

country's booming research enterprise. They returned to a vastly different intellectual environment: one with far more money for research, but dominated by political connections and more intolerant of dissent—and still hindered by a top-down distribution of grants and accolades. “The ethos and culture of the domestic research system” took a hit after 1989, notes Richard Suttmeier, an expert on Sino-American science cooperation at the University of Oregon, Eugene. “It is hard to recover from that.”

In surveys and interviews, overseas scientists tend to name the complex social relations shaping Chinese science as the key impediment to their return, Zweig says. “If you’re not part of the inner network, if you’re not part of the team of the director of the institute, you’re not going to get grants,” he says.

Returnees concur that fundamental cultural issues hamper Chinese science. One prominent scientist who was barred from China after 1989 for his political activities but eventually returned from the United States to head a lab on the mainland says that a rigid hierarchy and lack of openness thwart scientific debate. While the culture is gradually changing, he says, the top-down distribution of grants and a lack of investigator-initiated projects mean that “big investments are sometimes wasted.” Young scholars are discouraged from contradicting their advisers, He adds. “If you have a higher position, people think you are more right.”

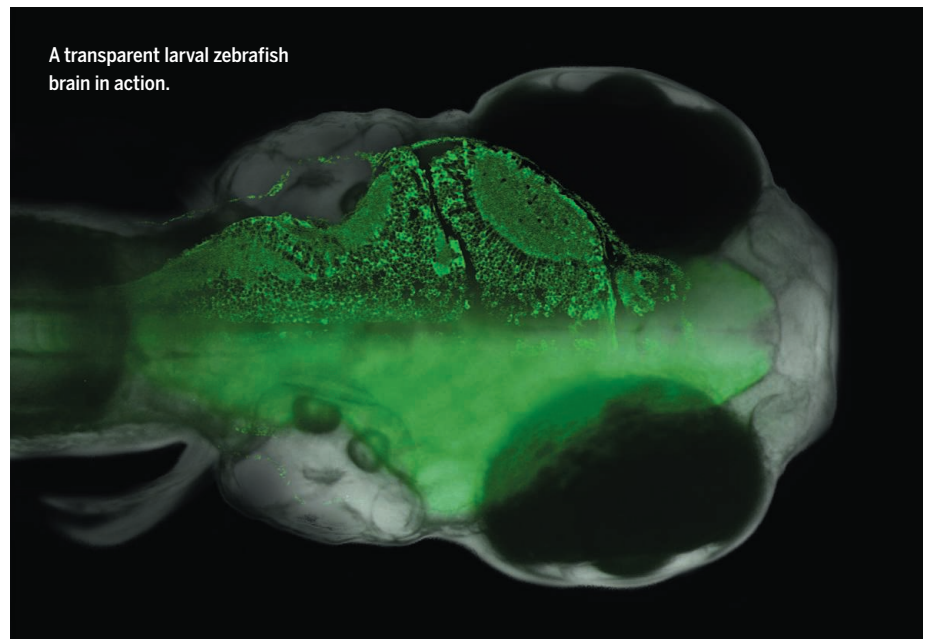
Such shortcomings seem to hardly register with Chinese science officials, many of whom question why the government's outlays haven't yielded more breakthroughs—or netted the nation a Nobel Prize in science. To try to boost innovation, the government has stepped up efforts to bring overseas Chinese scientists back home. Foreign-born researchers are now wooed, too, under the Recruitment Program of Foreign Experts introduced in 2011. Some say that scientists brought in under such programs are helping change China's research culture—by instituting reforms within their labs and sitting on university committees dedicated to institutional change. China's science ministry has even consulted former dissidents for their thoughts on scientific reform.

But the recruitment drive misses the point, Zhang contends: “The most important question is not talent. It is the loss of vitality.” In the wake of the Tiananmen crackdown, he says, Chinese intellectual life lost its edge. Without that, he notes, “They can train engineers and scientists, but the really original inventions won't come from China.” ■

PODCAST

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NEUROSCIENCE

BRAIN project meets physics

Neuroscientists have some wild ideas for measuring brain activity. Physicists are providing a reality check

By Emily Underwood

Neuroscientists were over the moon in April 2013 when President Barack Obama announced a bold new initiative to study the human brain in action. But in their heady excitement, some may have forgotten to check the math in their first proposals. At least, that's the contention of a group of physicists, engineers, and neuroscientists meeting this week in Arlington, Virginia, to discuss which ideas are likely to succeed and which may fall flat.

Key to the success of the roughly \$100 million Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative is crafting new tools or methods to measure neural activity either from inside or outside the brain. Unfortunately, some ideas “violated either a physical law or some very significant engineering constraint or biological constraint,” says neurophysicist Partha Mitra of Cold Spring Harbor Laboratory in New York, who helped organize the meeting, sponsored by the National Science Foundation.

The goal is to have a realistic discussion of what the physical limits are, he says, so “scientists who want to make devices will not make crazy proposals,” or, “if a proposal

is crazy, one could recognize it as such” and look for other ways to make the idea work.

One such “fanciful” idea is to build nanosized radios that could snuggle up to individual neurons to record and transmit information about their activity, says physicist Peter Littlewood, director of Argonne National Laboratory in Lemont, Illinois. But any radio small enough to be injected into the brain without causing significant harm would not be able to transmit any information out through tissue and bone, he says. Make the devices any more powerful, he adds, and they'd likely cook the surrounding brain. Another aspiration that is likely doomed is to get microscopes that probe the brain with pulses of light to penetrate much further than they already do, Mitra says. A little more than 1 mm is possible, he adds, but even 1 cm is “out of the question, since the signal to background [noise] ratio decreases exponentially with depth.”

