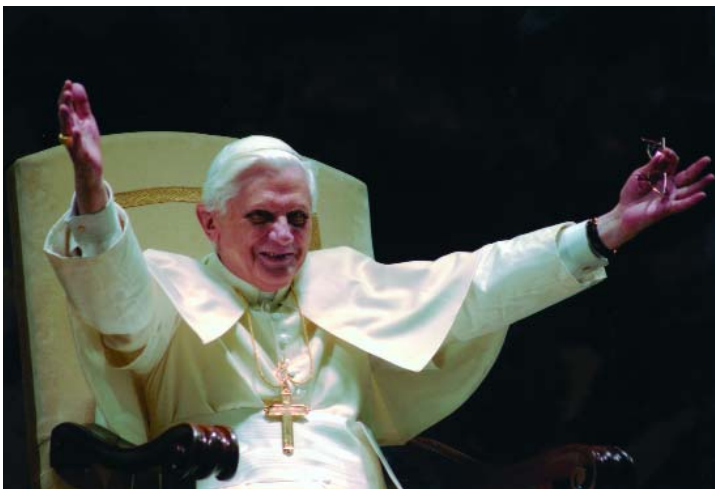
THE PONTIFICAL ACADEMY OF SCIENCES

Plenary Session on

PREDICTABILITY IN SCIENCE: ACCURACY AND LIMITATIONS

3-6 November 2006

VATICAN CITY 2006



As I wrote in the encyclical *Deus Caritas Est*, at the source of Christian existence – and thus also at the origin of our witness as believers – is not an ethical decision or a great idea, but the encounter with the person of Jesus Christ, 'who gives life a new horizon and with this its decisive direction' (n. 1). The fecundity of this encounter manifests itself in a particular and creative way in the current human and cultural context as well, above all in relationship with the reason that has given rise to the modern sciences and to the related technologies.

A fundamental characteristic of the latter of these is, in fact, the systematic employment of the tools of mathematics in order to work with nature and to place its immense energies at our service. Mathematics as such is a creation of our intelligence: the correspondence between its structures and the real structures of the universe – which is the premise for all the modern scientific and technological developments, already formulated explicitly by Galileo Galilei with the famous assertion that the book of nature is written in mathematical language – arouses our admiration and raises a great question. It implies, in fact, that the universe itself is structured in an intelligent manner, in such a way that there exists a profound correspondence between our subjective reason and reason as objectified in nature. So it becomes inevitable to ask if there must not exist a single originating intelligence, which would be the common source of both the one and the other.

And so it is reflection on the development of the sciences which itself brings us back to the creator Logos. This reverses the tendency to give primacy to the irrational, to chance and necessity, bringing back into focus our intelligence and freedom. On these bases, it again becomes possible to expand the spaces of our rationality, to reopen it to the great questions of truth and goodness, to bring together theology, philosophy, and science, in full respect for their proper methods and their reciprocal autonomy, but also in the awareness of the intrinsic unity that holds them together.

This is a task that stands before us, a fascinating adventure in which it is worthwhile to exert oneself, in order to give a new impulse to the culture of our time and to restore the full citizenship of Christianity within it.

The programmatic address from Pope Benedict XVI to the National Conference of the Church in Italy, 19 October 2006.

INTRODUCTION

WERNER ARBER & NICOLA CABIBBO

In its last two business meetings the PAS Council discussed several alternative topics that had been proposed for the next Plenary Session of the Pontifical Academy of Sciences in November 2006. On the basis of these deliberations the Council has chosen the theme of 'Predictability in Science'. This theme is situated at the interphase between fundamental science and its practical applications to the benefit of human beings. We will welcome contributions on scientific predictions of impending dangers, such as earthquakes, on the outlook for climate change, on the analysis of nuclear and other technologies, in the role of prediction in the medical sciences, and on many other scientific predictions and modelling approaches that frequently also have their applications with impact on cultural and socio-political developments.

