

Lab Weds Brain Research and Physics

Magnets and modeling may help reveal secrets of brain development and disease.

What are you thinking? Researchers at NeuroSpin won't read your mind, but they do want to know how it works. The new facility near Paris will study the brain at previously untapped spatial and temporal scales.

Neurons can currently be probed a million at a time using magnetic resonance imaging (MRI), or by the dozen with electrical recordings. "We want to address the middle scale—clusters of 1000 to 10 000 neurons," says founding director Denis Le Bihan, who holds a PhD in physics and a medical degree and is the driving force behind NeuroSpin. Going to higher MRI field strengths, he adds, will sharpen the resolution by about a factor of 10, from a few millimeters to hundreds of micrometers and from one second to hundreds of milliseconds.

Big biology

"The beauty of MRI," Le Bihan says, "is that we have not reached the physical limits of the technique. That's not true for other techniques, such as microscopy, where the resolution is given by the wavelength of light." MRI is limited by the diffusion of molecules, he adds. "Diffusion will blur the images, but we are far from this." Today, the strongest MRI machines for humans are 9.4 tesla—and only two are in use. Achieving 11.7 T, says Le Bihan, "pushes the technology to the limits, but we are not breaking new ground. This avoids taking too much risk."

Still, it will be technically challenging, says Guy Aubert, former head of the French research agency CNRS who, now in Saclay with the

French Atomic Energy Commission (CEA), is overseeing the building of a whole-body 11.7-T magnet for NeuroSpin. The lab will also have a 3-T scanner; a 17-T scanner for rodents; spectroscopy and microscopy tools; lab space for electronics, biology, neurophysiology, and chemistry; and facilities for human clinical studies. Says Aubert, "I think it's the first time—at least in France—that life science is building big equipment like in physics."

Ground was broken for NeuroSpin in late January. The instruments are to be installed starting next year, and the facility should be fully functioning in 2009. Setting up NeuroSpin costs "several tens of millions of euros," says Le Bihan, who will move his research from the Service Hospitalier Frédéric Joliot in Orsay. The CEA, the greater Paris region, and other public and private sources are footing the bill. "We are now knocking on the door of [the European Commission in] Brussels for money"—and to make NeuroSpin a European user facility, Le Bihan says.

The facility will house some 160 researchers, half permanent and half visitors. Says Le Bihan, "Chemists will develop contrast agents and tracers. We need physicists, mathematicians, computer scientists—new software will be developed to analyze the huge amount of data that will be produced—neuroscientists, electro-

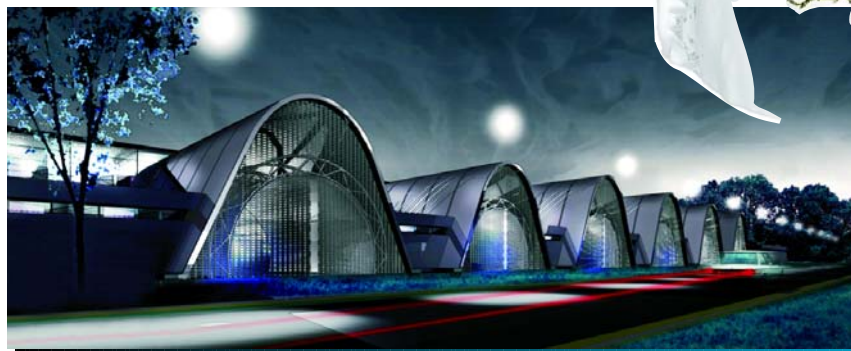
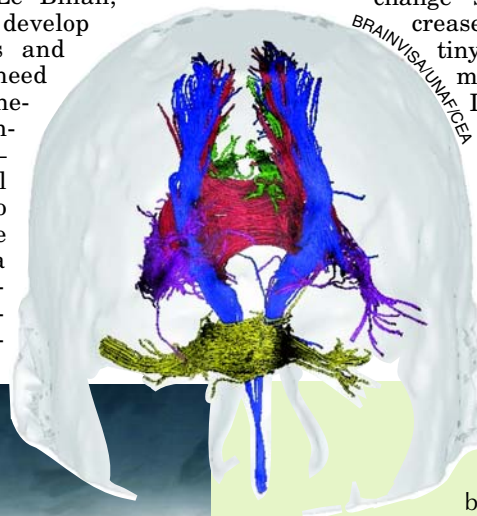
physiologists, psychiatrists. Physicists and engineers from CEA will provide specific knowledge on magnetism, cryogenics, radio frequencies, and management of large projects. Theoretical physicists might be attracted because there is a need to build a working model of the brain."

From magnets to mental illness

Research planned for NeuroSpin ranges from magnet development to cognitive studies to mental illness, brain development, and brain dysfunction. The high magnetic fields may shed light on autism, language development, aging, how the mind produces and appreciates art, and early detection of neurological disorders such as Alzheimer's and Parkinson's diseases. "It's like getting a microscope to look at the brain noninvasively in three dimensions," says Le Bihan.

For example, by using transgenic mice, "we hope to see how genes and the environment interact during brain development," says Le Bihan. "Many brain disorders in adults can be the consequence of what happens during early stages of brain development, including [during] pregnancy."

