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99

Science and the Future of Mankind

Science for Man and Man for Science

PROCEEDINGS

WORKING GROUP
12-14 NOVEMBER 1999

JUBILEE PLENARY SESSION
10-13 NOVEMBER 2000

VATICAN CITY
2001

SCIENCE AND THE FUTURE OF MANKIND

Science for Man and Man for Science

Address:
THE PONTIFICAL ACADEMY OF SCIENCES
CASINA PIO IV, 00120 VATICAN CITY

PONTIFICIAE ACADEMIAE SCIENTIARUM SCRIPTA VARIA
99

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Science for Man and Man for Science

the
PROCEEDINGS
of

the Preparatory Session
12-14 November 1999
and
the Jubilee Plenary Session
10-13 November 2000

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

MMI

The opinions expressed with absolute freedom during the presentation of the papers of these two meetings, although published by the Academy, represent only the points of view of the participants and not those of the Academy.

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PREFACE

This volume contains the proceedings of two meetings of the Pontifical Academy of Sciences: the working group of 12-14 November 1999 on 'science for man and man for science' and the Jubilee Plenary Session of 10-13 November 2000 on 'science and the future of mankind'. The two meetings dealt with very similar subjects, indeed the first was intended to prepare the ground for the second, and it is for this reason that it was decided to publish them in a single volume. Both these meetings addressed two topics which the Academy had been subjecting to debate for some time. On the one hand, there is the original relationship that the human being has with science, which, as the work of man, should always be at the service of human development. On the other, there is science, which, even when it deals with topics which are not specifically human has, and expresses, an idea of man, and this is something which we should strive to be aware of – that is to say: what does contemporary science say about the human being? One may think here, for example, of the important mind-body problem on which the Academy has produced more than one publication.

The first topic, 'science for man and man for science', was the subject of the working group of 12-14 November 1999. The first part of this topic, 'science for man', was examined in great detail by the Pontifical Academy of Sciences in the 1970s and 1980s and discussed at length by the recent World Conference on Science. In its final declaration on science and the use of scientific knowledge, this notion was expressed by that conference with the formula: science for knowledge; knowledge for progress, which included science for peace; science for development; and science in society and science for society. The Pontifical Academy of Sciences believes that we must explore the ways in which science can help in developing and promoting the specifically human dimension of man, society, and the environment. At the same time, the Academy believes that we should also discuss the ways in which, in contrary fashion, in certain situations, science can be responsible for a decline in the quality of life, as happens in particular in the case of damage done to the environment, the consequences of the invention and use of sophisticated weapons, etc. The second part of this topic, 'man for science', involved identifying the impact of recent scientific discoveries and advances on our vision of man, both directly and indirectly.

This question bore upon the topic addressed by the Jubilee Plenary Session of 10-13 November 2000: 'science and the future of mankind'. With a strong interdisciplinary approach and through papers given by experts from different regions of the world, this meeting explored how science conditions the life of contemporary man. From physics to biology, and from the earth sciences to chemistry, leading scholars addressed themselves to the ways in which science is shaping and will shape the future of mankind. In addition, in the context of the Jubilee year 2000, the Pontifical Academy could not but refer to that ultimate horizon which begins on the outer frontiers of science. From philosophy to theology, from cosmology and biology to a new natural theology, from the Messianic ideal to the progress of science, and from the North to the South of the globe, the various speakers sought to illustrate the relationship between science and the deepest direction of man.

In covering these two topics, this volume thus presents a rather complete picture of the realities and the challenges which mankind now faces at the beginning of the third millennium. It does this in the belief that, as observed by the encyclical *Fides et Ratio*, every advance of science, wherever it may take place, does not close the horizon of transcendence to man, and that the fullness of faith leads man to knowledge of science, as is demonstrated by the fact that modern science was born during the Christian era with the assimilation of the message of freedom placed by Christ in the heart of man.