According to Webster's dictionary the word prediction has two meanings: (1) a predicting or being predicted, and (2) a prophecy. Obviously, only the first meaning applies to our proposed theme. Therefore the word science in the title is important. It is not our role to debate on prophecies. Predictions on a scientific basis can be more or less accurate and have in most cases their intrinsic limitations. We therefore consider expressing this in a subheading. The proposed theme would then read as follows: 'Predictability in Science: Accuracy and Limitations of Predictions based on Scientific Knowledge'.

We expect that all scientific disciplines can contribute with selected examples to a wide debate on scientific predictions and their relevance to society. Thereby, the awareness of natural limitations that are inherent to many predictions plays an important role and it can insure the trust in science in interactions between science and the civil society. The distinction between certainties and uncertainties has since long been made by many scientists presenting scientific knowledge, theories and models on natural developments. A candid discussion on this theme by the Pontifical Academy of Sciences can represent a clarifying view for both the scientific community and the general public.

BACKGROUND NOTE

M. GOVIND KUMAR MENON

The idea behind this meeting is that a great deal is done within science which only scientists would deal with; but there are, increasingly, many other aspects of science which have public implications, that figure extensively in the audiovisual and print media. With regard to the latter, a public understanding of accuracy and uncertainty in the predictions, arising from scientific knowledge, become important.

Most of these aspects of general public interest relate to complex phenomena; and some relate to ethical issues that could have political, social and economic ramifications. For example, issues relating to weather prediction, climate change, prediction of earthquakes, the possibility of major natural disasters such as an asteroid hitting the earth, pandemics from the sars virus, bird flu and the like that could cross over from animals to people, all figure in societal discussions these days. In most of these cases, the issue is that whilst there is a very good scientific basis at the initial stages, as one proceeds down the line, to predictions of relevance to society, many aspects such as complexity, non-equilibrium phenomena, chaos and the like come in introducing uncertainties in the predictions.

Thus, one has clear-cut observations on the carbon dioxide concentrations in the atmosphere and how they have increased with time. One knows that carbon dioxide is a greenhouse gas; and there are also other greenhouse gases. The increase in their concentrations will result in a greenhouse effect, which will cause a rise in global temperature. Sources, pathways, sinks and budgets at each stage will define what ultimately happens.

These will have implications on sea levels, change in climate patterns, extreme events in precipitation, availability of water etc. At each stage there is a greater degree of uncertainty, and an increasingly poorer predictability and lack of consensus. Society gets confused and begins to doubt whether scientists know what they are talking about e.g. the fun many have at the expense of meteorologists. When one gets to the human dimensions of global change, behavioural change etc come into the picture, e.g involving economics, psychology and social behaviour, human dislike for measures that demand lifestyle changes. This is the type of problem dealt with by the Inter-Governmental Panel on Climate Change.

The above somewhat lengthy real life example was only to illustrate the nature of the problem because the public generally assumes that science can be certain and give accurate answers.

There is then the possibility of climate engineering to reduce greenhouse effects. But this could raise ethical issues related to tampering with a natural system and predictability of the hazards involved in this.

There is the issue relating to genetically modified organisms and their large scale use in society. There are many who are opposed to this on the grounds that one would not know what might ultimately happen; and more particularly in relation to the environment.

There is the broad area of environment and ecology where society seldom looks at the price being paid for certain pathways of development. For example, what is the price to be attached to the ecological services provided by water?

Today, there are very significant advances in modelling capabilities and one needs to evaluate the accuracy and limitations in prediction based on these techniques. While it would be possible with increasing knowledge and capabilities to have predictions in many areas, these would never be 100% correct, and one would have to live with uncertainty. In fact, it is this uncertainty that makes further development of science exciting, because there is so much more to know and to understand.

However, there is also the question of decisions that have to be taken by governments and society at any point in time for which advice from the scientific community is called for. This would bring out the importance of the precautionary principle, to avoid getting into a situation that might lead to catastrophic events.

It is felt that the intrinsic issue of scientific uncertainty, particularly in complex, non-equilibrium systems, and limits of predictability need to be discussed from the viewpoint of various angles. It is felt that apart from natural scientists it would be important to have some distinguished thinkers who deal with dimensions that human society is normally concerned with e.g. economic, social and behavioural aspects also participate in this plenary session. This is because many of these areas are characterised by non-equilibrium complex situations and are also increasingly using the techniques developed in the pure sciences for their analysis.

