



THE PONTIFICAL ACADEMY OF SCIENCES

Plenary Session on

**Complexity and Analogy in Science:
Theoretical, Methodological and Epistemological Aspects**

5-7 November 2012 • Casina Pio IV

Working Group on

**Neurosciences and the Human Person:
New Perspectives on Human Activities**

8-10 November 2012 • Casina Pio IV



VATICAN CITY 2012



The imagery of nature as a book has its roots in Christianity and has been held dear by many scientists. Galileo saw nature as a book whose author is God in the same way that Scripture has God as its author. It is a book whose history, whose evolution, whose 'writing' and meaning, we 'read' according to the different approaches of the sciences, while all the time presupposing the foundational presence of the author who has wished to reveal himself therein. This image also helps us to understand that the world, far from originating out of chaos, resembles an ordered book; it is a cosmos. Notwithstanding elements of the irrational, chaotic and the destructive in the long processes of change in the cosmos, matter as such is 'legible'. It has an inbuilt 'mathematics'. The human mind therefore can engage not only in a 'cosmography' studying measurable phenomena but also in a 'cosmology' discerning the visible inner logic of the cosmos. We may not at first be able to see the harmony both of the whole and of the relations of the individual parts, or their relationship to the whole. Yet, there always remains a broad range of intelligible events, and the process is rational in that it reveals an order of evident correspondences and undeniable finalities: in the inorganic world, between microstructure and macrostructure; in the organic and animal world, between structure and function; and in the spiritual world, between knowledge of the truth and the aspiration to freedom. Experimental and philosophical inquiry gradually discovers these orders; it perceives them working to maintain themselves in being, defending themselves against imbalances, and overcoming obstacles. And thanks to the natural sciences we have greatly increased our understanding of the uniqueness of humanity's place in the cosmos.

Address of His Holiness Benedict XVI to the Members of the Pontifical Academy of Sciences, Friday, 31 October 2008.

*Complexity and Analogy in Science:
Theoretical, Methodological and Epistemological Aspects*

PROLOGUE

In the past decades scientific investigations have been quite successful by reductionistic research approaches. But scientists are ever more aware that their specific knowledge obtained so far will have to become integrated into a more holistic understanding of the reality of nature, which shows ever higher degrees of complexity and analogy. Evidence of this can be found, for example, in micro and macro physics as well as in biological systems. The Council presumes that most of our Academicians will be able to contribute with their personal view and experience to the proposed topic. This can offer a welcome occasion to learn from one another and to outline promising approaches for future scientific investigations.

The concept of complexity in science has many different meanings with regard to theoretical, methodological and epistemological aspects, while its basic meaning remains stable. It is, first of all, the theory of nonlinear complex systems, which is used with regard to physics and quantum systems as well as to cellular organisms and the brain. The aim of the Plenary Session is to explore the important concept of complexity in science in general and in different scientific disciplines. Are the concepts used analogous, or can a phenomenon be, for instance, complex from the biological point of view, but not from the physical one? Shall our practice just ignore problems we cannot currently handle – or can science render apparently complex systems in simple underlying theories? Furthermore, is there a difference between complex and complicated such that some complex systems are not actually complicated even though all complicated systems are indeed complex? In general, complexity has become an important area of research in several disciplines in the last decades. For instance, the complexity and the ensuing unpredictability of weather systems has been known for a long time.

In systemic approaches to fully understand functions and evolution of life, one may have to consider each individual organism as a complex system of biological functions, then each ecosystem as a complex system of mutually interactive organisms belonging to different species, and finally, the entire living world together with its different habitats as a large planetary system of steady, but slow, co-evolution.

Werner Arber & Jürgen Mittelstraß



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PROGRAMME

Monday, 5 November 2012

Welcome

- 9:00 *Welcome*
Werner Arber, President of the Pontifical Academy of Sciences
H.E. Msgr. Marcelo Sánchez Sorondo, Chancellor of the Pontifical Academy of Sciences

Introduction

- 9:10 *Complexity, Reductionism, and Holism in Science and Philosophy of Science*
Jürgen Mittelstraß
- 9:30 Discussion

Session I: PHYSICS, ASTROPHYSICS AND MATHEMATICS
Chair: Werner Arber

- 9:40 *Complexity at the Fundamental Level*
Antonino Zichichi
- 10:10 Discussion
- 10:20 *Kolmogorov Complexity as a Hidden Factor of Scientific Discourse: From Newton's Law to Data Mining*
Yuri I. Manin
- 10:50 Discussion
- 11:00 Coffee break
- 11:30 *Scaling in the Complex Systems*
Rudolf Muradyan
- 11:40 *Complexity in Space Engineering*
Krishnaswamy Kasturirangan
- 11:50 *Complexity and Analogy in the Search of Extraterrestrial Life*
José G. Funes
- 12:00 Discussion
- 12:10 *From Big Bang to Biospheres: The Scope and Limits of Explanation*
Martin J. Rees
- 12:20 Discussion
- 12:30 *Quantum Simulation of Computationally Intractable Problems and Questions About Emergence*
William D. Phillips
- 12:50 Discussion
- 13:10 Lunch at the Casina Pio IV



Chair: Rafael Vicuña

- 14:30 *Recurrent Ideas in Mathematical Modelling*
Luis A. Caffarelli
- 15:00 Discussion
- 15:10 *Complexity in Chemistry: From Disorder to Order*
Gerhard Ertl
- 15:40 Discussion
- 15:50 *Probing the Limits of Quantum Physics by Precision Spectroscopy of Hydrogen*
Theodor W. Hänsch
- 16:20 Discussion

