Embargoed until Oct. 18, 1:30 p.m. CDT
Press Room, Oct 17–21: (312) 791-6619

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RESEARCHERS IDENTIFY BRAIN DIFFERENCES BETWEEN SPECIES, OFFER POSSIBLE BASIS FOR COMPLEX BEHAVIORS AND DISEASE

Continued strides in the understanding evolution of the brain and behavior 200 years after Darwin's birth

CHICAGO — New tools are enabling researchers to identify neural similarities and differences between species. The findings may help to explain faculties, like language, and diseases, like Parkinson's, that are unique to humans. They were presented at Neuroscience 2009, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news on brain science and health.

In the 200 years since Charles Darwin's birth, scientists have learned much about the evolution of the brain, but many questions remain. Researchers are examining how the brain adapts to the environment and how the nervous system developed from a simple set of circuits to an intricate, stratified structure. These findings help explain the variation in behaviors in the animal kingdom and the rise of complex cognitive functions.

Research released today shows that:

- The patterns of genes expressed in human and primate brains differ. These variations offer insight into diseases, like Alzheimer's disease and schizophrenia, which affect humans but not closely related animals (Todd Preuss, PhD, abstract 225.1, see attached summary).

Other recent findings discussed at the meeting show:

- New technologies that allow researchers to examine and compare the genomes and proteomes of multiple species help explain the evolution of complex brains and behaviors (Seth Grant, MB BS, see attached speaker's summary).
- The brain uses similar strategies to process visual, auditory, and olfactory stimuli, suggesting it uses a set of common mechanisms to adapt to the natural environment (Tatyana Sharpee, PhD, see attached speaker's summary).
- Many aspects of neuroscience can be understood in evolutionary terms, from the complexity of brain structure to the intricacies of animal behavior (John Hildebrand, PhD, see attached speaker's summary).

"While Darwin's theory of evolution through natural selection is the foundation of biology, until recently there was no information about molecules or genes, and our understanding of brains was in its infancy. Today, we appreciate that the brain is not a static entity, but a dynamic process that continuously shifts and changes over time," said Leah Krubitzer, PhD, of the University of California, Davis, an expert on the evolution of the brain. "We also know that the behavior of individuals and populations substantially alters the physical environment in which an individual develops — and thus alters the brain itself."

This research was supported by national funding agencies, such as the National Institutes of Health, as well as private and philanthropic organizations.

– more –

Related Presentations:

Symposium: **Origins and Evolution of Brain and Behavior**
Wednesday, Oct. 21, 8:30–11 a.m., Room S100A

Minisymposium: **Common Principles of Adaptation to Natural Environments**
Saturday, Oct. 17, 1:30–4 p.m., Room S406B

Public Symposium: **In Celebration of Darwin: Evolution of Brain and Behavior**
Saturday, Oct. 17, 1:30–4 p.m., Room S100B

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Abstract 225.1 Summary

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Gene Patterns in the Brain Differ between Humans and Other Primates

Findings offer insight into mental illness and other diseases that preferentially affect humans

New research at Neuroscience 2009, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health, identifies different patterns of genes in the brains of humans and nonhuman primates. The findings may indicate what distinguishes people from other animals and why humans are vulnerable to brain diseases that do not affect other animals.

The researchers, led by Genevieve Konopka, PhD, in the laboratory of Daniel Geschwind, PhD, MD, at the University of California, Los Angeles, compared the genes found in the brains of humans, chimpanzees, and rhesus macaques. Humans had greater expression of genes important for the development and organization of the nervous system in brain regions important for cognition. Humans also had increased expression of genes involved in the maturation and migration of brain cells. The findings relied on a new technique called next generation sequencing.

"These results provide clues to the genetic changes that accompanied the evolution of language and complex cognitive processes, and may help explain the particular susceptibility of humans to neurodegenerative diseases," said Todd Preuss, PhD, a researcher on human brain evolution and a co-author of the study.

The research was supported by the National Institute of Mental Health, A.P. Giannini Foundation, and the National Alliance for Research on Schizophrenia and Depression.