THURSDAY, 2 NOVEMBER 2006

13:30	Council Meeting
19:30	Dinner at the Casina Pio IV

FRIDAY, 3 NOVEMBER 2006

9:00	*Welcome* **Prof. Nicola Cabibbo**, President of the Pontifical Academy of Sciences
9:05	*The Subject of the Meeting* **Prof. Werner Arber**, Coordinator of the Meeting and PAS Academician
9:15	*Commemoration of* **Prof. Richard Southwood** *by* **Prof. Raymond Hide**
9:30	*Self-Presentation of* **Prof. Theodor W. Hänsch** • **Prof. Ingo Potrykus**
10:15	Coffee Break
	Session I **CHAOS AND PREDICTIONS IN PHYSICS AND ASTRONOMY** Chairperson: **Prof. Werner Arber**
10:45	**Prof. Rudolf Muradian** *Predictions in Astrophysics and Cosmology* Discussion
11:30	**Prof. Antonino Zichichi** *Complexity and Predictions at the Fundamental Level of Scientific Knowledge* Discussion
12:30	Lunch at the Casina Pio IV
	Session II **GEOSCIENCES AND ENVIRONMENTAL EVOLUTION** Chairperson: **Prof. Nicole M. Le Douarin**
15:00	**Prof. Vladimir Keilis-Borok** *Predictability of Complex Systems, with Special Reference to Geological Disasters* Discussion
16:00	**Prof. Veerabhadran Ramanathan** *Global Warming Science: Predictions, Surprises and Insurmountable Uncertainties* Discussion
17:00	Coffee Break
17:30	**Prof. Mario J. Molina** *Predictability of Science and Climate Change* Discussion
18:30	**Prof. Paul J. Crutzen** *An Example of Geo-Engineering: Cooling Down Earth's Climate by Sulfur Emissions in the Stratosphere* Discussion
19:30	Dinner at the Casina Pio IV

Saturday, 4 November 2006

	Session III **PREDICTIONS IN THE LIFE SCIENCES** Chairperson: **Prof. William D. Phillips**
9:00	**Prof. Rafael Vicuña** *Attempts to Predict a Minimal Genome* Discussion
10:00	**Prof. Umberto Veronesi** *The New Possibilities of Prediction and Prevention of Cancer* Discussion
11:00	Coffee Break
11:30	**Prof. Werner Arber** *Stochastic Genetic Variations and their Role in Biological Evolution* Discussion
12:30	Lunch at the Casina Pio IV
	Session IV **PHILOSOPHICAL AND SOCIETAL ASPECTS** Chairperson: **Prof. M. Govind Kumar Menon**
14:00	**Prof. Jean-Michel Maldamé** *Epistemological Study of the Vocabulary of Prediction in Science and in Theology* Discussion
15:00	**Prof. Michael Heller** *Predictability, Measurement and Cosmic Time* Discussion
16:00	Coffee Break
16:30	**Prof. Jürgen Mittelstrass** *Epistemological Remarks on the Concept of Predictability* Discussion
17:30	**Prof. Antonio Battro** *Predictability: Prophecy, Prognosis and Prediction. A Study in Neuroeducation* Discussion
18:30	Dinner at the Casina Pio IV

Sunday, 5 November 2006

8:30	Departure from Domus Sanctae Marthae to visit the Papal Villa at Castel Gandolfo
10:00	Holy Mass at Castel Gandolfo
11:00	Presentation of the Pius XI Medal to Prof. Ashoke Sen
13:00	Lunch at the Papal Villa
15:00	Departure from Castel Gandolfo and return to the Domus Sanctae Marthae
18:30	Dinner at the Casina Pio IV