Session II: CHEMISTRY AND BIOLOGY
Chair: Veerabhadran Ramanathan

- 16:30 *Deciphering Complexity in Biology: Induction of Embryonic Cell Differentiation by Morphogen Gradients*
Edward M. De Robertis
- 17:00 Discussion
- 17:10 Coffee break
- 17:40 *Life's Biochemical Complexity*
Rafael Vicuña
- 18:10 Discussion
- 18:20 *Systems Biology of Cancer Cell Growth*
Lilia Alberghina
- 18:30 Discussion
- 18:40 *Gradual Increases in Complexity Lead to the Emergence of Novel Principles of Information Processing: The Cerebral Cortex as an Example*
Wolf J. Singer
- 19:00 Discussion
- 19:10 Dinner at the Casina Pio IV



Tuesday, 6 November 2012

9:00 *Highlights of Nanoscience*
Chintamani N.R. Rao

9:30 Discussion

Session III: EARTH AND ENVIRONMENTAL SCIENCES
Chair: Paul J. Crutzen

9:40 *Complexity in Climate Change Science*
Mario J. Molina

10:10 Discussion

10:20 Coffee break

10:50 *Climate Change and Protection of the Habitat that Sustains Us: What Can Be Accomplished?*
Veerabhadran Ramanathan

11:10 Discussion

11:20 *Towards a Sustainable Use of Natural Resources by Respecting the Laws of Nature*
Werner Arber

11:40 Discussion

11:50 *Complex Network Analysis of the Virtual Water Trade Among Nations*
Ignacio Rodriguez-Iturbe

12:10 Discussion

12:20 Lunch at the Casina Pio IV

Session IV: SCIENCE, EDUCATION AND THEOLOGY
Chair: Jürgen Mittelstraß

14:30 *Analogy, Identity, Equivalence*
Michał Heller

14:50 Discussion

15:00 *Educating to Complexity: A Challenge*
Pierre J. Léna

15:30 Discussion

15:40 *Infinité du monde et infinité de Dieu: quelle corrélation?*
Jean-Michel Maldamé

16:00 Discussion

16:10 Coffee break

Closed Session, Commemorations, Self-Presentations

16:40 Closed Session

Commemorations

Bernardo Colombo (Enrico Berti), **Har G. Khorana** (Werner Arber), **Carlo Maria Martini** (Georges M.M. Cottier), **Rudolf Mößbauer** (Theodor W. Hänsch), **Andrej Szczeklik** (Antonio M. Battro)

Self-Presentations of New Members

Joachim von Braun, **Vanderlei S. Bagnato**

Future activities of our Academicians. Members' proposals: topics, candidates, etc.

20:00 Dinner at the Casina Pio IV

Wednesday, 7 November 2012

- 8:45 Visit to the Vatican Museums and Sistine Chapel (optional)
- 11:00 Pius XI Medal Award Ceremony (Casina Pio IV).
Winners: Prof. Trees-Juen Chuang, Prof. Ulrich Pöschl
- 13:00 Lunch at the Casina Pio IV
- 18:00 Bus leaves the Domus Sanctae Marthae to take the Participants to Villa Madama
- 18:30 Concert of the Choir of the Italian Spouses Association of the Italian Ministry of Foreign Affairs followed by a dinner at Villa Madama, invited by Foreign Minister Giulio Terzi di Sant'Agata
Villa Madama was designed by Raphael in 1518, just before his death, for Cardinal Giulio de' Medici, cousin of the reigning Pontiff Leo X



*Neurosciences and the Human Person:
New Perspectives on Human Activities*

PROLOGUE

Working Group 8-10 November 2012 – Each generation of neuroscientists, philosophers and theologians has the task of analyzing and assessing new advances in the understanding of the human person, dignity and value within nature.

The Pontifical Academy of Sciences acknowledged this responsibility through two important workshops which should be seen as milestones.

The first was held in 1964 and was on 'The Brain and Conscious Experience' (Study Week, 28 Sept.-3 Oct. 1964, SV 30. Chairman: John C. Eccles; edited by Pietro Salviucci).

The second was held in 1988 and was on 'Brain Research and the Mind-Body Problem. Epistemological and Metaphysical Issues' (5 Oct. 1988, SV 79. Round Table Discussion. Chairman: Carlos Chagas; edited by Giuseppe del Re).

In 1964 the President of the Academy was George Lemaître and the Chancellor was Pietro Salviucci. There were 24 participants, including the Academicians John Eccles, Corneille Heymans, Giuseppe Moruzzi and Roger Sperry. Among the invited scientists there were Edgar Lord Adrian, Creutzfeldt, Ragnar Granit, Hebert Jasper, Benjamin Libet, Vernon Mountcastle and Hans-Lukas Teuber.

In 1988 the President was Carlos Chagas and the Directors were Enrico di Rovasenda and Renato Dardozzi. There were 22 participants. The theologians were Enrico di Rovasenda, Jan Schotte, and Giovanni Marchesi and the philosophers were Giuseppe del Re, Vittorio Mathieu, Peter Henrici, Paolo A. Rossi and Francesco Calvo. Among the scientists were the Academicians John C. Eccles, Jérôme Lejeune and János Szentagothai. This Round Table was preceded by a Study Week Session on the 'Principles of Design and Operation of the Brain' which had a long list of distinguished participants.

Continuing this important lineage of research and reflection, it is thus appropriate to gather for another meeting to continue the dialogue of the current generation between neuroscientists, philosophers and theologians in this scientific age. Significantly, this workshop on 'Neurosciences and the Human Person: New Perspectives on Human Activities' comes after another 24 years, the lifetime of a generation and the same time span that separated the first two meetings of the Academy.

Neuroscientists have made fundamental improvements since the last meeting in 1988 with the introduction of advanced neurobiological and genetic technologies – and a corresponding new language – which deserve analysis in order to have a better understanding of the status of the human being that is in line with these new scientific discoveries. Philosophers and theologians, in their turn, are increasingly aware of the particular discoveries, epistemologies and languages that science has developed and try to interpret this new significant data in the light of the Socratic principle 'know yourself'. It follows that man's knowledge is not derived from a single perspective – that of external observation, explanation, and experimentation: this knowledge develops in the interface between the observation of nature and reflective understanding. The human being is an observable entity, like all organisms but at the same time it reflects on itself, it is a 'self-interpreting being'. Thus, understanding the human condition requires analysis of the various levels of knowledge and descriptions involving reconciliation between insights derived from the first, second and third person perspective in this age of rapid scientific progress. We hope that this dialogue between the different approaches and languages, which we propose for these three days, will enrich the contemporary understanding of the human person.