This preface would certainly not be complete without an expression of gratitude to the President, Prof. Nicola Cabibbo, the Council, and the Academicians and the experts who gave papers at, took part in, and thus made possible, these meetings. An expression of gratitude, also, to the fifty Academicians who took part in the closed session of the General Assembly of November 2000, at which it was decided to produce a study-document (published at the end of this volume) on the use of genetically modified food plants to combat hunger in the world. The Pontifical Academy of Sciences is also deeply grateful to the Holy Father John Paul II who not only follows and supports its activities with great interest and care, as is demonstrated by his Address to the Jubilee Plenary Session which is published in this volume, but also is convinced that today more than ever before a new alliance between Science and Faith can help to purify faith and open science to the salvation of man.

MARCELO SÁNCHEZ SORONDO,
Bishop-Chancellor of the Pontifical Academy of Sciences

ADDRESS TO THE HOLY FATHER

NICOLA CABIBBO

Holy Father,

This Audience that you have granted to the Pontifical Academy of Sciences on the occasion of the Plenary Session on 'Science and the Future of Mankind' offers an opportunity to cast our eyes back over the decades passed since its foundation by Pius XI in 1936. Pius XI wanted to renew the glorious Academy of the Lincei which at the beginning of the seventeenth century, during the age of the Renaissance, was the leading light of scientific endeavour.

During these years the Academy has followed two lines of research. The first has sought to evaluate and assess the rapid progress of scientific knowledge and its impact on the evolving concept of nature. Certain scientific ideas, which were speculative extrapolations a few decades ago, have since become well ascertained facts.

'Big Bang' cosmology, proposed in the thirties by our former President, Father Lemaître, is today confirmed by innumerable results, ranging from cosmic background radiation and its observed fluctuations, which beautifully mirror the birth of galaxies, to the relative abundance of chemical elements in the universe. The development of molecular biology has clarified the mechanisms underlying the evolution of living organisms, and has also provided the basis by which to establish a complete genealogy of life from humble bacteria to the higher organisms.

For many years the Academy has repeatedly been honoured by the keenly-felt interest Your Holiness has always shown towards these developments. During the same period the Academy has completed important studies, such as those on the determination of the state of death which proved crucial for clarifying the ethical status of organ transplants, and the preparatory studies on the Galileo case.

The second, and perhaps the more urgent, line of research in which our Academy has engaged looks at the consequences for mankind of the rapid development of scientific knowledge and the resulting swift increase in technical capabilities. Recently, in 'Fides et Ratio', you urged all scientists never to lose sight of the 'sapiential dimension', where technical prowess must be matched by respect for the ethical imperative to protect human life and dignity.

Over the years the Academy has met many times to discuss the difficulties and problems which third-world countries encounter in their development: food and agriculture, health, energy and water, industry and the dangers which derive from its often unsupervised development, and the ways in which the application of scientific knowledge can help to solve such difficulties and problems.

The Academy has also addressed itself to the dangers that the unwise use of technology can represent for our planet and mankind as a whole, but has at the same time considered the ways in which scientific progress can best be used to defend humanity against actual and potential dangers, both natural and man-made, and to meet its more urgent needs.

A high point in our activities was certainly represented by the solemn warning which the Academy issued in 1982 about the dangers of an unbridled race in the perfection and stockpiling of atomic weapons. I would like to recall an earlier example of this warning – in 1942 Pius XII warned of the impending danger of the development of nuclear weapons capable of massive destruction. His attention had been directed to this danger by one of the early members of our Academy, Max Planck, the discoverer of quantum physics.

This Plenary Session, and the preparatory meeting held last year, have acquired a special meaning from their being held at the same time as the Jubilee Year of the third millennium. The Academy, which this year has welcomed twelve new members – among whom four Nobel-prize winners – would like to take this opportunity to renew its special relationship with the Holy See. We will do so in the conviction that the far-seeing project of an Academy devoted to promoting and monitoring the advancement of science has proved fruitful in the past and remains fully valid as we face up to the challenges of the new millennium.