MONDAY, 6 NOVEMBER 2006

	Session V **RESEARCH PROCEDURES: THEORIES AND THEIR VERIFICATION, SERENDIPITY** Chairperson: **Prof. Paul J. Crutzen**
9:00	**Prof. William D. Phillips** *When Results are Better than Predicted: A Case Study* Discussion
10:00	**Prof. Michael Sela** *On Unpredictability in Research Projects* Discussion
11:00	**Fr. Prof. Stanley L. Jaki** *Science as Prediction and the Unpredictability of Science* Discussion
11:30	**Audience with the Holy Father Pope Benedict XVI**
13:30	Lunch at the Casina Pio IV
	Session VI **PUBLIC PERCEPTION AND POLICY IN THE CONTEXT OF UNCERTAINTY** Chairperson: **Prof. Nicola Cabibbo**
15:00	**Prof. M. Govind Kumar Menon** *A Short Background Note* Discussion
16:00	**General Discussion**
16:45	Coffee Break
17:30	**Closed Session for Academicians**
18:30	Dinner at the Casina Pio IV

COMMEMORATION

Commemorative address by Raymond Hide in honour of Academician Thomas Richard Edmund Southwood (20 June 1931-26 October 2005) Elected to the Pontifical Academy of Sciences 1992

T. Richard Edmund Southwood (1931-2005)

Emeritus Linacre Professor of Zoology and former Vice-Chancellor of the University of Oxford, Sir Richard Southwood (hereafter RS) died in Oxford on 26 October 2005. By his own account (see his entry in the 2004 Yearbook of the Pontifical Academy of Sciences), his main scientific contributions were in ecology with a strong bias to entomology, and environmental sciences and policy. A Fellow of the Royal Society, during his distinguished career he received many other honours in recognition not only of his influential research and teaching in zoology but also of his activities as an outstanding university administrator and valued government advisor. He became a member of the Pontifical Academy of Sciences in 1992.

RS was born on 20 June 1931 in the town of Northfleet in the County of Kent in south-east England, where his father owned a dairy farm, and he received his secondary education at the nearby Gravesend Grammar School, which he attended from 1942-49. He then went on to Imperial College London where in 1955 he obtained a PhD degree on the basis

of research on time trends and patterns of species diversity, making use of the long-term data sets on insects held at the Rothamsted Experimental Station near Harpenden, where he met and married his future wife Alison Langley.

During his subsequent career, he served first on the staff of Imperial College, where he became Professor of Zoology and Applied Entomology and Chairman of the Division of Life Sciences, and then, from 1979-93, as Linacre Professor of Zoology at the University of Oxford. His outstanding skills as an administrator from which Imperial College London and the Department of Zoology at Oxford University had already greatly benefited led to his appointment as Vice-Chancellor of the University (from 1989-93). A Vice-Chancellor's many duties include fund-raising on behalf of the University, another activity in which RS enjoyed notable success.

Outside the University RS served with distinction as chairman of an international conference held in 1986 on Biological Effects of Low-Level Radiation and also of several U. K. government bodies also dealing with important and politically sensitive issues, including the Royal Commission on Environmental Pollution (1981-86), National Radiological Protection Board (1985-94), Working Party on Bovine Spongiform Encephalopathy (1988-89), Round Table on Sustainable Development (1995-99) and Interagency Committee on Global Environmental Change (1997-2000).

According to one close colleague, RS was 'one of the most notable ecologists and zoologists of his generation (but) he leaves an even more lasting legacy through his superb skills as a mentor and builder of academic departments -first at Imperial College London, and later at Oxford University- whose distinguished individuals added up to more than the sum of their parts. A disproportionate number of the world's top ecological researchers today are British, and almost all of them were directly influenced by him'.

Notwithstanding his many other duties at Oxford, for eighteen years he found the time to give stimulating undergraduate lectures there. These provided the basis of his last book *The Story of Life,* published by the Oxford University Press in 2002 (paperback 2003). The excerpts from this 'masterly overview impressive in depth, breadth and clarity of the origin and evolution of life' that were selected for presentation at a moving memorial service held last February in the Chapel of Merton College Oxford to celebrate the life of this remarkable man were the opening and closing paragraphs of the book. For their eloquence and the challenges they present to all of us they are worth repeating here.

'Consider the amazing variety of life today: the great herds of animals that roam the African plains, the shoals of fish that teem in coral reefs or the flocks of penguins that huddle on the Antarctic ice. Yet what we see around us is but one still from the film ("movie") of life, a glimpse that we can only understand if we know what came before. This is the book of the film of all life'.