We may imagine another meeting of our Academy on this same issue in 2036 but we certainly cannot predict the topics and the technologies that will be discussed then. Our fields are expanding rapidly and the scientific, philosophical and theological challenges will increase accordingly.

We sincerely thank all the participants for their valuable contribution.

A.M. Battro, S. Dehaene, M. Sánchez Sorondo, W.J. Singer



*Neurosciences and the Human Person:
New Perspectives on Human Activities*

PROGRAMME

Thursday, 8 November 2012

9:00 *Welcome* (Marcelo Sánchez Sorondo)
Introduction (Antonio M. Battro)

1. ORIGINS OF MIND

Moderator: Uta Frith • Rapporteur: Wolf J. Singer

9:10 *Hominid Evolution and the Emergence of the Genus Homo!*
Yves Coppens

9:30 Discussion

9:50 *Human Origins From a Genomic Perspective*
Svante Pääbo

10:10 Discussion

10:20 *Mind or Soul? Two Notions in the Light of Contemporary Philosophy*
Enrico Berti

10:40 Discussion

11:00 **Papal Audience**

12:30 Lunch at the Casina Pio IV

14:00 **General discussion session 1** (guided by Wolf J. Singer)

2. THE DYNAMIC BRAIN AND CONSCIOUSNESS

Moderator: Michael S. Gazzaniga • Rapporteur: Yves Coppens

15:00 *The Unity of Experience: Temporal Coherence Rather than Spatial Convergence?*
Wolf J. Singer

15:20 Discussion

15:40 *Brain Rhythms, Cognition, and Consciousness*
Earl K. Miller

16:00 Discussion

16:20 *Searching for Brain Mechanism of Conscious Access and Introspection*
Stanislas Dehaene

16:40 Discussion

17:00 Coffee break

17:30 *Consciousness and Self-Consciousness. In Favour of a Pragmatic Dualism in the Philosophy of Mind*
Jürgen Mittelstraß

17:50 Discussion

18:10 *Neuroscience of Self-Consciousness and Subjectivity*
Olaf Blanke

18:30 Discussion

18:50 **General discussion session 2** (guided by Yves Coppens)

20:00 Dinner at the Casina Pio IV



Friday, 9 November 2012

3. TOWARDS A NEUROSCIENTIFIC UNDERSTANDING OF FREE WILL

Moderator: Michael I. Posner • Rapporteur: Jürgen Mittelstraß

- 9:00 *The Neuroscience of Human Choice*
Timothy E. Behrens
- 9:20 Discussion
- 9:40 *False Perceptions and False Beliefs: Understanding Schizophrenia*
Christopher D. Frith
- 10:00 Discussion
- 10:30 Coffee break
- 11:00 *Addiction: A Brain Disease of Free Will*
Nora D. Volkow
- 11:20 Discussion
- 11:40 *Understanding Layers: From Neuroscience to Human Responsibility*
Michael S. Gazzaniga
- 12:00 Discussion
- 13:00 Lunch at the Casina Pio IV
- 15:00 *Self-Knowledge and the Adaptive Unconscious*
Timothy D. Wilson
- 15:20 Discussion
- 15:40 *Law, Neurosciences and Behaviour*
Owen D. Jones
- 16:00 Discussion
- 16:20 *Interaction Between Two Readings: The Naturalistic and the Socratic "Know Thyself"*
Marcelo Sánchez Sorondo
- 16:40 Discussion
- 17:00 Coffee break
- 17:30 **General discussion session 3** (guided by Jürgen Mittelstraß)
- 20:00 Dinner at the Casina Pio IV



Saturday, 10 November 2012

4. SOURCES OF HUMAN COMPREHENSION AND INCOMPREHENSION

Moderator: Nora D. Volkow • Rapporteur: Antonio M. Battro

9:00 *Are There Innate Mechanisms That Make Us Social Beings?*
Uta Frith

9:20 Discussion

9:40 *The Evolution of Cooperation*
Martin A. Nowak

10:10 Discussion

10:30 Coffee break

11:00 *The Christian View of the Human Person and the Soul*
Georges M.M. Cardinal Cottier

11:20 Discussion

11:40 *Developmental Sources of Prejudice*
Elizabeth S. Spelke

12:00 Discussion

12:20 **General discussion session 4** (guided by Antonio M. Battro)

13:15 Lunch at the Casina Pio IV

5. CAN NEUROSCIENCE IMPROVE THE BRAIN AND MIND?

Moderator: Elizabeth S. Spelke • Rapporteur: Stanislas Dehaene

15:00 *The Birth of the Mind*
Jacques Mehler

15:20 Discussion

15:40 *How Genes and Experience Shape Will*
Michael I. Posner

16:00 Discussion

16:20 *New Interfaces for the Brain*
John P. Donoghue

16:40 Discussion

17:00 Coffee break

17:30 *Circuits for Action Diversification*
Silvia Arber

17:50 Discussion

18:10 *Homo Docens and the Teaching Brain*
Antonio M. Battro

18:30 Discussion

18:50 **General discussion session 5 and Final Statement** (guided by Stanislas Dehaene)

20:00 Dinner at the Casina Pio IV



*Complexity and Analogy in Science/
Neurosciences and the Human Person*

LIST OF PARTICIPANTS



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Complexity and Analogy in Science/ Neurosciences and the Human Person