To this project, Holy Father, you have devoted attention and offered your encouragement during the course of your Pontificate, and we will do our best to be worthy of your beneficence over the coming years. Thank you.

ADDRESS OF THE HOLY FATHER JOHN PAUL II ON THE OCCASION OF THE JUBILEE PLENARY SESSION OF THE PONTIFICAL ACADEMY OF SCIENCES

Mr. President,

Distinguished Ladies and Gentlemen,

1. With joy I extend to you my cordial greetings on the occasion of the Plenary Session of your Academy, which, given the Jubilee context in which it is taking place, takes on special significance and value. I would like, first of all, to thank your President, Professor Nicola Cabibbo, for the kind words that he addressed to me on behalf of you all. I extend my keenly-felt expression of thanks to you all for this meeting and for the expert and valued contribution which you offer to the progress of scientific knowledge for the good of humanity.

Continuing, and almost completing, your deliberations of last year, you have dwelt over the last few days on the stimulating subject of 'science and the future of mankind'. I am happy to observe that in recent years your study-weeks and plenary assemblies have been dedicated in an increasingly explicit way to investigating that dimension of science which we could define as anthropological or humanistic. This important aspect of scientific research was also addressed on the occasion of the Jubilee of Scientists, celebrated in May, and, more recently, on the occasion of the Jubilee of University Teachers. I hope and wish that reflection on the anthropological contents of knowledge and the necessary rigour of scientific research can be developed in a meaningful way, thereby offering illuminating indications for the overall progress of man and society.

2. When one speaks about the humanistic dimension of science, thought is directed for the most part to the ethical responsibility of scientific research because of its consequences for man. The problem is real and has given rise to constant concern on the part of the Magisterium of the Church, especially during the second part of the twentieth century. But it is

clear that it would be reductive to limit reflection on the humanistic dimension of science to a mere reference to this concern. This could even lead some people to fear that a kind of 'humanistic control of science' is being envisaged, almost as though, on the assumption that there is a dialectical tension between these two spheres of knowledge, it was the task of the humanistic disciplines to guide and orientate in an external way the aspirations and the results of the natural sciences, directed as they are towards the planning of ever new research and extending its practical application.

From another point of view, analysis of the anthropological dimension of science raises above all else a precise set of epistemological questions and issues. That is to say, one wants to emphasise that the observer is always involved in the object that is observed. This is true not only in research into the extremely small, where the limits to knowledge due to this close involvement have been evident and have been discussed philosophically for a long time, but also in the most recent research into the extremely large, where the particular philosophical approach adopted by the scientist can influence in a significant way the description of the cosmos, when questions spring forth about everything, about the origins and the meaning of the universe itself.

At a more general level, as the history of science demonstrates to us rather well, both the formulation of a theory and the instinctive perception which has guided many discoveries often reveal themselves to be conditioned by philosophical, aesthetic and at times even religious and existential prior understandings which were already present in the subject. But in relation to these questions as well, the analysis of the anthropological dimension or the humanistic value of science bears upon only a specific aspect, within the more general epistemological question of the relationship between the subject and the object.

Lastly, reference is made to 'humanism in science' or 'scientific humanism' in order to emphasise the importance of an integrated and complete culture capable of overcoming the separation of the humanistic disciplines and the experimental-scientific disciplines. If this separation is certainly advantageous at the analytical and methodological stage of any given research, it is rather less justified and not without dangers at the stage of synthesis, when the subject asks himself about the deepest motivations of his 'doing research' and about the 'human' consequences of the newly acquired knowledge, both at a personal level and at a collective and social level.