'Will humans having made so much progress by increasing the carrying capacity of their habitat finally end by overexploiting the world and giving the kaleidoscope another shake? But life is flexible, and we can be sure that the frame of the kaleidoscope will be filled with a new pattern of colours. In contrast, we, in our prodigious numbers, are locked by our agricultural and commercial activities into the current climatic regime. Can political stability survive the stresses that will arise when this changes or will we doom ourselves? We carry a burden of responsibility to learn from our knowledge of the world and its past. Time is short, but we do have the ability to change'.

Predictability in Science: Accuracy and Limitations

ABSTRACTS

Stochastic Genetic Variations and their Role in Biological Evolution

I will explain that spontaneous genetic variations represent the driving force of biological evolution. New genetic variations are principally stochastic and they occur quite rarely so that genetic stability of organisms is largely insured. Despite this widely accepted situation, genetic variation depends on activities of products of so-called evolution genes. Some of these activities act as variation generators and work at most with statistical reproducibility; the result of their action cannot be predicted from case to case. Other enzymatic evolution activities act as modulators of the frequencies of genetic variation. The products of evolution genes act in cooperation with a number of nongenetic elements that depend largely on intrinsic properties of matter. Consequences of these insights on our world view will be discussed.

WERNER ARBER

Predictability: Prophecy, Prognosis and Prediction. A Study in Neuroeducation

Predictability can be studied in a cognitive space defined by three independent parameters, Prophecy, Prognosis and Prediction. Prophecy is based on projections into possible worlds, Prognosis on anticipations in the actual world and Prediction on the mod-

elling of constructed worlds. In this dynamical space predictability could be represented as a path in time, with many loops and twists during a scientific quest. In order to illustrate this point I will try to follow my own scientific experience of the complex path of predictability taking the example of the digital and brain revolutions in neuroeducation. Finally I will discuss the new concept of 'metaprediction' based upon some robust findings on brain activities in mathematics and physics.

ANTONIO M. BATTRO

Predictability, Measurement and Cosmic Time

If we agree that the possibility of making empirical predictions belongs to the core of the physical method, the macroscopic physics can be done only on a space-time manifold which is equipped with a 'timelike direction field' (predictions point to the future, retrodictions point to the past). A theorem says that if a manifold admits a nonvanishing direction field, it can carry a Lorentz metric; moreover, this metric can be chosen in such a way that the direction field would be timelike in it. Such a Lorentz metric is a necessary condition for the very concept of space and time measurements on a manifold to be meaningful. However, for physical measurement operations of space and time it is not enough. One has to guarantee that small changes in the Lorentz metric do not result in large differences in measurement results, i.e., that the Lorentz metric be *causally stable*. But owing to the Hawking theorem a Lorentz metric is causally stable if and only if the global cosmic time can be defined on the space-time manifold equipped with this Lorentz metric.

MICHAEL HELLER

Chaos in Self-Exciting Dynamos and the Main Geomagnetic Field

Nonlinear feedback and coupling in dynamical systems operating under fixed boundary conditions can produce persistently chaotic behaviour, which is unpredictable beyond a finite 'predictability horizon'. But in some circumstances feedback and coupling inhibit chaos, producing *order* rather than *disorder*. Both types of behaviour may have to be invoked in the interpretation of long-term variations of the main geomagnetic field (MGF). The MGF is generated by (mainly buoyancy-driven) magnetohydrodynamic (MHD) flow in the Earth's liquid metallic outer core, where the electrical conductivity is high enough (but not too high) for efficient MHD self-exciting dynamo action to take place. Amongst the nonlinear agencies operating in the MHD 'geodynamo' are Lorentz forces, involving interactions between the electric currents generated by the geodynamo and concomitant magnetic fields. One generic nonlinear process in self-exciting dynamos is the redistribution of kinetic energy by such forces. When operating within a steadily-forced self-exciting Faraday-disk homopolar dynamo loaded with a nonlinear motor connected in series with the coil, Lorentz forces usually cause persistent large-amplitude chaotic fluctuations. But over a wide range of conditions they inhibit, rather than promote, fluctuations, in some cases eliminating them altogether. If this 'nonlinear-quenching' process occurs in the MHD geodynamo it could account for the high degree of intermittency seen in the long-term behaviour of the MGF, as exhibited by the time-series of geomagnetic 'polarity reversals', the most striking features of which include intervals lasting as long as 3×10^7 years during which no polarity reversals appear in the palaeomagnetic record. Implied by this hypothesis, which could be tested with the aid of valid numerical geodynamo models, is that eddies driven mainly by Lorentz forces play a crucial role in the attenuation of fluctuations. Also crucial, and in principle testable, is the role played by modest changes in the lateral boundary conditions imposed on core motions by very slow irregular convection in the highly-viscous overlying mantle.

