THE WORLD'S MOST COMPLEX PUZZLE

Global brain research projects, supported by powerful new imaging technology, make neuroscience a promising field for young researchers.

by **Francisco J. Barrantes**

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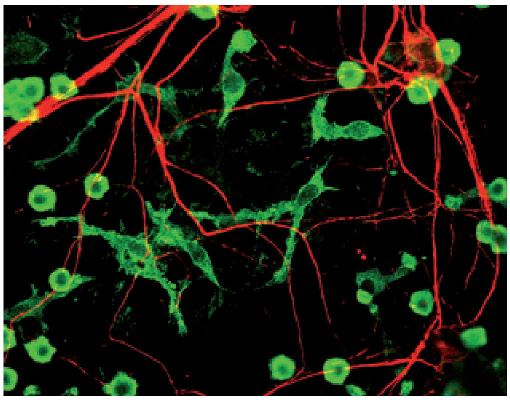
Neuroscience will offer tremendous opportunities to new generations of scientists in the developing world. At the higher echelons of science and politics there is deep interest in understanding the most complex machine in nature, the brain. Billions of dollars are being invested to map brain connections, and while it is a daunting task, it can yield enormous benefits.

Modeling the brain, the goal of decade-long computational and neuroinformatics efforts – the Human Brain Project and the BRAIN Initiative, for example – constitutes a challenging exercise. This is an organ with an astronomical number of units (10^8) and beyond-imagination number of connections (10^{15}), some of which can change rapidly over time. A few hundred neurological conditions and neuropsychiatric diseases add layers of complexity.

Imaging technology is opening new horizons for the study of the brain and behavior. Two related magnetic resonance imaging (MRI) techniques, diffusion spectroscopy and functional MRI (fMRI), are being used to map the brain´s structural and functional connectivity, respectively. Their use as diagnostic tools and their increasingly intensive application to cognitive, mnemonic and other behavioral phenomena is allowing us to explore how the brain functions, even taking into account social context, ethical connotations, subtle cultural idiosyncrasies and other dimensions. Aversions, punishment, and a range of emotions are being interrogated. Advances on this front might be very informative in neurodegenerative diseases like Alzheimer´s and Parkinson´s or in neurodevelopmental diseases like the schizophrenias. These tools may also support advances in neuropharmacogenomics, the personalized tailoring of medicine to treat neurological diseases.

Theoretical and experimental research aimed at understanding higher brain functions are converging thanks to developments in artificial intelligence and neural theory and discoveries. The finest structures observable in the brain are the synapses and the tiny post-synaptic specializations called dendritic spines. Dynamic changes in these structures have been associated with synaptic plasticity, which is essential for the brain's most interesting assets, learning and intelligence. These areas of research are likely to be the most rapidly advancing ones in coming years.



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Another thought-provoking field uses neurogenetic data to examine historic forces that shaped the brain of *Homo sapiens* and related species. This work is highly interdisciplinary, involving neuroscientists, pharmacologists, ethnobiologists, population and mathematical biologists, physical and cultural anthropologists, historians, sociologists, physicians specialized in nutrition and genetic diseases and geographers specialized in human geography. Add questions about the future of the human brain, and philosophers can be added to that list. ◘