3. But beyond these questions and issues, to speak about the humanistic dimension of science involves bringing to the fore an 'inner' or 'existen-

tial' aspect, so to speak, which profoundly involves the researcher and deserves special attention. When I spoke some years ago at UNESCO, I had the opportunity to recall that culture, and thus also scientific culture, possesses in the first instance a value which is 'contained within the subject itself' (cf. *Insegnamenti*, III/1 [1980] 1639-1640). Every scientist, through personal study and research, completes himself and his own humanity. You are authoritative witnesses to this. Each one of you, indeed, thinking of his own life and his own experience, could say that research has constructed and in a certain way has marked his personality. Scientific research constitutes for you, as it does for many, the way for the personal encounter with truth, and perhaps the privileged place for the encounter itself with God, the Creator of heaven and earth. Seen from this point of view, science shines forth in all its value as a good capable of motivating an existence, as a great experience of freedom for truth, as a fundamental work of service. Through it, each researcher feels that he is able himself to grow, and to help others to grow, in humanity.

Truth, freedom and responsibility are connected in the experience of the scientist. In setting out on his path of research, he understands that he must tread not only with the impartiality required by the objectivity of his method but also with the intellectual honesty, the responsibility, and I would say with a kind of 'reverence', which befit the human spirit in its drawing near to truth. For the scientist, to understand in an ever better way the particular reality of man in relation to the biological-physical processes of nature, to discover always new aspects of the cosmos, to know more about the location and the distribution of resources, the social and environmental dynamics, and the logic of progress and development, becomes translated into a duty *to serve more fully the whole of mankind*, to which he belongs. For this reason, the ethical and moral responsibilities connected to scientific research can be perceived as a requirement within science, because it is a fully human activity, but not as control, or worse, as an imposition which comes from outside. The man of science knows perfectly, from the point of view of his knowledge, that truth cannot be subject to negotiation, cannot be obscured or abandoned to free conventions or agreements between groups of power, societies, or States. Therefore, because of the ideal of service to truth, he feels a special responsibility in relation to the advancement of mankind, not understood in generic or ideal terms, but as the advancement of the whole man and of everything that is authentically human.

4. Science conceived in this way can encounter the Church without difficulty and engage in a fruitful dialogue with her, because it is precisely man

who is ‘the primary and fundamental way for the Church’ (*Redemptor Hominis*, 14). Science can then look with interest to biblical Revelation which unveils the ultimate meaning of the dignity of man, who is created in the image of God. It can above all meet Christ, the Son of God, the Word made flesh, the perfect Man. Man, when following him, also becomes more human (cf. *Gaudium et Spes*, 41).

Is it not perhaps this centrality of Christ that the Church is celebrating in the Great Jubilee of the year 2000? In upholding the uniqueness and centrality of God made Man, the Church feels that she is given a great responsibility – that of proposing divine Revelation, which, without in any way rejecting ‘what is true and holy’ in the various religions of mankind (cf. *Nostra Aetate*, 2), indicates Christ, ‘the way, the truth, and the life’ (Jn 14:6), as the mystery in which everything finds fullness and completion.

In Christ, the centre and culmination of history (cf. *Terzo Millennio Adveniente*, 9-10), is also contained the norm for the future of mankind. In Him, the Church recognises the ultimate conditions allowing scientific progress to be also real human progress. They are the conditions of charity and service, those which ensure that all men have an authentically human life, capable of rising up to the Absolute, opening up not only to the wonders of nature but also to the mystery of God.

5. Distinguished Ladies and Gentlemen! In presenting you with these reflections on the anthropological contents and the humanistic dimension of scientific activity, it is my heartfelt desire that the discussions and investigations of these days will produce much fruit for your academic and scientific endeavour. My hope and wish is that you can contribute, with wisdom and love, to the cultural and spiritual growth of peoples.

To this end, I invoke upon you the light and the strength of the Lord Jesus, real God and real Man, in whom are united the rigour of truth and the reasons of life. I am pleased to assure you of my prayers for you and your work, and I impart upon each of you my Apostolic Blessing, which I willingly extend to all those you hold dear.

