

FROM PROTONS TO POETRY

Neurological and psychiatric disorders affect a growing number of individuals—nearly one in five Americans in a given year and more than two billion people worldwide. Furthermore, the scope of neuroscience is vast—ranging from the most basic cellular-level research to translational medicine—and many unanswered questions remain. Interesting niche areas have emerged in neuroscience research such as neuroeconomics, neuromarketing, and neural networks. Together, these factors make neuroscience one of the more exciting and opportunity-laden fields in which to pursue a scientific career.

By Emma Hitt

The subject areas that qualify as neuroscience are as far-reaching and as interconnected as neurons themselves. Consequently, neuroscientists often work on questions that span several distinct subfields. Many neuroscience programs are interdepartmental and take on the structure of an institute rather than a department. For example, the mission at the Neuroscience Institute of Stanford is to “achieve a new synthesis from molecules to mind, from analysis to application, from science to society.” According to director **William Mobley**, the goal is to translate the science “all the way from looking at synaptic function to deciding how children can learn how to read more effectively.” The institute includes 150 faculty participants from the Schools of Medicine, Humanities and Sciences, Engineering, Education, Law, and Business.

Likewise, the Harvard Center for Neurodegeneration and Repair resides in small areas of many buildings and labs rather than being confined to one building. “The center has affiliations with 18 hospitals, and whenever we set ourself a new research challenge, we identify the very best people in the community and draw them into a new collaborative program,” says **Adrian Ivinson**, the center’s director. “That’s very different from the approach in usual principal investigator–based labs.” To answer questions about complex neurological diseases such as Alzheimer’s and multiple sclerosis, one needs biostatisticians, disease experts, clinical experts, high throughput genotyping capacity, databases and databanks, and “you need them at a level that you couldn’t expect to find in one lab,” he says.

At Berkeley, the Helen Wills Neuroscience Institute has four main divisions: cellular and molecular, developmental, systems and computational, and cognitive and behavioral. According to **John Flannery**, the acting director, the institute has 50 faculty distributed across the campus, conducting research from the cellular level all the way up to dealing with patients. “Graduates from our group can not only go to a basic science department, they could go to a medical school clinical department, and there’s a lot of interest in pharmaceuticals and biotechnology, especially in the Bay area,” says Flannery.

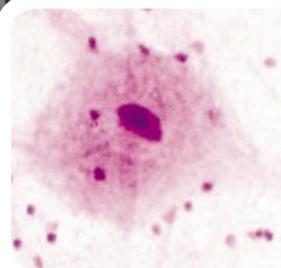
Translational Cures

Research likely to garner the most financial support will be that which has clinical applications, collectively called translational research. Psychiatric disorders are in fact brain disorders that involve abnormal activity in brain circuits, so having researchers who understand the brain in a deep and integrated way is going to be critical for the future, says **Thomas Insel**, director of the US National Institute of Mental Health (NIMH). “We need to have people who are interested in these illnesses and yet also are skilled in neuroscience. Neuroscience M.D.-Ph.D.s and Ph.D.s are definitely an important cohort for increasing NIMH support,” he adds.

“The evidence keeps coming that there are genetic causes or risk factors for most if not all neurological diseases,” notes **Lars Olsen**, past chair of the Department of Neuroscience, at the Karolinska Institutet in Stockholm, Sweden. “A striking example is Parkinson’s disease—we know for sure that some forms are directly inherited and that complex genetic risk factors appear important for the rest of the cases.” According to Olsen, a trend in academia and industry will be to establish that Parkinson’s disease for example, is not **continued** »



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From top: **Michael Lehman**, chair of the Department of Anatomy and Cell Biology at the University of Western Ontario with students; **Thomas Insel**, director of the US National Institute of Mental Health; **Glenda Halliday** and student **Christine Song**.

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one disease, but perhaps 10, and to develop individualized treatments based on understanding of etiology.

Programs tailored to translational research are springing up nationwide in part due to initiatives in translational research put forth by the US National Institutes of Health (NIH), notably, the NIH's Blueprint for Neuroscience Research. The Blueprint is a co-

operative effort among 16 NIH institutes, centers, and offices that supports the development of new tools, training opportunities, and other resources to assist neuroscientists in both basic and clinical research.

Most of the major medical schools now have translational research programs, says **Raquel Gur**, the director of the neurotherapeutics program at the Institute for Translational Medicine and Therapeutics at the University of Pennsylvania. "Translational research is really the call of the hour," she says. According to Gur, whose program specializes in schizophrenia, translational neuroscience requires thoughtful consideration of the relevance of basic research findings to human behavior. "Until we started our translational research efforts, basic and clinical scientists read different journals, and now they are e-mailing each other relevant articles."