BIOGRAPHIES OF PARTICIPANTS

Lilia Alberghina is Director of SYSBIO, Centre of Systems Biology, and Emeritus Professor of Biochemistry at the University of Milano-Bicocca, Milan, Italy. She has been awarded a Laurea honoris causa in Molecular and Industrial Biotechnology at the University of Naples “Federico II” and a “Premio Feltrinelli” from the Accademia dei Lincei; she is also Fellow of the Accademia dei XL. Her research interests started on the biochemistry of cell growth and division (when she was research associate at the Johns Hopkins University, Baltimore, MD, USA) and in more recent years focused on signal transduction, cell cycle control and protein engineering. Lilia Alberghina has pioneered in Italy the new field of Systems Biology. The results of her studies have opened new understanding of the molecular mechanisms controlling cell cycle progression and more specifically entrance into S phase. Presently she is focusing on the molecular

network that underlies cancer cell growth. The results of her studies have been published in more than 300 papers on scientific international journals. Lilia Alberghina has also published books, including *Biotechnologie e Bioindustria* (L. Alberghina, E. Cernia, UTET, 1996), *Protein Engineering in Industrial Biotechnology* (Harwood Academic publisher, 2000) and, with Hans Westerhoff, a book on *Systems Biology: Definitions and Perspectives*, Springer Verlag 2005.

Silvia Arber holds a joint appointment as a full Professor at the Biozentrum, University of Basel and is a senior investigator at the Friedrich Miescher Institute (FMI) in Basel, Switzerland. Silvia Arber obtained her PhD in the research group of Pico Caroni at the FMI in 1996. She subsequently moved to the laboratory of Thomas Jessell at Columbia University in New York for her postdoctoral work from 1996-2000 where



she worked on the role of transcription factors in neuronal differentiation in the spinal cord. In her own laboratory, she aims to identify the principles that allow neuronal circuits to orchestrate accurate and timely control of motor behavior in response to a variety of stimuli such as sensory cues or voluntary initiation of movement, using the mouse as a model system. To decipher how motor circuits engage in the control of movement, her laboratory elucidates the organization and function of neuronal circuits, by studying synaptic connectivity, genetic and molecular identity of neuronal subpopulations as well as functional properties. Silvia Arber received numerous awards, including the Pfizer award, the HFSP 10th anniversary award, the Latsis award and Schellenberg award for research on spinal cord development, plasticity and regeneration.

Tim Behrens is a Wellcome Trust Fellow and University Research Lecturer at the University of Oxford. He is an honorary lecturer at University College London. He is interested in the mechanisms that underlie learning and decision-making in humans and other mammals. His research bridges the gap between cellular models of cortical function and large scale measurements that can be taken from human imaging and behavioural techniques; and in doing so he attempts to bridge the gap between theories and recordings in human and animal neuroscience. He also has a strong interest in brain connections and neuroanatomy in humans and other primates, and is the lead investigator on anatomical connectivity for the Human Connectome Project.

Olaf Blanke is director of the Center for Neuroprosthetics at the Ecole Polytechnique Fédérale de Lausanne (EPFL), holds the Bertarelli Foundation Chair in Cognitive Neuroprosthetics, and is consultant neurologist at the Department of Neurology (Geneva University Hospital). He received his MD and PhD in neurophysiology from the Free University of Berlin. Blanke's research targets the brain mechanisms of body perception, corporeal awareness and self-consciousness, applying paradigms from cognitive science, neuroscience, neuroimaging, robotics, and virtual reality in healthy subjects and neurological patients. His two main goals are to understand and control neural own body representations to develop a neurobiological model of self-consciousness and subjectivity and to apply these findings in the emerging field of cognitive and systems neuroprosthetics.

Yves Coppens was born in 1934 in Brittany. He has been trained in geology, zoology, botany (University of Rennes) and paleontology (doctoral degrees University of Paris, Sorbonne). His career, starting in 1956, has been conducted in different institutions, all of them in Paris, successively at the National Scientific Research Center (in the department of Vertebrate Paleontology and Human Paleontology of the Sorbonne and in the Institute of Paleontology of the National Museum of Natural History), at the Museum of Man (professor and deputy director in 1969,

Director in 1979) before being appointed Chair of Anthropology of the National Museum of Natural History in 1980 and Chair of Paleoanthropology and Prehistory of the College de France in 1983. Yves Coppens is a member of many scientific institutions all over the world, the French Academy of Sciences, the French Academy of Medicine, the Royal Academy of Sciences, Literature and Fine Arts of Belgium, the Royal Academy of Medicine of Belgium, the Academia Europaea, the national Academy of Sciences of Rome, the Royal Anthropological Institute of Great Britain and Ireland (honorary fellow), the Royal Society of South Africa (foreign associate), the Academy of Malagasy (associate) etc. Yves Coppens received numerous scientific awards from France (prix Edmond Hébert 1963 of the Academy of Sciences, prix André C. Bonnet 1969 of the Academy of Sciences, Grand prix Jaffé 1974 of the Academy of Sciences, Grand prix scientifique 1975 of the Foundation of France, silver medal 1982 of the Scientific Research Center, André Duveyrier medal 1989 of the society of Geography, prix 2008 of the Georges Pompidou Foundation, prix Agrippa d'Aubigné 2010), from Belgium (the Fourmarier medal 1975 of the Geological Society of Belgium, the Vandebroek medal 1987 of the Belgian society of geology, paleontology and hydrology, the Chaos award 2009 of the University of Liege), from Italy (the Fabio Frassetto prize 2005 of the Academia dei Lincei, the Nonino prize 2007, the Andersen prize 2008), from Sweden (the Carl Gustaf Bernhard medal 1997 of the royal Academy of Sciences), from UNESCO (the Kalinga prize 1984) and so on. He received honorary doctorates from the Universities of Chicago, Bologne, Liège, Mons, and honorary citizenships of 29 towns (France and Marocco). His name has been given to an asteroid, and to institutions, universities, colleges, school, libraries, labs, promotion, streets and a Chair at the University of Recife (Brazil). He is Commandeur de la Légion d'Honneur, Grand Officier du Mérite, Commandeur des Palmes Académiques, Commandeur des Arts et des Lettres, Commandeur de l'Ordre du Mérite de la Principauté de Monaco, Officier de l'Ordre National du Tchad, etc. Yves Coppens is a field paleontologist; he has organized, led or co-led many expeditions in tropical Africa (4 campaigns in Chad, 1960-1966, 10 campaigns in the lower Omo valley in Ethiopia, 1967-1976, 5 campaigns in the Afar desert in Ethiopia, 1972-1977), in Asia (Indonesia, the Philippines, China, Siberia, Mongolia), and many surveys in north and south Africa, the Middle East, south America as well as excavations in France etc. As a result of this field research, he collected tons of fossil vertebrates, hundreds of Hominids (he signed or co-signed 6 new Hominid taxa) and of course an impressive amount of data. His research focused on Vertebrate Paleontology (Proboscidians, Hippos), their assemblages and their meaning in paleoenvironments, climates and biochronology, as well as on Paleoanthropology. He is renowned for his hypotheses showing the correlations between hominid evolution and the evolution of the environments (the *East side story* 10 million years ago was not geographically confirmed but the (*H*) *Omo event*, 2.7