RAYMOND HIDE

Some Predictions in Astrophysics and Cosmology

In 1962 a sudden paradigm change occurred in particle physics: G. Chew and S. Frautschi discovered that spin and mass of hadrons are not independent quantities. Experimentally observed mesons and baryons appear to lie on nearly linear and parallel Regge trajectories. This has served as a source of inspiration for the present author to apply these ideas for revealing and explaining universal spin-mass relations for cosmic objects and display remarkable evidence of the simplicity and unity of nature.

RUDOLF MURADIAN

When Results are Better than Predicted: A Case Study

Experiments on laser cooling of atomic gases reached temperatures much lower than a simple and compelling theory had predicted. One consequence of this remarkable result was that one of the main goals of laser cooling, improved atomic clocks, was realized. In the light of this experience, I consider the prospect that it may be unwise to fully analyze the prospects of a new experiment before undertaking it.

WILLIAM D. PHILLIPS

On the Unpredictability of Individual Research

Undoubtedly, the great discoveries of science lead, predictably, to research trends resulting from them. Thus, the discovery of the double helix led to thousands of studies, ultimately leading to the breaking of the genetic code, and – in turn – after close to fifty years, to the elucidation of the human genome. Similarly, in physics, after the discovery of the theory of relativity or the theory of atoms, it was to be expected that – usually only after several years – a stream of studies resulting from these theories – would appear in a predictable fashion. I would like to generalize these observations by stating that – at a 'macro' level – it is safe to assume that science is, to a large extent, predictable.

My contention is that this is not true at the 'micro', the individual research level. As most scientists are expected to write grant proposals – in which they describe their plans for research and the results they expect to reach – it is of interest to ascertain to what extent their predictions resemble the actual results. It would be depressingly boring if there were too much resemblance between the plans and the subsequent reality. In all fairness, it must be stated that 'predictable' is not necessarily 'predicted', and if the results are actually opposite to what was predicted, in many cases this leads to breakthroughs of uncommon interest. We must be continuously watchful because very often the 'unpredictable' is lost because of lack of attention. The discovery of Fleming in 1928 of penicillin is due to his having paid attention to a Petrie dish with transparent areas in which the bacteria disappeared. This stresses the importance of serendipity which I define as 'luck meeting the prepared mind'.

I would like to give a few examples from my own research experience, and I refer to the discovery of the first synthetic polypeptide antigens, to the discovery of determinant-specific genetic control of immune response, to the discovery of a synthetic copolymer of amino acids that became an efficient drug against the exacerbating- remitting stage of multiple sclerosis, and to the discovery of a synergistic effect of a specific monoclonal antibody and of a chemotherapeutic drug in fighting cancer.

Michael Sela

The New Possibilities of Prediction and Prevention of Cancer

The predictivity of cancer defines the ability to assess the individual levels of risk of developing the disease. Unfortunately there is no possibility of identifying a generic risk of cancer, because under this name we may figure one hundred or more different types of malignant tumours, in any possible organ of our complex organism. As most carcinogenic agents are in the environment, the lifestyle of any person, his nutritional habits, his working activity, indoor or outdoor, and any specific habit, like smoking and heavy alcohol consumption, will be important in the risk assessment. Moreover as cancer strikes mainly in the old age, life expectancy is another important predictor. Environmental factors (chemical, physical, viral) will interact with the cellular genome of the population, making specific mutations of DNA. The damaged DNA may be repaired by specific enzymes, defined as DNA-repair mechanism, which however is different in various individuals so that persons whose DNA-repair mechanism is very active are more protected than persons whose ability to repair the DNA is lower. Finally there are inherited genetic conditions which may favour the appearance of a limited number of different types of cancer (retinoblastoma, colon carcinoma, breast carcinoma and others). Cancer may be prevented with different measures. The first is the elimination from the environment of all carcinogenic agents. Secondly, by means of a correct lifestyle with behaviours which will reduce the risk. Thirdly, with a special way of food consumption which includes a large quantity of fruit and vegetables and a very little amount of fat of animal origin. Finally many studies are underway to develop active principles which may block the carcinogenic process.

