PLANT BIOTECHNOLOGY

Consumer Power Heralds Hard Times for Researchers

Since the European public became concerned about transgenic food, researchers have been hit by the fallout: reduced funding from governments and industry

The consumer-led backlash in Europe against genetically modified crops has forced some of the world's major players in agricultural biotech, most notably Monsanto, to beat a retreat. But the multinational behemoths are not the only ones taking a hit: Academic researchers across Europe are now becoming victims. Europe could see an exodus of plant biotech talent unless politicians "face up to their role as driving forces in society and send some clear signals as to their intentions with respect to this technology," says Claus Christiansen, research director of the Danish food giant Danisco.

High-profile campaign. Public opinion is forcing politicians and industrialists to think twice about funding plant biotech.

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The once-hot field has been cooling off for a few years, European plant biotechnologists say, since they began to sense that national research agencies were losing enthusiasm for their work. Industry too began to scale back its own research programs as well as collaborations with academic groups. But now the alarm bells are really ringing. Plant biotech fared poorly in the first round of grants in the $17.6 billion Fifth Framework Programme (FP5), the latest 5-year European Union (E.U.) effort to support cross-border R&D collaborations. Statistics from a researchers' umbrella organization, the European Plant Biotechnology Network (EPBN), suggest that in the various funding categories open to plant biotech proposals, only 3% to 10% of applications succeeded, compared with 10% to 30% in the previous Framework Programme.

Across the whole E.U., FP5 grants are spread pretty thinly, accounting for only about 5% of total public research funding, but they are increasingly important as catalysts. According to Oxford University's head of plant sciences, Christopher Leaver, E.U. funding is crucial in creating networks between research centers in different countries and for recruiting and training young scientists internationally.

One much cited casualty of FP5 is the "yellow rice" project headed by Peter Beyer of the University of Freiburg in Germany and Ingo Potrykus of the Swiss Federal Institute of Technology in Zurich. With much fanfare, the E.U. announced last year that with FP4 funding the team had genetically engineered a rice strain to produce β-carotene, the precursor of vitamin A. The scientific community and media hailed this as a triumph for plant biotechnology and raised hopes for battling vitamin A deficiency in the Third World. Despite huge interest from developing countries and additional support from overseas funding bodies, when the group applied for FP5 funds mainly to develop hardier strains that could be grown in the field, they were turned down. Potrykus interprets the cold shoulder from FP5 administrators in Brussels as "a reaction to the political climate in Europe with its strong negative feelings against GMOs [genetically modified organisms]."

E.U. officials dismiss the idea of a conspiracy against transgenic plant research. "There are no grounds for this rumor," says Bruno Hansen, director of FP5's Quality of Life program committee, which oversees most plant biotech funding. Still, other officials concede that plant biotech faces more hurdles within FP5 than in previous programs. The explicit aims of the Framework programs have always been to increase the competitiveness of European industry and support other E.U. goals, but areas of basic research thought important to industry, such as biotechnology, were widely supported. Now every grant must have an explicit payoff for European industry or E.U. socioeconomic efforts, making it difficult for basic research to find a niche. Under FP5, there is no longer a separate budget for plant biotechnology, so "plant projects, which are generally slow to deliver, are handicapped in competition with other organisms," says EPBN project manager Karin Meztlaff. Holger Rasmussen of the Danish Ministry of Research concedes that with Framework's new focus, scientists "have difficulties getting funding for less applied projects."

As if troubles at the pan-European level weren't enough, scientists worry that national funding agencies are also tuned in to public fears about transgenic foods. In the Netherlands, says plant geneticist Richard Visser of Wageningen University, shrinking public funds for fundamental research and industry's reluctance to support plant biotech projects are squeezing the field from both sides. The past year has been hard for Danish plant research too. A government-funded plant biotech program was not renewed when it ended last year, and the major industry research sponsor—Danisco, a food and ingredient company—has virtually pulled out of plant biotechnology. Many observers interpret this as a response to pressure at last year's stockholders meeting not to invest in GMOs. Across Europe, industry is battening down the hatches. Klaus H. Nielsen, director of research at Danish seed company DLF-Trifolium, says, "Apart from a few initiatives, everybody is waiting for the negative atmosphere to blow over."

But with the biotech industry becoming increasingly global, large corporations always have the option to move their research efforts, and collaborations with academic researchers, to parts of the world where conditions are more favorable. "We are following agrobiotech development closely, and it would be very sad if Europe were affected by the current GMO opposition and lost its science base," says Nigel Pool, director of external affairs with the Anglo-Swedish drug and biotech giant AstraZeneca. Researchers point out that European companies are already making significant investments overseas, such as the Swiss agrobiotech giant Novartis, which has put $600 million into a center for plant research in San Diego and is heavily supporting a center for plant genomics at the University of California, Berkeley.

So should European researchers keep their heads down and wait for public antipathy for their work to die down? Plant geneticist Jonathan Jones of the John Innes Centre near Norwich, U.K., predicts that "in the long run, European plant science will lose out if the current development continues. The most talented scientists will have to move elsewhere for opportunities, and Europe will see fewer start-up companies in the plant biotechnology sector." Oxford's Leaver adds that "recruiting top-quality workers for plant research at the postgraduate and postdoctoral level is a major problem in the U.K.," where concerns about GM foods run particularly deep. And in Germany, plant geneticist Heinz Saeidler of the Max Planck Institute for plant propagation research in Cologne says he is getting fewer students, who see poor career prospects in such an unpopular field.