million years ago was adopted worldwide). His lab has also pioneered important research on the functional anatomy of early hominid (demonstration of early double locomotion, bipedal and arboreal, of some of them, *Australopithecus afarensis* and *Orrorin tugenensis*). He authored or co-authored over a thousand of scientific papers and books. Professor Yves Coppens took part in workshops at the PAS in 1981 and 2010.

John P. Donoghue is the Henry Merritt Wriston Professor and Professor of Neuroscience and Engineering, as well as the Director of the Brown Institute for Brain Science at Brown University where he has been a faculty member for more than twenty-five years. His laboratory investigates the function of cerebral cortex and is also engaged in translational research to create neurotechnologies for people with paralysis to regain independence and control. His basic neuroscience research examines the way populations of neurons in the cerebral cortex convert plans, thoughts or ideas into skilled arm movements. This work combines novel implantable multi-neuron sensors developed in his laboratory and mathematical methods to understand how ensembles of neurons represent information and how they compute new information through their interactions. The knowledge and technical advances gained from this fundamental research is being translated into a human brain computer interface technology, called BrainGate. This neurotechnology has the potential to restore useful functions for people with paralysis, providing control of a computer, an assistive robot; it might also allow the brain to be reconnected to paralyzed muscles or to use revolutionary prosthetic limbs for amputees. BrainGate is designed to physically reconnect the brain to the outside world through a tiny 'chip' the size of a baby aspirin, that is implanted in the motor area of the cerebral cortex. Pilot trials of BrainGate have already demonstrated the ability for humans with longstanding and severe paralysis to use their own intentions to use send text messages, reach and grasp objects with a robotic arm, and drive a wheelchair. Moving these early stage demonstrations to real world use is one of next goals of the team of researchers Donoghue leads. He was the founding chairman of the Department of Neuroscience in the Alpert Medical School at Brown, a position he held for thirteen years. The Brown Institute for Brain Science, which he founded and leads, unites more than one hundred Brown faculty members in interdisciplinary basic, translational and clinical research on the nervous system. Dr. Donoghue has published widely in the fields of Neuroscience and Neurotechnology along with his many undergraduate, graduate and postdoctoral students who are now well-recognized, independent scientists and clinicians. He was also a co-founder and scientific director of Cyberkinetics, a start-up company (now no longer operating) that played a key role in translating BrainGate to human pilot clinical trials. Dr. Donoghue's research has been honored by Germany's Zülch Prize, the "In Praise of Medicine" award from Erasmus University,

the 2010 Pioneer in Medicine award from the Brain Mapping Society, and a Jacob Javits award from the NIH. In addition, the BrainGate project won the 2004 Innovations Award for Neuroscience from Discover Magazine, and the 2007 R&D 100 Award, among many other awards. Donoghue's work has been featured widely in the media, including the *New York Times*, the CBS television show *60 Minutes*, PBS' *Frontline*, Discovery and History Channel documentaries and other international media. He has served on numerous United States federal panels for the National Institutes of Health, the National Science Foundation and the Department of Defense. He is also a member of the National Research Advisory Council of the Department of Veterans Affairs, and a Fellow of the American Institute for Medical and Biomedical Engineering, the American Association for the Advancement of Science, and the American Academy of Arts and Sciences.

Christopher D. Frith is Emeritus Professor of Neuropsychology at the Wellcome Centre for Neuroimaging at University College London, Niels Bohr Visiting Professor in the Interacting Minds project at the University of Aarhus, and Fellow of All Souls College, Oxford. Since completing his PhD in 1969 he has been funded by the Medical Research Council and the Wellcome Trust to study the relationship between the mind and the brain. He is a pioneer in the application of brain imaging to the study of mental processes. He has contributed more than 400 papers to scientific journals and is known especially for his work on agency, social cognition, and understanding the minds of people with mental disorders such as schizophrenia. For this work he was elected a Fellow of the Royal Society in 2000 and a Fellow of the British Academy in 2008. Among his books are: *Schizophrenia: A Very Short Introduction* (2003, with Eve Johnstone), *The Neuroscience of Social Interaction: Decoding, Imitating and Influencing the Actions of Others* (2004, edited with Daniel Wolpert) and *Making up the Mind* (2007). In 2009 he was awarded the Strömberg medal for work on Schizophrenia, the European Latsis Prize (Jointly with U. Frith) for work on 'human mind, human brain' and the International Prize from the Fyssen Foundation for work on Neuropsychology.