Umberto Veronesi

Attempts to Predict a Minimal Genome

In recent years, advances in functional genomics and computational biology have led to considerable progress in our comprehension of gene structure and expression. One of the most defying issues that geneticists are presently addressing is the so-called minimal genome project, consisting in the attempt to define the minimum number of genes that are necessary to sustain a free-living cellular organism. Predictability plays an essential role in the accomplishment of this goal, which is being approached both theoretically and experimentally. It is expected that the lowest number of genes will be identified under the most favorable conditions imaginable, that is, in the presence of a full complement of nutrients and in the absence of environmental stress. The ability to correctly define the minimal gene set goes to the heart of our understanding of cellular life. In addition, it should provide some insight into the earliest stages of biological evolution, since it is assumed that simpler, free living cells with genomes much smaller than those of extant microbes must have proliferated then.

Rafael Vicuña

Memorandum

1) Every day a bus will leave the Domus Sanctae Marthae at 8:45 for the Academy fifteen minutes before the beginning of the session. A bus will depart from the Academy at the end of each session (about 21:00) to take participants back to the Domus Sanctae Marthae. From 3 to 6 November lunch and dinner for the participants will be served at the Academy except on Sunday, 5 November, when only dinner will be served after the visit to the Papal Villa at Castel Gandolfo.

2) Every day, except Sunday, Holy Mass will be held at 7:00 at the Domus Sanctae Marthae for those who would like to attend.

Note
Please give your **form for the refunding of expenses** to the secretariat at least one day before your departure so that you can be refunded immediately.

STANDING RULES FOR MEETINGS

1. The Academy invites a number of illustrious scholars who have especially studied a given question and have arrived at different conclusions to meet in Rome at its headquarters, the 'Casina Pio IV', situated in the Vatican City, so as to make a joint examination of all the data on the question.

2. The chief aim of these discussions is to endeavour to reach a common view on the subject of the meeting, but when this is not possible to formulate precisely the reasons for this inability. The scholars invited to these meetings undertake in advance to concentrate their efforts on this.

3. A critical examination of these reasons should lead either to agreement on a partial or provisional solution or else to the conclusion that, on the basis of the information presently available, it is impossible to establish unity on the question concerned. In the latter event the scholars involved will be called upon:

a) to define the reasons why agreement appears to be impossible for the present;

b) to specify the kind of research work it would be desirable to undertake in order to solve the problem.

4. The invitation will be addressed by the Academy to only a small number of representatives of each branch of learning: these will be selected from scholars who are not connected with the Academy. These representatives will be joined during the discussions by members of the Academy who are experts in the same discipline. This invitation, moreover, will apply only to the study of one precise question by each branch of learning.

5. The debates will be strictly private and will take the form of papers and talks in the presence only of a few members of the Pontifical Academy of Sciences who have special knowledge of the subject under discussion.

6. The conclusions arrived at will be published in the form of a 'Statement' (to which may be added individual notes) mentioning:

a) the points on which agreement was reached;

b) the points on which it was impossible to reach agreement;