THE PONTIFICAL ACADEMY OF SCIENCES

Working Group
on

SCIENCE FOR MAN AND MAN FOR SCIENCE

(12-14 November 1999)

Programme

Friday, 12 November 1999

9:10-9:20	General introduction (N. CABIBBO)
9:20-10:20	*World Conference on Science* (W. ARBER)
10:20-11:00	Coffee break
11:00-11:50	*Technology between Science and Man* (P. GERMAIN)
11:50-12:30	*The Future of Energy* (C. RUBBIA)
12:30-13:00	*Spinning Fluids, Geomagnetism and the Earth's Deep Interior* (R. HIDE)
13:00-15:00	Lunch
15:00-15:40	*The Mathematisation of Science* (L.A. CAFFARELLI)
15:40-16:20	*Mathematics: Recent Developments and Cultural Aspects* (Y.I. MANIN)
16:20-16:50	Coffee break
16:50-17:40	*Science as Utopia* (J. MITTELSTRASS)
17:40-18:30	*Modern Research in Astronomy* (G.V. COYNE)

8:30-19:10	*The Role of Atmospheric Chemistry in Global Range Research with Emphasis on the Tropics: Research Needs* (P.J. CRUTZEN)

Saturday, 13 November 1999

9:10-10:00	*Which Economic System is Likely to Best Serve Human Societies? The Scientific Question* (E. MALINVAUD)
10:00-10:50	*Coping with Uncertainty: the Economics of Global Warming* (P.S. DASGUPTA)
10:50-11:10	Coffee break
11:10-12:00	*Global Sustainability and Social Justice* (P.H. RAVEN)
12:00-12:30	*Choice and Responsibility in Problems of Population* (B.M. COLOMBO)
12:30-13:10	*The Search for Man* (J. MARÍAS)
13:00-15:10	Lunch
15:10-15:50	*Sciences and Meaning: Science Faced with the Crisis of Meaning* (F. JACQUES)
15:50-16:30	*The Concept of Specificity for Vaccinations against Cancer, against Infectious and Autoimmune Diseases* (M. SELA)
16:30-17:00	Coffee break
17:00-17:40	*Society in the Face of Scientific and Technological Development: Risk, Decision, Responsibility* (A. BLANC-LAPIERRE)
17:40-18:30	*Challenges for the Agricultural Scientists* (T.-T. CHANG)
20:00-23:00	Dinner offered by Dr. R.M. Tay, Ambassador of the Republic of China to the Holy See, at the 'Mandarin Restaurant' in Rome.

Sunday, 14 November 1999

9:00-11:00	Discussion

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THE PONTIFICAL ACADEMY OF SCIENCES

Jubilee Plenary Session
on

SCIENCE AND THE FUTURE OF MANKIND

(10-13 November 2000)

Programme

Friday, 10 November

9:00-9:10	N. Cabibbo: *General Introduction*
9:10-9:50	*Commemorations of the Deceased Academicians:* Lichnerowicz André (11.12.98) *Mathematical Physics;* McConnell James Robert (13.2.99) *Theoretical Physics;* Herzberg Gerhard (3.3.99) *Nobel Laureate in Chemistry, 1971;* Chagas Carlos (16.2.00) *Biology and Biophysics;* Brück Hermann Alexander (4.3.00) *Astronomy*; Döbereiner Johanna (5.10.00) *Soil Microbiology*.
9:50-10:25	*Self-presentation of the New Academicians:* T.-T. Chang – C. Cohen-Tannoudji – R. Farina – N.M. Le Douarin – M.J. Molina – J.E. Murray – S. Pagano – F. Press – R. Vicuña – C.N. Yang – A.H. Zewail – A. Zichichi
10:25-11:00	C.N. Yang: *Quantization, Symmetry and Face Factors – Thematic Melodies of Twentieth-Century Theoretical Physics*
11:00-11:40	Coffee break
11:40-12:25	C. Cohen-Tannoudji: *Light and Matter*
12:25-13:00	E. Berti: *The Relationship between Science, Religion and Aristotelian Theology Today*
13:00-15:00	Lunch