Most researchers believe the public will come to embrace transgenic crops, especially after future varieties show traits that genuinely benefit consumers, such as increased nutritional value or the elimination of natural allergens. But by then it may be too late for European researchers. "The worst case scenario is Europe taking a break to think about things," warns Nielsen. "By not concentrating on this research now we risk having to import the future products of plant biotechnology from elsewhere." —LONE FRANK

Lone Frank writes from Copenhagen, Denmark.

NEUROSCIENCE

Cold Numbers Unmake the Quantum Mind

Calculations show that collapsing wave functions in the scaffolding of the brain can't explain the mystery of consciousness

Sir Roger Penrose is incoherent, and Max Tegmark says he can prove it. According to Tegmark's calculations, the neurons in Penrose's brain are too warm to be performing quantum computations—a key requirement for Penrose's favorite theory of consciousness.

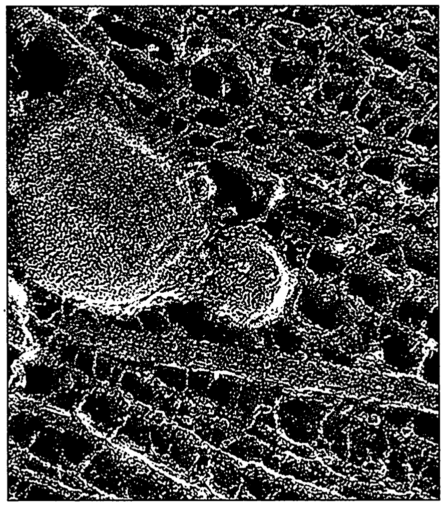
Penrose, the Oxford mathematician famous for his work on tiling the plane with various shapes, is one of a handful of scientists who believe that the ephemeral nature of consciousness suggests a quantum process. In the realm of the extremely small, an object with a property such as polarization or spin may exist in any of a number of quantum states. Or, bizarrely, it may inhabit several quantum states at once, a property called superposition. A quantum superposition is extremely fragile. If an atom in such a state interacts with its environment—by being bumped or prodded by nearby atoms, for instance—its waveform can "collapse," ending the superposition by forcing the atom to commit to one of its possible states.

To some investigators, this process of coherence and collapse seems strikingly similar to what goes on in the mind. Multiple ideas flit around below the threshold of awareness, then somehow solidify and wind up at the front of our consciousness. Quantum-consciousness aficionados suspect that the analogy might be more than a coincidence. Eleven years ago, Penrose publicly joined their number, speculating in a popular book called *The Emperor's New Mind* that the brain might be acting like a quantum computer.

"Between the preconscious and conscious transition, there's no obvious threshold," says Penrose's sometime collaborator Stuart Hameroff, an anesthesiologist at the University of Arizona in Tucson. Ideas start out in superposition in the preconscious and then wind up in the conscious mind as the superposition ends and the waveform collapses. "The collapse is where consciousness comes in," says Hameroff.

But what exactly is collapsing? From his studies of neurophysiology, Hameroff knew of a possible seat for the quantum nature: "microtubules," tiny tubes constructed out of a protein called tubulin that make up the skeletons of our cells, including neurons. Tubulin proteins can take at least two different shapes—extended and contracted—so, in theory, they might be able to take both states at once. If so, then an individual tubulin protein might affect its neighbors' quantum states, which in turn affect their neighbors'—and so forth, throughout the brain. In the 1990s, Penrose and Hameroff showed how such a tubulin-based quantum messaging system could act like a huge quantum computer that might be the seat of our conscious experience.

The idea attracted a few physicists, some consciousness researchers, and a large number of mystics. Quantum physicists, however, largely ignored it as too speculative to be worth testing with numerical calculations. Now Tegmark, a physicist at the University of Pennsylvania, has done the numbers. In the February issue of *Physical Review E*, Tegmark presents calculations showing just what a terrible environment the brain is for quantum computation.



CREDIT: N. HIROKAWA

Broken thread. Microtubules decohere too fast to generate our thought patterns.

Combining data about the brain's temperature, the sizes of various proposed quantum objects, and disturbances caused by such things as nearby ions, Tegmark calculated how long microtubules and other possible quantum computers within the brain might remain in superposition before they decohere. His answer: The superpositions disappear in 10^{-13} to 10^{-20} seconds. Because the fastest neurons tend to operate on a time scale of 10^{-3} seconds or so, Tegmark concludes that whatever the brain's quantum nature is, it decoheres far too rapidly for the neurons to take advantage of it.

"If our neurons have anything at all to do with our thinking, if all these electrical firings correspond in any way to our thought patterns, we are not quantum computers," says Tegmark. The problem is that the matter inside our skulls is warm and ever-changing on an atomic scale, an environment that dooms any nascent quantum computation before it can affect our thought patterns. For quantum effects to become important, the brain would have to be a tiny fraction of a degree above absolute zero.

Hameroff is unconvinced. "It's obvious that thermal decoherence is going to be a problem, but I think biology has ways around it," he says. Water molecules in the brain tissue, for instance, might keep tubulin coherent by shielding the microtubules from their environment. "In back-of-the-envelope calculations, I made up those 13 orders of magnitude pretty easily."

Some members of the quantum-consciousness community, however, concede that Tegmark has landed a body blow on Penrose-Hameroff–type views of the brain. "Those models are severely impacted by these results," says physicist Henry Stapp of Lawrence Berkeley National Laboratory in California. (Stapp's own theory of quantum consciousness, he says, is unaffected by Tegmark's arguments.)

Physicists outside the fray, such as IBM's John Smolin, say the calculations confirm what they had suspected all along. "We're not working with a brain that's near absolute zero. It's reasonably unlikely that the brain evolved quantum behavior," he says. Smolin adds: "I'm conscientiously staying away" from the debate. —CHARLES SEIFE