Scientific Presentation: Sunday, Oct. 18, 1–2 p.m., South Hall A

225.1, Comparative Gene Expression in Primate Brain

G. KONOPKA, J. DAVIS-TURAK, M. OLDHAM, T. FRIEDRICH, B. O'CONNOR, G. COPPOLA, F. GAO, S. F. NELSON, **T. M. PREUSS**[4], D. H. GESCHWIND; Neurol., Human Genet., UCLA, Los Angeles, CA; Pathology, Emory Univ., Atlanta, GA

TECHNICAL ABSTRACT: To understand higher cognitive functions unique to humans, a more thorough study of comparative gene expression in the brains of humans and other primates needs to be conducted. Prior studies used microarray technologies that were significantly challenged by cross-species differences causing hybridization artifacts. The advent of next generation sequencing technologies permits investigation of gene expression free from issues of probe choice and sequence bias, providing a far more accurate and complete view of evolutionary divergence in the brain transcriptome. We conducted gene expression sequencing of three brain regions from three primates: human, chimpanzee, and rhesus macaque using tag-based library generation on the Illumina Genome Analyzer. For comparison, we also performed microarray analysis using two different whole genome microarray platforms: Affymetrix and Illumina. Four to six unique samples for each brain region and species were run separately and standard outlier analysis performed. Next generation sequence based analysis identified twice as many expressed RefSeq genes compared with microarrays. Using the rhesus macaque data as outgroup data, we determined which changes in gene expression between human and chimpanzee occurred along the human lineage. We also found region-specific differences in gene expression within species and between species. Gene ontology and signaling pathway analysis algorithms also revealed several significantly enriched categories unique to human brain. These studies are the first of its kind to use new sequencing technology to examine brain gene expression across multiple species. Future studies will include utilizing improved library generation methods and sequencing machines to examine low abundance transcripts and novel spliced isoforms.

Speaker's Summary

Chair: Seth Grant, MB BS (44-12) 2349-5380
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Cambridge, U.K.

Symposium: **Origins and Evolution of Brain and Behavior**
Wednesday, Oct. 21, 8:30–11 a.m., Room S100A

The goal of this symposium is to promote discussion and research into the discovery of evolutionary principles underlying brain complexity and behavior. We chose 4 areas that address key principles across the broad spectrum of brain evolution starting from the molecular origins of the brain through to studies of evolution of the primate and human lineage. These questions have been reinvigorated by new molecular approaches including large scale molecular studies of the genome (e.g., high throughput sequencing of Neanderthal DNA), transcriptome (e.g., large scale in situ hybridizations) and proteome (e.g., synapse proteomics of multiple species).

The origins of synapses and neuron types are key issues for all neuroscience and the link from these origins to the organization of circuits in both simple invertebrate and complex mammalian brains will be addressed. We will aim to link these principles to specific as well as the overall repertoire of behaviors through studies of genetic manipulation of mice as well as comparative cognition of birds and humans. The sequencing of the Neanderthal genome, the closest human ancestor of modern humans, with comparative studies of primates and other species will address the issues of molecular evolution of the brain in humans.

The order of presentations from brain origins to humans provides a simple program structure and speakers will exploit common molecular links to synapses, neurons and circuits to provide overlap and continuity. This symposium is designed to have very broad appeal as it touches on fundamental biological questions and presents a wide range of approaches: molecular, anatomical, physiology, psychology, psychiatry, and paleontology.

Speaker's Summary

Chair: Tatyana Sharpee, PhD
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Minisymposium: **Common Principles of Adaptation to Natural Environment**
Saturday, Oct. 17, 1:30–4 p.m., Room S406B

This mini-symposium will bring together researchers studying different sensory systems in order to elucidate the common principles of neural adaptation to natural environment, through a combination of experimental and computational approaches. Despite the different physical origins, natural stimuli in vision, audition, and olfaction have a number of common statistical characteristics. These include strong correlations between stimulus values at nearby points in space and time, as well as large deviations from their mean values that are poorly described by Gaussian distribution. A number of recent findings suggest that common adaptation strategies are used in the brain to achieve efficient coding of natural stimuli. Speakers will present data comparing adaptation to natural stimulus statistics in visual, auditory, and somatosensory stimuli, and discuss the types of multi-layer neural networks that can yield efficient representation of both visual and olfactory stimuli. However, experimental findings in different sensory modalities are not always equivalent. When disagreements arise, it is often not clear whether this is because the experiments targeted different layers of neural processing or different sensory systems. A joint discussion of such results will help identify "missing" experiments needed to the test the generality of principles of adaptation to the natural sensory environment.

Speaker's Summary

Speaker: John Hildebrand, PhD
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Public Symposium**: In Celebration of Darwin: Evolution of Brain and Behavior**
Saturday, Oct. 17, 1:30–4 p.m., Room S100B

The complexity of the brain challenges our abilities to understand its mechanisms of function. An evolutionary perspective provides a powerful means to clarify how the brain and behavior are both substrates and determinants of evolutionary change. Ultimately, every aspect of the brain can best be understood in evolutionary terms. How did higher functions and complexity arise? Are "simple" systems replaced by more complex ones? Does that change the basic neuronal algorithms for solving discrete tasks? Does behavior play a major role in natural selection?