B. O'NEILL

A long-limbed basketball player who looks like he could be fresh out of graduate school, O'Neill seems to peel away layers of uncertainty as he speaks. His slow-paced answers to questions often begin with a detailed preamble of assumptions, conditions, and footnotes. But as the father of two daughters, he says, "thinking about how the world will be in 50 years is not so abstract for me anymore."

At IIASA, his work focuses on building realistic demographic projections, and China has become his main beat. Different predictions of how the country's population will age and urbanize—and how carbon-emission policies will shape Chinese consumption—have an enormous effect on global climate change scenarios. But obtaining accurate demographic data has been difficult. With the help of a Chinese member of his new team, O'Neill has done an analysis revealing that the IPCC assumptions about China's rate of urbanization and energy consumption could be off by a factor of 2.

Learning about learning

Earlier this year, O'Neill organized a unique meeting at IIASA, bringing together experts from different areas of climate science, economics, and demography to think about how they generate knowledge. One of the most important questions that emerged, says Klaus Keller, a climate scientist at Pennsylvania State University in State College, is how do you avoid "the Wile E. Coyote effect?" The cartoon coyote often doesn't realize he's falling off a cliff until he looks down, too late to turn back. One of the potential cliffs in climate change involves the ocean's conveyer-belt system—known as the meridional overturning circulation (MOC)—which prevents a Siberian chill from spreading across western Europe by carrying warm water north from the equator. Scientists worry that global warming could abruptly change or even shut down the MOC. "These are the kind of climate thresholds that we need to identify," says Keller.

Scientists need to know more about the natural variability in MOC behavior, says O'Neill. But they don't even know "how precise your measurements have to be" or how large an area must be studied

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before uncertainty could be sufficiently reduced to spot "the edge of the cliff." He argues that the only way to attack such complex uncertainties with limited time and resources is to have scientists from different fields work together, assessing observations over many years to learn which approaches pay off the most. O'Neill and others did exactly this with 2 decades of research on the carbon cycle, finding that some kinds of observations narrowed uncertainty in model parameters far better than others. Such big-picture, multidisciplinary studies are low on the priority scale of funding agencies, but this is exactly what's needed if you want "to learn about the potential of an MOC shutdown," he says.

The second big question to emerge from the IIASA sessions is how can we tell if mainstream research is headed in the wrong direction? O'Neill, Michael Oppenheimer, and Mort Webster, climate scientists at Princeton and the Massachusetts Institute of Technology in Cambridge, respectively, use the term "negative learning" to describe cases in which scientific consensus builds around the wrong model. "This is what happened with ozone," says Oppenheimer. People believed that ozone's key interactions are with other gases, until scientists realized that the critical reactions driving ozone depletion occur on the surfaces of airborne particles. With revised reaction rates, it was suddenly clear that the planet's protective ozone layer was in much bigger trouble than had been thought. Oppenheimer proposes that scientists team up with philosophers and historians to find common signs of negative scientific learning. A search for such red flags could be built into climate science's regular review process. And O'Neill says more funds should be set aside to explore hypotheses outside the mainstream.


Modelers' home. A Habsburg palace near Vienna is inhabited by IIASA scientists.

Researchers desperately need a strategy for tackling climate uncertainties, O'Neill says. Michael Schlesinger, a climate scientist at the University of Illinois, Urbana-Champaign, points to another example. Polar ice sheets are melting more rapidly than anticipated, and some observers fear that this could lead to a catastrophic sea-level increase (*Science*, 24 March, p. 1698). "Things are happening right now with the ice sheets that were not predicted to happen until 2100," Schlesinger says. "My worry is that we may have passed the window of opportunity where learning is still useful."

Whether a catastrophe can be averted using some form of scientific introspection—or learning about learning, as O'Neill calls it—remains unclear. The concept, like O'Neill's career, is still at an early stage of development.

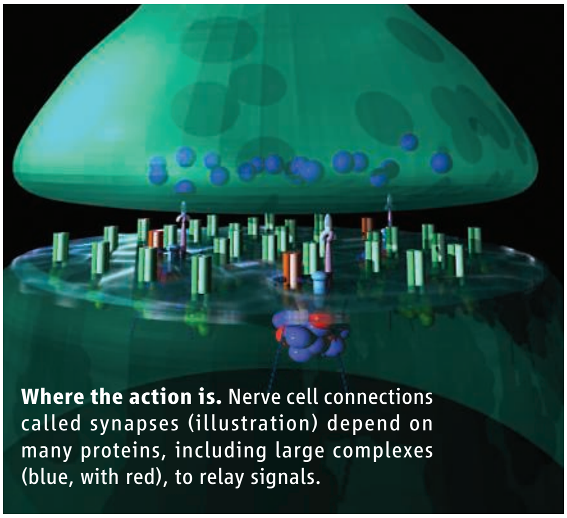
–JOHN BOHANNON

NEUROSCIENCE

Brain Evolution on the Far Side

Over evolutionary time, the protein portfolio of the receiving side of the synapse has become more sophisticated—could that be why brains got bigger and smarter?

Mind the gap. To Londoners, that phrase, which warns subway commuters to be careful stepping off platforms onto trains, has become such a cliché that it's emblazoned on T-shirts and posters. But to Seth Grant, who works at the Wellcome Trust Sanger Institute in Hinxton, just an hour or so north of London, it's an apt summation of his research focus.


Where the action is. Nerve cell connections called synapses (illustration) depend on many proteins, including large complexes (blue, with red), to relay signals.

After years of studying the 10- to 50-nanometer gaps between nerve cells called synapses, Grant is convinced that a key to the evolution of the brain lies within these crucial connections. The human brain relies on a quadrillion synapses to connect its circuitry, and Grant has been comparing, in species big and microscopic, the protein milieu of the synapse's far side, the portion that receives another neuron's signals.

As nerve cells fire, the transmitting neuron quickly releases chemicals called neurotransmitters—the release takes about 200 microseconds in the giant squid—that zip across the synapse to another nerve cell's membrane. That "postsynaptic" membrane is awash with cell surface receptors and signaling molecules standing by to relay incoming signals throughout the cell. And with some 1100 proteins, says Grant, "the most molecularly complex structure known [in the human body] is the postsynaptic side of the synapse."

Grant maintains that these proteins hold new clues about the evolution of the brain. He has found major species differences among the protein content of the postsynapse, disparities that could help explain, for example, the improved cognitive capacities of vertebrates. "Maybe synapse protein evolution has been more important than [increases in] brain size," says Grant.

His work also suggests that neurobiological research with invertebrates is less relevant to the human brain than researchers have assumed. "The textbook version is that a synapse is the same thing in a human and a slug," says Svante Pääbo, a molecular geneticist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. "[Grant] shows that that is not likely to be the case."

Many evolutionary biologists attribute the unique properties of the human brain to its relatively large size and complex cortex. But Grant thinks that ever-more-intricate molecular interactions within synapses have made possible the circuitry that underlies our ability

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