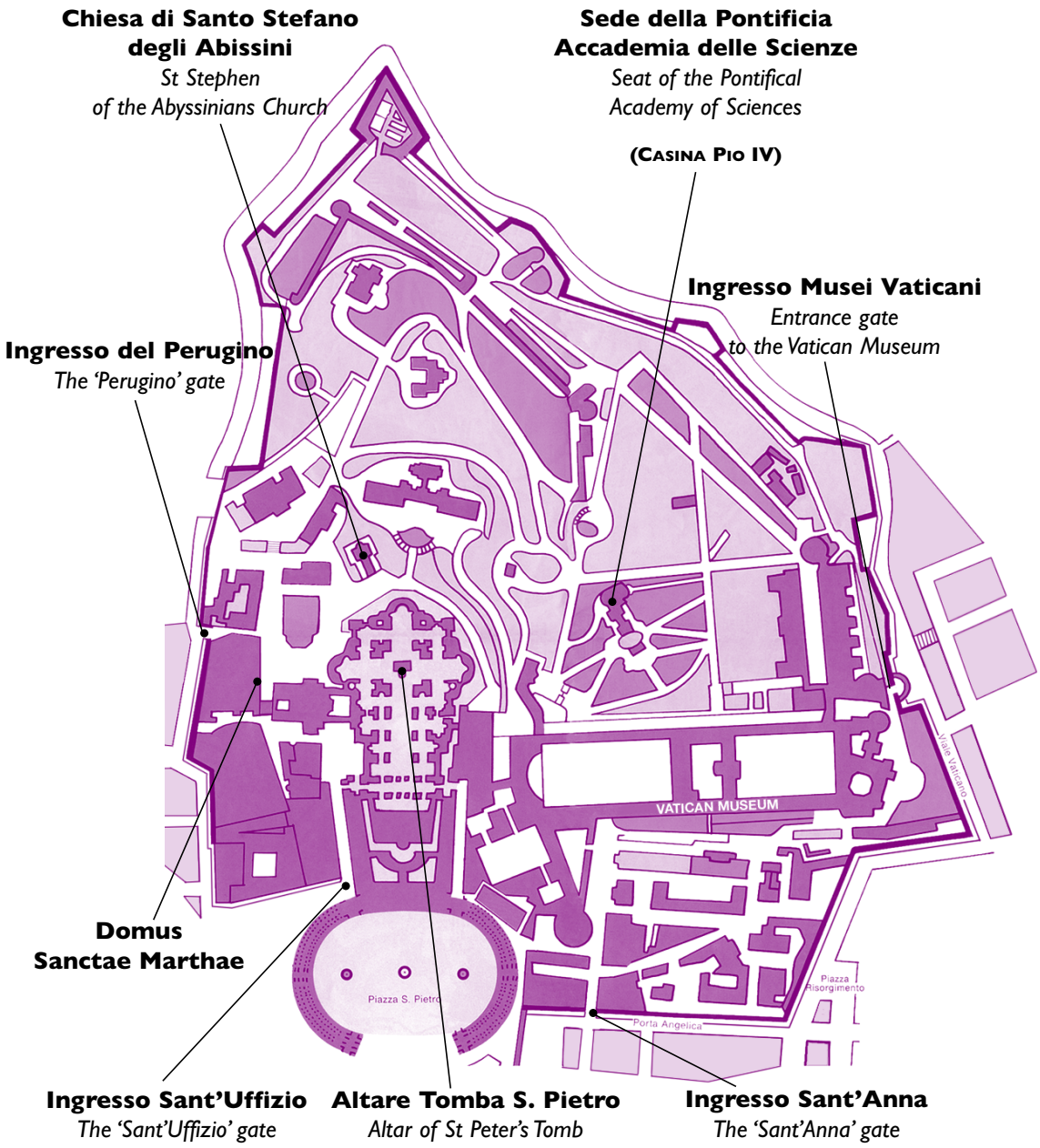
c) the reasons why it was not possible to reach agreement;

d) suggestions about the research work that appears most appropriate in order to arrive at a solution of the difficulties.

7. The 'Statement' arrived at will be immediately printed and transmitted by the Pontifical Academy of Sciences to all the centres of learning which might be interested in it.

FRONT COVER: Michelangelo Buonarroti, *The Delphic Sibyl*, 1509, fresco, Sistine Chapel, Vatican

2 November 2006 (11)



CASINA PIO IV
V-00120 VATICAN CITY
Tel: +39 0669883451 • Fax: +39 0669885218
Email: academy.sciences@acdscience.va

For further information please visit:
http://www.vatican.va/roman_curia/pontifical_academies/acdscien/index.htm