CHAIRPERSON: W. Arber

15:00-15:50	A. Eschenmoser: *Design* versus *Selection in Chemistry and Beyond*
15:50-16:30	C.N.R. Rao: *Chemical Design of New Materials*
16:30-16:55	Coffee break
16:55-17:50	N.M. Le Douarin: *Developmental Biology: Novel Trends and Prospects*
17:50-18:30	G. Cottier: *Erreur, Correction, Réhabilitation et Pardon*

Saturday, 11 November

CHAIRPERSON: V.I. Keilis-Borok

9:00-10:00	C.H. Townes: *Parallelism and Ultimate Convergence of Science and Religion*
10:00-10:40	R. Swinburne: *Natural Theology in the Light of Modern Cosmology and Biology*
10:40-11:00	Coffee break
11:00-11:40	J.-M. Maldamé: *Messianisme et Science Moderne*
11:40-12:20	W.E. Carroll: *Creation and Science*
12:20-13:30	W.J. Singer: *The Evolution of Consciousness*
13:30-15:10	Lunch

CHAIRPERSON: A. Eschenmoser

15:10-15:40	F. Press: *Earth Sciences: Remarkable Scientific Progress, Extraordinary Opportunity for Human Betterment*
15:40-16:30	M.J. Molina: *Global Change and the Antarctic Ozone Hole*
16:30-16:50	Coffee break

CHAIRPERSON: N. Cabibbo

16:50-17:30	M. Moshinsky: *Science for Man and Man for Science: a View from the Third World*
17:30-18:00	R.L. Mössbauer: *Physics in the Past Century and in the Future*
18:00-18:30	S.L. Jaki: *The Christological Background of the Origin of Newton's First Law*
20.00-21.30	Dinner offered by H.E. Raymond Tai, Ambassador of the Republic of China to the Holy See (Hotel Columbus, Via della Conciliazione, 33)

Sunday, 12 November

8:30-16:30	Visit to the 'Ville Pontificie' of Castel Gandolfo
10:00-10:10	'Pius XI Medal' Award – *Self-Presentations* (Prof. Mark M. Davis, 1996 – Prof. Gillian P. Bates and Prof. Stephen W. Davies, 1998)
10:10-12:00	Discussions
12:00-13:00	Visit to the gardens of Castel Gandolfo
13:00	Lunch

Monday, 13 November

CHAIRPERSON: L.A. Caffarelli

9:00-9:40	V.I. Keilis-Borok: *Colliding Cascades: a Model for Prediction of Critical Transitions*
9:40-10:20	A.H. Zewail: *Science for the Have-nots*
10:30-10:50	Coffee break
10:50-13:00	Papal Audience
13:00-15:00	Lunch

CHAIRPERSON: N. Cabibbo

15:00-15:40	Minoru Oda: *Why and how Physicists are Interested in the Brain and in the Mind*
15:40-16:30	V.C. Rubin: *Imaging the Universe: Past and Future*
16:30-17:00	Coffee break
17:00-17:50	R. Omnés: *Some Advances in the Interpretation of Quantum Mechanics and Consequences in Philosophy*
17:50-18:30	P. Poupard: *Christ and Science*
19:00	Holy Mass (in memory of Prof. Carlos Chagas)

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COMMEMORATION OF ACADEMICIANS

ANDRÉ LICHNEROWICZ

André Lichnerowicz was elected to our Pontifical Academy of Sciences in 1981. He was a very active member and attended nearly all the plenary sessions. He was with us in November 1998, indeed very present, making very fruitful remarks during the discussions on many scientific papers and also during our business session.