Uta Frith is Emeritus Professor of Cognitive Development at University College London and Research Foundation Professor at the University of Aarhus. She has received a number of honorary degrees and is a fellow of the British Academy, the Royal Society, member of the Leopoldina and Foreign Associate of the NAS. She received jointly with Chris Frith the 2009 European Latsis Prize for work on 'Human Mind – Human Brain'. Uta Frith has studied neuro-developmental disorders, in particular autism and dyslexia. She was one of the first to recognise the importance of Asperger syndrome, and has proposed and contributed to theories of autism referred to as *Theory of Mind* and *Central Coherence*, which attempt to define cognitive phenotypes. Her books include *Autism: explaining the enigma* (1989, second edition 2003); *Autism: A Very*

Short Introduction (2008); and *Autism in History* (with R. Houston, 2000). She has recently edited (with F. Happé, 2010) a volume on *Autism and Talent*. With Chris Frith she has written several reviews on social cognition. Uta Frith's other interests include the support of women in science, and the application of insights from neuroscience to education.

Michael S. Gazzaniga is the Director of the Sage Center for the study of Mind at the University of California, Santa Barbara. He received a Ph.D from the California Institute of Technology, where he worked with Roger Sperry, and had primary responsibility for initiating human split-brain research. He has established Centers for Cognitive Neuroscience at Cornell Medical School, the University of California-Davis and at Dartmouth. He is the founding editor of the Cognitive Neuroscience Institute and the *Journal of Cognitive Neuroscience*. He was a member of the President's Council on Bioethics from 2001-2009. He is a member of the American Academy of Arts and Science, the Institute of Medicine and the National Academy of Sciences. His new book is based on his Gifford Lectures—*Who's in Charge? Free Will and the science of the brain*.

Owen D. Jones, of Vanderbilt University, holds the New York Alumni Chancellor's Chair in Law and is also Professor of Biological Sciences. He is also Director of the *MacArthur Foundation Research Network on Law and Neuroscience*. Professor Jones' research and scholarship bridges law, biology, and behavior. And his work aims to deepen understandings of law-relevant behaviors by integrating social science and life science perspectives. Professor Jones' work, both empirical and theoretical, appears in multiple scientific and legal venues. Recently, he and colleagues have used brain-imaging (fMRI), behavioral biology, and behavioral economics to learn more about how the brain's varied operations affect behaviors relevant to law. For example, he co-discovered with Vanderbilt colleagues the brain activity underlying decisions of whether to punish someone and, if so, how much. After receiving his B.A. from Amherst College and his J.D. from Yale Law School, Professor Jones clerked for Judge Thomas Penfield Jackson of the U.S. District Court for the District of Columbia. He came to Vanderbilt from Arizona State University, where he was Willard H. Pedrick Distinguished Research Scholar, Professor of Law, Professor of Biology, and Faculty Fellow of the Center for the Study of Law, Science and Technology.

Jacques Mehler (17/08/1936 Barcelona, Spain). As a graduate student at Harvard, Mehler witnessed the birth of the Cognitive Revolution that brought together Psychology, Linguistics, Anthropology, Biology, Philosophy and Computer Science. After obtaining his PhD in 1964, Mehler worked at Harvard and MIT. He also spent one year at Piaget's Institute in Geneva. He became a psycholinguist and a developmental scientist, carrying out studies with young children. He devoted most of his career to language processing

and acquisition. In 1967 Mehler accepted a position at the CNRS in Paris where he founded and directed the Laboratoire de Sciences Cognitives et Psycholinguistique (LSCP). He became Directeur de Recherche in 1980, and Directeur d'Etudes in 1986. In 2001 Mehler moved to SISSA, in Trieste, where he established Language, Cognition and Development (LCD) laboratory, to pursue studies of the mind/brain system during development. He organized a neonate-testing unit in Udine at the University Hospital and helped develop a Near Infrared Spectroscopy brain-imaging laboratory to explore the mind/brain mechanisms in neonates. In 2010 Mehler has been awarded an ERC Advanced Grant for his PASCAL research project, hosted by SISSA, to continue investigating the human ability to acquire language and the underlying biological endowment that provides specific language learning mechanisms. Mehler has published over 250 peer-reviewed papers in high profile journals and reference books. In 1970, Mehler founded *Cognition*, a journal that became a landmark of the field. He was its Editor in Chief until 2006. His book, *Naître Humain*, has been re-edited several times and was translated into seven languages. The complete list of his publications and their PDFs are available at: <http://www.sissa.it/cns/lcd/publications.htm>. Mehler was elected member of many prestigious associations (American Ass. Arts & Sciences; American Philosophical Society; Academia Europea, inter alia). Mehler was awarded several prizes and two Honorary Doctorates: Université Libre de Bruxelles (1998) and Utrecht University (2010).

Earl K. Miller is the Picower Professor of Neuroscience at the Massachusetts Institute of Technology. Professor Miller uses experimental and theoretical approaches to study the neural basis of the high-level cognitive functions that underlie complex goal-directed behavior. His laboratory has provided insights into how categories, concepts, and rules are learned, how attention is focused, and how the brain coordinates thought and action. This work has established a foundation upon which to construct more detailed, mechanistic accounts of how executive control is implemented in the brain and its dysfunction in diseases such as autism, schizophrenia and attention deficit disorder. Professor Miller is the recipient of a variety of awards, including the National Institute of Mental Health MERIT Award (2010), the Mathilde Solowey Award in the Neurosciences (2007), election to the International Neuropsychological Symposium (2006), Fellow of the American Association for the Advancement of Science (2005), the Picower Chair at MIT (2003), the National Academy of Sciences Troland Research Award (2000), and the Society for Neuroscience Young Investigator Award (2000). His paper, "An Integrative Theory of Prefrontal Cortex Function" (Miller and Cohen, 2001), has been designated a Current Classic as among the most cited papers in Neuroscience and Behavior.