But physicists and engineers shouldn't simply shoot down outlandish proposals—or gripe about the intrinsic messiness of the brain's biology. They should model themselves as “fancy technicians” who can help develop revolutionary tools, Littlewood says. There are precedents for such collaboration, he notes: He, Mitra, and their colleagues at Bell Labs, for ex-

ample, helped develop functional magnetic resonance imaging in the 1990s.

One area where physical scientists can help today is in fashioning small, strong, conductive wires that can record from many different neurons simultaneously, says neurophysicist David Kleinfeld of the University of California, San Diego. For decades, neuroscientists have relied largely on electrodes fashioned from fragile glass pipettes. But only a small number of these sensors will fit in a given brain region without disrupting connections between cells or killing them outright. Biophysicist Timothy Harris at the Janelia Farm Research Campus in Ashburn, Virginia, and others have had some success at making much smaller ones for fish and fly brains—some, made of silicon, are roughly 3 microns wide, about 25 times thinner than a human hair.

These probes are by no means the tiniest possible—polymer-coated carbon nanotubes, for example, can be 0.1 microns or smaller across and are highly conductive. Such thin wires tend to be very short and too flexible to get into the brain easily, however—when pushed, they simply buckle. One question Harris plans to pose at the meeting is whether the probes could be magnetized, then pulled, rather than pushed, into the brain with a powerful magnet.

Ultimately, researchers hope to measure neural activity inside the brain without poking wires into living tissue, and there, too, physics can help. Harris has his eye on light-sheet microscopy, which shines a plane of light across a living brain tissue, illuminating neurons engineered to fluoresce green or red when they are flooded by calcium during neuronal firing. Last year, neuroscientist Misha Ahrens and colleagues at Janelia Farm used this technique to produce the first “real” whole-brain activity map of a zebrafish larva, Harris says.

A larval zebrafish brain is 1000 times smaller than a mouse brain, however. It is also conveniently transparent, while mouse and human brain tissue scatter and blur light. Using the same optical techniques that astronomers employ to discern very faint or close-together stars with a telescope, researchers such as physicist Na Ji, also at Janelia Farm, have discovered ways to distinguish between hard-to-see neurons in murky brain tissue.

In preparation for the meeting, Mitra has brushed off an old copy of *Principles of Optics* by Emil Wolf and Max Born, one of the most venerable and difficult physics tomes. Getting back to basics, he hopes, will help him and his BRAIN project colleagues determine which rules must be followed to the letter, and which might be cleverly circumvented. ■

PARTICLE PHYSICS

Plan to internationalize U.S. project may face headwind

Washington may be reluctant to share control of a long-baseline neutrino experiment on U.S. soil

By **Adrian Cho**

It's a gamble that leading U.S. particle physicists say they must take: To finally get started on their next megaproject at the United States' sole particle physics lab, they want to make it an international collaboration—even if that means ceding direct control to a council of member nations. Doing so could open the way to an ambitious effort to study elusive particles called neutrinos and ensure the future of the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. But the approach may not fly with Congress.

The recommendation comes from a draft road map for U.S. particle physics presented on 22 May to a federal advisory panel in Bethesda, Maryland. The report of the ad hoc Particle Physics Project Prioritization Panel (P5) strikes a decidedly more international tone than previous plans. It urges the government to “[p]ursue the most important opportunities wherever they are, and host unique, world-class facilities that engage the global scientific community.”

“The case for proceeding this way is persuasive [because] collaboratively, we can address all the physics” originally envisioned for the Fermilab project, says Andrew Lankford, a particle physicist at the University of California, Irvine, and chair of the High Energy Physics Advisory Panel (HEPAP), the Department of Energy (DOE)

and National Science Foundation panel that commissioned the report. “The question is, will the decision-makers in Washington appreciate it?”

P5 has followed the lead taken by European particle physicists last May, when they revised their long-term strategy. The European report suggested that Europe, the United States, and Japan share the field's biggest projects. Europe would continue to run the world's highest energy atom smasher, the 27-kilometer-long Large Hadron Collider (LHC) at the European particle physics laboratory, CERN, in Switzerland—which 2 years ago unearthed the long-sought Higgs boson. Europe might also contribute to a massive neutrino experiment, perhaps in the United States, and to the proposed International Linear Collider (ILC), a 30-kilometer electron-positron collider that would study the Higgs boson in great detail. Japanese physicists hope to host the ILC.

The P5 report calls for the United States to stay fully involved in the LHC and its planned upgrades. More than 1200 U.S. physicists now work on LHC experiments, about a third of the total. Similarly, if Japan goes forward with the ILC, the United States should join that collaboration—if money allows.

If Europe is willing to work on somebody else's neutrino experiment, the P5 report has one to offer: a so-called long-baseline neutrino facility. It would fire neutrinos 1300 kilometers to a gigantic detector filled with

Ups and downs

The proposed configuration of Fermilab's next neutrino experiment has fluctuated.

DATE	DETECTOR SIZE (KILOTONNES)	DEPTH (M)	COST
2009	300 water or >50 liquid argon	1480	—
2010	200 water or 33 liquid argon	1480	\$990 million
2011	Combination of water and argon	1480	~\$1.1 billion
March 2012	33 liquid argon	1480	\$1.5 billion
August 2012	10 liquid argon	Surface	\$789 million
Present	>40 liquid argon	1480	To be determined

Source: *AIP Conf. Proc.* **1222**, 479 (2010), *Science* **330**, 904 (2010), Fermilab, DOE



BRAIN project meets physics

Emily Underwood (May 29, 2014)

Science **344** (6187), 954-955. [doi: 10.1126/science.344.6187.954]

Editor's Summary

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