In gray matter, Le Bihan says, "when neurons get activated, they change shape. They increase their volume a tiny bit, and the water mobility decreases. If you can monitor this change in diffusion, you may be able to determine or infer which regions of the brain are being activated." Diffusion MRI also promises



Modeling the brain

will be the focus at NeuroSpin (left), an interdisciplinary lab being built in Saint Aubin, 40 km southwest of Paris. The facility's strong magnetic fields will, for example, yield finer detail in in-vivo visualizations of the brain's white matter (shown in false color, above) with diffusion magnetic resonance imaging. (Rendering by architect Claude Vasconi, reproduced courtesy of CEA.)

to help unravel disorders affecting white matter—the fibers that connect different regions of the brain—such as dyslexia, multiple sclerosis, and schizophrenia.

Another approach, MRI and spectroscopy of heavier nuclei such as

sodium, phosphorus, carbon, or oxygen—instead of hydrogen, the MRI workhorse—opens the way for broader study of brain metabolism, neurotransmission, and disease. “We use carbon-13 and oxygen-17,” says Le Bihan. “The abundance of those nuclei is very low, hence the need for very high fields.”

“I think [NeuroSpin] is a wonderful facility,” says Kamil Ugurbil, director of the Center for Magnetic Resonance Research at the University of Minnesota. “They are trying to combine and facilitate interactions between many different types of scientists. Such efforts go on already, but it’s based on individual efforts. By consciously planning this, both in terms of building design and in terms of organization, they may be able to achieve much better results.”

Toni Feder

Visas Extended for Students, Scientists

After months of trying to strike a balance between openness and security, State Department officials have changed immigration rules to allow foreign researchers and students in science and technology fields classified as “sensitive” to maintain their US visa clearances for up to four years.

“This change will ensure that the US continues to have access to the world’s best and brightest scientists, and that’s good for science and for security,” said Representative Sherwood Boehlert (R-NY), chairman of the House Committee on Science.

The Visas Mantis program was established in 1998 to prevent scientists from transferring protected technology out of the US. In the wake of the September 11th attacks, the program was tightened, and foreign scientists and many students were required to undergo complete security reviews every time they left the US and wanted to return. The reviews were cumbersome and often took months. As a result, many of the students and scientists

found it risky to leave the US for any reason.

In 2003 a one-year clearance period was implemented, but that was of little help to foreign students, researchers, and scholars involved in multiyear programs. The new policy grants clearances of two years to researchers and scholars, and four

years to students. The extended clearances apply only to those returning to the same program or activity for which the visa was originally granted.

The relaxation of standards came after George Atkinson, science adviser to the secretary of state, joined the consular affairs and nonproliferation bureaus to negotiate for the change with

Statue Hid Hipparchus Star Catalog

Since Alexandria’s great library was ransacked 1600 years ago, astronomers have searched in vain for a copy of the Hipparchus star catalog, the earliest sky map known to have used a coordinate system. Now, an astrophysicist vacationing in Naples, Italy, believes he has found a copy sitting in plain view on a statue of Atlas, the Greek god sentenced to bear the weight of the heavens.

The two-meter-tall statue, called the Farnese Atlas, was unearthed in the 1400s and is in the National Archaeological Museum in Naples. It is believed to be a second-century-AD Roman copy of an earlier Greek original. For years historians had speculated that the globe on the giant’s shoulders, which is marked with 41 Greek constellations and with lines indicating the celestial equator, tropics, and ecliptic, contained an accurate sky map.

But no one with technical training had published anything about the Farnese Atlas until Bradley Schaefer of Louisiana State University, Baton Rouge, came along last year. “I have a nice fun result simply because I am the first astrophysicist to run an analysis,” he says. His research will appear in the *Journal for the History of Astronomy* next month. The sky map Schaefer identified will help astronomers and historians determine how much of Hipparchus’s work was used in later star catalogs. In addition to creating the sky map, the second-century-BC astronomer discovered the wobble of Earth’s axis, recorded the first observations of a nova, calculated the length of the year to within six minutes, and is said to have devised the magnitude scale for star brightness still used by astronomers today.

Schaefer dated the statue’s sky map by taking advantage of one of Hipparchus’s observations: Stars and constellations move slowly over time with respect to the celestial equator, tropics, and meridian lines. By digitizing high-precision photographs of the globe, Schaefer was able to mathematically match locations of constellations to a date. According to his calculations, the map rendered on the globe was created in 125 BC, give or take 55 years. The positions of the constellations on the globe are too accurate to be an artistic interpretation, says Schaefer. The date, plus the shapes of the constellations, clinch the mapmaker as Hipparchus, and rule out other potential sources, such as verbal descriptions of the night sky by Aratus (275 BC), Eudoxus (366 BC), or the Assyrian observer (1130 BC), and Ptolemy’s later catalog from about AD 128.

“Schaefer’s given a pretty convincing argument, and the real ingenuity here is working out the star positions just from the pictures,” says Owen Gingerich, a Harvard University astronomy historian. “Perhaps the most fascinating part of this discovery,” Schaefer says, “is simply that we have recovered one of the most famous known examples of ‘lost ancient wisdom.’ ”

Paul Guinnessy



The Farnese Atlas (above). Compensating for the slow movement of stars across the sky was the key in dating the constellations on the globe (right) to 125 BC.



GERRY PICUS/GRIFITH OBSERVATORY