Martin A. Nowak is Professor of Biology and of Mathematics at Harvard University and Director of the Program for Evolutionary Dynamics. Dr. Nowak



works on the mathematical description of evolutionary processes, including the evolution of cooperation and human language, and the dynamics of virus infections and human cancer. His work has contributed to the following scientific discoveries: the mechanism for HIV disease progression (1991), spatial game dynamics (1992), generous tit-for-tat and win-stay, lose-shift (1993), the rapid turnover and evolution of drug resistance in HIV infection (1995), dynamics of HBV infection (1996), mechanisms for the evolution of genetic redundancy (1997), evolution of cooperation by indirect reciprocity (1998), the mathematical approach for studying the evolution of human language (1999-2002), evolutionary game dynamics in finite populations and the 1/3 rule (2004), evolutionary graph theory (2005), the first quantification of the in vivo kinetics of a human cancer (2005), five rules for the evolution of cooperation (2006), dynamics of language regularization (2007), "winners don't punish" (2008), evolutionary set theory (2009), a mechanism for the evolution of eusociality (2010) and dynamics of resistance in targeted cancer therapy (2012). Dr. Nowak has published more than 300 peer-reviewed scientific papers in collaboration with over seventy co-authors. Dr. Nowak has written three books: *Virus Dynamics* (with Robert May) published by Oxford University Press in 2000; *Evolutionary Dynamics* published by Harvard University Press in 2006; and *SuperCooperators* (with Roger Highfield) which was published by Simon & Schuster in 2011 and reviewed in the New York Times.

Svante Pääbo has developed technical approaches that allow DNA sequences from extinct creatures such as mammoths, ground sloths and Neandertals to be determined. He also works on the comparative genomics of humans, extinct hominins and apes, particularly the evolution of gene activity and genetic changes that may underlie aspects of traits specific to humans such as speech and language. In 2010, his group determined the first Neandertal genome sequence and described Denisovans, a sister group of Neandertals, based on a genome sequence determined from a small bone found in Siberia. Svante Pääbo holds several honorary degrees and is a member of numerous academies. He is currently a Director at the Max-Planck Institute for Evolutionary Anthropology in Leipzig, Germany.

Michael Posner is currently Professor Emeritus at the University of Oregon and Adjunct Prof. of Psychology in Psychiatry at the Weill Medical College of Cornell, where he served as founding director of the Sackler Institute. Posner is well known for his work with Marcus Raichle on imaging the human brain during cognitive tasks. A volume *Images of Mind* resulted from that collaboration. He has worked on the anatomy, circuitry, development and genetics of three attentional networks underlying maintaining alertness, orienting to sensory events and voluntary control of thoughts and ideas. His methods for measuring these networks have been applied to a wide range of neurological, psychiatric and developmental

disorders. He edited *Cognitive Neuroscience of Attention* describing this work. His current research involves training of attention in young children and adults to understand the interaction of specific experience and genes in shaping attention. Books describing this work are *Educating the Human Brain* with M.K. Rothbart and *Attention in the Social World*. His work has been recognized by numerous awards including 7 honorary degrees, election to the National Academy of Sciences of the USA, and in 2008 by the National Medal of Science.

Elizabeth S. Spelke teaches at Harvard University, where she is the Marshall L. Berkman Professor of Psychology. She previously taught at MIT, Cornell University, and the University of Pennsylvania after studying at Harvard, Yale and Cornell Universities. Spelke investigates the origins and nature of knowledge of objects, actions, number, geometry, and social relationships through studies of human infants, children, human adults and non-human animals. A member of the National Academy of Sciences and the American Academy of Arts and Sciences, her honors include the Distinguished Scientific Contribution Award of the American Psychological Association, the William James Award of the American Psychological Society, the IPSEN prize in neuronal plasticity, and the Jean Nicod Prize.

Nora D. Volkow, M.D., became Director of the National Institute on Drug Abuse (NIDA) at the National Institutes of Health in May 2003. NIDA supports most of the world's research on the health aspects of drug abuse and addiction. Dr. Volkow's work has been instrumental in demonstrating that drug addiction is a disease of the human brain. As a research psychiatrist and scientist, Dr. Volkow pioneered the use of brain imaging to investigate the toxic effects and addictive properties of abusable drugs. Her studies have documented changes in the dopamine system affecting, among others, the functions of frontal brain regions involved with motivation, drive, and pleasure in addiction. She has also made important contributions to the neurobiology of obesity, ADHD, and aging. Dr. Volkow was born in Mexico, attended the Modern American School, and earned her medical degree from the National University of Mexico in Mexico City, where she received the *Robins* award for best medical student of her generation. Her psychiatric residency was at New York University, where she earned the *Laughlin Fellowship Award* as one of the 10 Outstanding Psychiatric Residents in the USA. Dr. Volkow spent most of her professional career at the Department of Energy's Brookhaven National Laboratory (BNL) in Upton, New York, where she held several leadership positions including Director of Nuclear Medicine, Chairman of the Medical Department, and associate Director for Life Sciences. In addition, Dr. Volkow was a professor in the Department of Psychiatry and associate Dean of the Medical School at the State University of New York (SUNY)-Stony Brook. Dr. Volkow has published more than 530 peer-reviewed articles and written



more than 80 book chapters and non-peer reviewed manuscripts, and has also edited three books on neuroimaging for mental and addictive disorders. During her professional career, Dr. Volkow has been the recipient of multiple awards, including her selection for membership in the Institute of Medicine in the National academy of Sciences and the International Prize from the French Institute of Health and Medical Research for her pioneering work in brain imaging and addiction science. She was recently named one of *Time Magazine's* "top 100 People Who Shape our World" and was included as one of the 20 people to watch by *Newsweek* magazine in its "Who's Next in 2007" feature. She was also included in *Washingtonian Magazine's* 2009 list of the "100 Most Powerful Women" and named "Innovator of the year" by *U.S. News & World Report* in 2000.