Gur advises graduate students and junior postdocs in the neurosciences to push themselves to get what they need from their program or school rather than just accepting the resources available. "Ask yourself how you can become part of an interdisciplinary team that works toward a higher goal," she advises.

Going Global

Opportunities exist globally in the neurosciences. Neural engineering and psycho-neuroimmunology are areas of increasing interest in Australian neuroscience research, according to **Glenda Halliday**, president of the Australian Neuroscience Society. Other areas that are emerging include neural stem cell research, neuroinformatics, and computational neuroscience, she says.

At the Karolinska Institutet, areas of research include spinal cord injury and repair, the role of the dopamine system in health and disease, neurotrophic factors and their receptors, the synapse and vesicle recycling, and neuronal membrane receptors and receptor interaction. "Previously, almost all neuroscience Ph.D. students at Karolinska were recruited from



Funding increases are needed "to ensure that our best and brightest young people will enter the field and continue to make neuroscience research advances."

—David Van Essen

classes of students studying to become M.D.s," says Olsen "but in the last 10–15 years this has changed so that now a small minority of the students we accept for our Ph.D. program are derived from the M.D. curriculum classes."

Show Me the Money

By most accounts, the limited funds for the hiring of postdocs

and junior faculty make such positions competitive, and this holds true for the neurosciences. "It's difficult right now because the NIH budget is not keeping pace with the increasing expense of biomedical research," says Berkeley's Flannery. "Private universities such as Harvard, Yale, and Princeton have historically hired more at senior levels—tending to hire the most distinguished scholars they could find. Junior faculty would be hired for three to six years and then have to move elsewhere, although there is a trend to hire more junior faculty now, and this includes an effort to recruit more women and minorities into the sciences." (Find more on this trend in the careers feature published September 14,

2007 – "Make Way for the Next Generation: Junior Faculty Are Moving In" – dx.doi.org/10.1126/science.opms.r0700038.)

The total NIMH budget for 2007 is \$1.4 billion, a figure that has remained essentially flat since 2004. Approximately 3,000 grants for a total of \$1.405 billion are projected to be funded by the NIMH in fiscal year 2008. Similarly, the US National Institute of Neurological Disorders and Stroke (NINDS) funding has also remained consistent at \$1.533, \$1.534, and \$1.537 billion in 2006, 2007, and 2008, respectively. Current supported funding areas at NINDS and NIMH include counterterrorism and neuroscience research, neural prosthesis program, neural stem cells, adult and pediatric translational research and treatment development, and the NIH neuroscience Blueprint.

"Some institutions [in the United States] are no longer recruiting junior-level faculty who don't have their own grant support," says **Michael Lehman**, chair of the Department of Anatomy and Cell Biology at the University of Western Ontario and president-elect of the Association for Neuroscience Departments and Programs (ANDP). "It's a somewhat dismal environment for recruiting young scientists," he adds. "If only established investigators continue to be funded there will be a generational gap, and that's bad for neuroscience and science in general." **continued »**

Association for Neuroscience
Departments and Programs (ANDP)
www.andp.org

Australian Neuroscience Society
www.ans.org.au

Department of Anatomy and Cell Biology, University
of Western Ontario
www.uwo.ca/anatomy

Harvard Center for Neurodegeneration
and Repair
www.hcnr.med.harvard.edu

Helen Wills Neuroscience Institute, Berkeley
neuroscience.berkeley.edu

Institute for Translational Medicine and
Therapeutics, University of Pennsylvania
www.itmat.upenn.edu

Karolinska Institutet,
Department of Neuroscience
www.neuro.ki.se

NeuroInsights
www.neuroinsights.com

Neuroscience Institute of Stanford
neuroscience.stanford.edu

Neurotechnology Industry Organization
www.neurotechindustry.org

Society for Neuroscience (SfN)
www.sfn.org

US National Institutes of Health (NIH)
www.nih.gov

US National Institute of Mental Health (NIMH)
www.nimh.nih.gov

US National Institute of Neurological
Disorders and Stroke (NINDS)
www.ninds.nih.gov

It is not all doom and gloom, however, as scientists are being increasingly vocal about the funding shortfall. Earlier this year **David Van Essen**, president of the Society for Neuroscience (SfN), strongly urged the US House and Senate appropriations subcommittees on labor, health and human services as well as on education to increase NIH funding by 6.7 percent per year for each of the next three fiscal years, stating that this is needed “to ensure that our best and brightest young people will enter the field and continue to make neuroscience research advances.”

On the industry side, venture capital investment in new and emerging neurotechnology companies reached a record high in 2006, increasing 7.5 percent to \$1.67 billion, according to the Neurotechnology Industry 2007 Report, produced by NeuroInsights. Approximately one in four venture dollars now invested in life science companies in the United States goes to companies focused on the brain and nervous system, which represents a more than threefold increase since 1999, according to the NeuroInsights report. In 2006, the neurotechnology industry comprised over 500 companies, developing drugs, devices and diagnostics for the brain and nervous system, generating worldwide revenues of \$120.5 billion.

“I think people seeking a career in neuroscience need to be hopeful,” says Mobley. “My postdocs express concern about whether or not they will get funding and be able to pursue a career, but it’s important to remember that there are many possible ways to do great thinking and great science,” he says. “They need to find those pieces of the puzzle that fit them best and they should not give up hope.”

The Leaky Pipeline

As in other areas of science, women still have some catching up to do with regard to reaching the higher echelons of academia. The ANDP assesses neuroscience training, primarily in North America, and conducts a National Survey of Neuroscience Programs. The last ANDP survey was conducted in 2005, and a subsequent survey was scheduled to be sent out to member programs early this fall. The 2005 report included responses from 88 of the 140 graduate training programs that were members of the ANDP and indicated that women comprise more than 60 percent of the graduate students in neuroscience but approximately 25 percent of tenure-track faculty, a number that has changed little since 1998. Furthermore, the percentage of full professors who are women remains a low 21 percent.

The demands of life outside of a professional scientific career and the conscious or unconscious biases that exist can make it harder for women to advance. “All of these are active areas of discussion, not just in neuroscience, but in biomedical science over all,” Lehman says.

Table 1. Select Emerging Multidisciplinary Fields in the Neurosciences

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|-----------------------------------|---|
| Computational Neuroscience | Combines traditional neuroscience with computer science. |
| Neural Engineering | Uses engineering techniques to investigate the function and manipulate the behavior of the central or peripheral nervous systems. |
| Neural Networks | The application of neuroscientific studies of the structure and function of the human brain in machine information processing and decision making. |
| Neuroeconomics | Combines neuroscience, economics, and psychology to study how we make decisions. |
| Neuroergonomics | The matching of technology with neurologic capabilities to achieve safe working conditions. |
| Neuroesthetics | Understanding the esthetics of art and music at the neurological level. |
| Neuroethics | The ethics of neuroscience and neurotechnology research. |
| Neurolinguistics | The science concerned with the neural mechanisms underlying the comprehension, production, and abstract knowledge of language. |
| Neurophilosophy | Investigation of philosophical theories in relation to neuroscientific hypotheses, dealing with philosophical problems of the cognitive neurosciences and addressing questions about cognition and consciousness, and what the neural correlates of human consciousness may be. |
| Psychometrics | The theory and technique of educational and psychological measurement. |

Van Essen, with the SfN, notes that one of his society’s key interests is to encourage diversity in terms of increasing the number of both women and minorities coming into and succeeding at each stage of the pipeline. “Having successful role models [for upcoming scientists] is important,” he says.

Strategic Career Planning

Neuroscience has a flexibility in that it can be combined with a multitude of disciplines (Table 1), so an effort should be made to diversify skills while keeping in mind one’s career interests. For example, postdocs might benefit from getting an MBA, a computer science degree, or an economics degree to complement their conventional neuroscience training.

“Neuroscience training has many varied and productive career options for students,” Lehman says. “That’s in contrast to the traditional path of entering a medical school environment and depending on grant support. There are so many other types of career paths in which students can be happy, successful, and productive.”

Likewise, Van Essen recommends getting broad training, “not just in one narrow area of neuroscience, but trying to obtain a background that uses multiple approaches and can attack problems from a relatively broad perspective.”

A strong demand exists for people with regulatory and clinical trial management expertise related to neurological diseases and psychiatric illnesses, notes **Zack Lynch**, executive director, with the Neurotechnology Industry Organization.

Whatever path a student decides upon, neuroscience is replete with opportunities for graduate students and postdocs who have given thought to planning their career path. People who are just entering into this field will be the Nobel Prize winners of this next generation, says Insel. “This really is the place for the brightest and the best students to jump in because we know so little, and the opportunities are so great.”

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