Timothy D. Wilson is Sherrell J. Aston Professor of Psychology at the University of Virginia. He has pub-

lished over 100 articles in scholarly journals and edited books, primarily on the topics of self-knowledge and unconscious processing. His research has been funded by the National Science Foundation, the National Institute of Mental Health, and the Russell Sage Foundation. Wilson was elected to the American Academy of Arts and Sciences in 2009. At the University of Virginia, he has won an All University Outstanding Teacher Award and the Distinguished Scientist Award. In 2002 Wilson published *Strangers to Ourselves: Discovering the Adaptive Unconscious* (Harvard University Press). The *New York Times Magazine* listed the book as containing one of the best 100 ideas of 2002. In 2011 he published, *Redirect: The Surprising New Science of Psychological Change* (Little, Brown). The author Malcolm Gladwell said, "There are few academics who write with as much grace and wisdom as Timothy Wilson. I thought his last book *Strangers to Ourselves* was a masterpiece. *Redirect* is more than its equal."

For the biographies of the Academicians of the PAS see www.pas.va

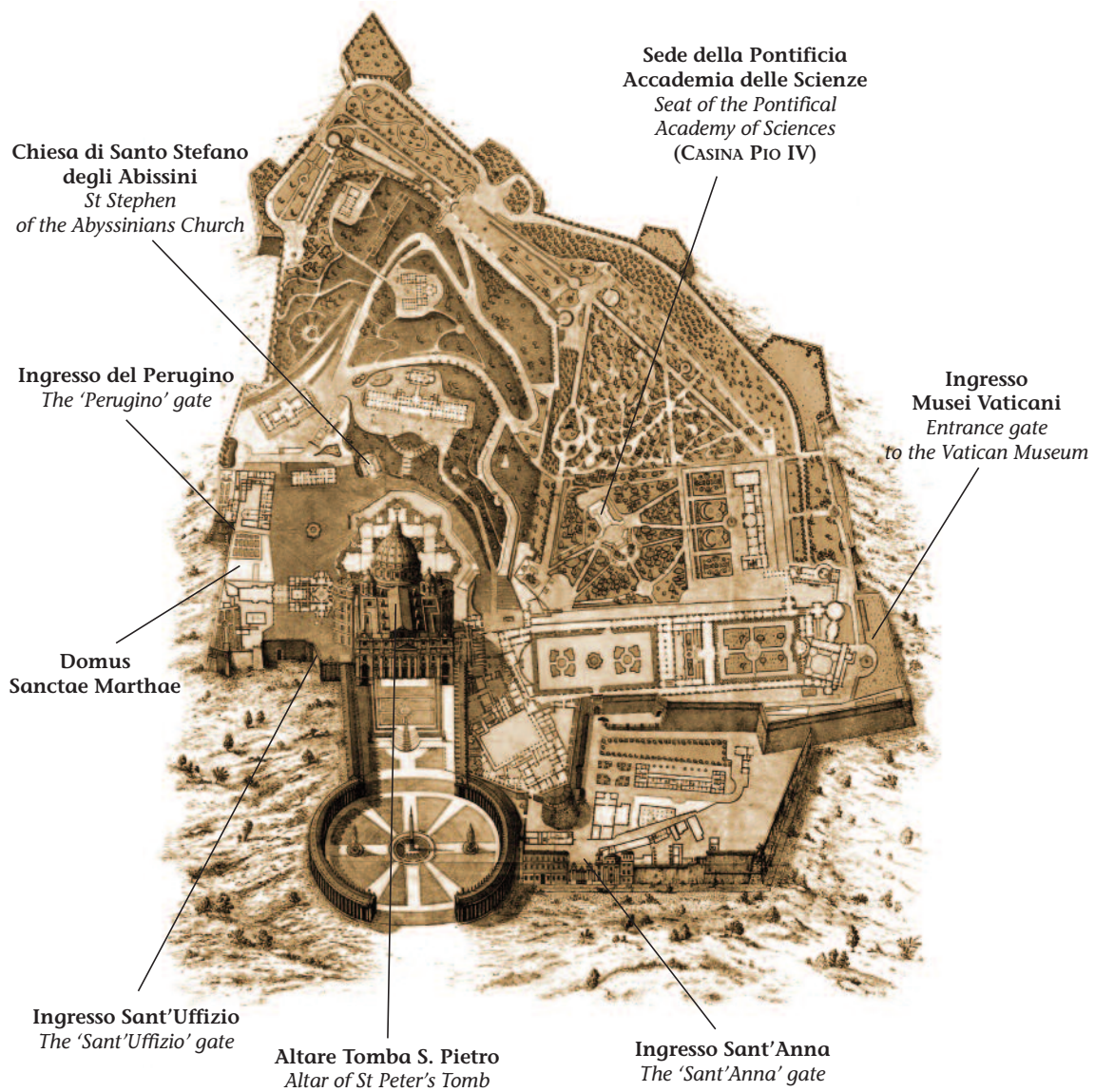
MEMORANDUM

- 1) From 5 to 10 November 2012 a bus will leave the Domus Sanctae Marthae for the Academy, 15 minutes before the beginning of the morning session (hrs. 8.45 am). The same service will be available every day at the end of the dinner (hrs. 21.00). On 7 November a bus will take the participants from the Domus Sanctae Marthae to Villa Madama (see programme) and then back to the Domus Sanctae Marthae after dinner.
- 2) Lunch and dinner for the participants will be served at the Academy except dinner on 7 November, which will be served at Villa Madama. If you are a vegetarian, please let us know as soon as possible.
- 3) Wifi is available in the Casina Pio IV's Conference hall. Please log in to the network called WLAN_PADS using "guest" as the username and "password" as the password.
- 4) Cable internet access is available at the Domus Sanctae Marthae at 7.50€ per day.
- 5) A visit to the Vatican Museums can be arranged for accompanying persons. Please leave your name with the secretariat in order to form a group.

Note

Please give your **form for the refunding of expenses** to the secretariat as soon as possible so that you can be refunded immediately.





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