He was born on 21 January 1915 in Bourbon l'Archambault, France. His parents were brilliant teachers: he had a literary father who was secretary general of the Alliance Française and a mathematician mother from the Ecole Normale Supérieure of Sèvres. He was a student of the Ecole Normale Supérieure in 1933, doctor in sciences in 1939 with a thesis on general relativity, and Maître de Conférences in mechanics at the Faculté des Sciences of Strasbourg, where he published his first treatise 'Algèbre et Analyse Linéaire' in which he presented theories which were rather poorly taught during that period in France. The book became immediately famous.

In 1949 André Lichnérowicz was appointed to a position in the Sorbonne, at the Faculté des Sciences de Paris, where he established a new diploma on mathematical methods in physics (MMP), and in 1952 he was appointed to a chair in mathematical physics at the Collège de France. He taught there until 1986 and he remained scientifically active until his death on 11 December 1998. His is a wonderful and exceptional curriculum.

André Lichnerowicz was an immensely cultured man, interested throughout his life in the most varied problems, whether scientific, philosophical, educational, artistic, social or religious in character. He was a great intellectual, always ready and happy to discuss issues and questions with people. He had a great desire to communicate his ideas. Talking with him was always fruitful. He understood rapidly what you wanted to say and often saw quickly the weakness of your position.

He showed an active interest in the role of sciences, and particularly of mathematics, in the life of the community. He was not only an active participant, but also one of the most important organisers during the fifties of national conferences, which were open to a broad public including people belonging to all political formations and whose object was to emphasise the need for a serious reform of the universities and our research system. (Caen 1956-Amiens 1960). He was one of the twelve scientists who belonged to the first Comité Consultatif de la Recherche Scientifique et Technique created by de Gaulle immediately after becoming President of the country in the late 1950s.

It should also be recorded that from December 1966 to June 1973 he was the president of the famous ministerial commission on the teaching of mathematics, which everybody called the 'Lichnerowicz commission'. The fundamental idea of Lichnerowicz was that to ensure the harmonious development of our society it was necessary to give our people a strong scientific culture and within such culture a prominent place was given to mathematical culture. The project was ambitious. Many Institutes de Recherche sur l'Enseignement Mathématique were created. Many are still in operation. They have done excellent work and it is thanks to them that the mathematical education of young people in France is still quite good. But most of the hopes and expectations of Lichnerowicz have not yet been realised. The commission met formidable obstacles which still remain and which have to be tackled if we want to bring to mathematics teaching the qualities dreamed of by Lichnerowicz. These obstacles were sociological inertia, administrative and corporate rigidity, the narrow-mindedness of many mathematicians, and the mathematical illiteracy of most of the population.

The mathematical production of Lichnerowicz was fantastic. He published more than 350 papers and books and he had a great many students of his own. One should emphasise that he was one of the first professors in France to introduce a closer kind of direction of theses. Instead of expecting to be told "Here is a thesis topic. Come back and see me when you have found a new result", the student knew that he could go to see him very often. Lichnerowicz considered himself responsible for anyone who was or had been his student. That explains why he had so many of them. He provided them with unfailing support, particularly when they had difficulties in their professional or private lives. Lichnerowicz knew how to choose for each one a thesis topic appropriate to that person's tastes and capacities, a topic which would permit him – encouraged and helped as much as necessary – to obtain the sought-for diploma. This remarkable diversity of choices offered by Lichnerowicz to his students came from the variety of his own interests.

It is time now to say a few words about his personal scientific achievements. This is an impossible task. Fortunately, five former students of Lichnerowicz who are all first-class mathematicians, Marcel Berger, Jean-Pierre Bourgignon, Yvonne Choquet-Bruhat, Charles-Michel Marle and André Revuz, have written a joint paper in the 'Gazette des Mathematiciens' (n. 32, 1999, pp. 90-109) which has been published in various forms in the Notices of the AMS (vol. 4, n. 11, pp. 1387-1396).

Lichnerowicz was at one and the same time a geometrician and a physicist. He was fascinated by mechanics and more generally by the mathematical representation of the physical universe. Let us note only briefly the most important domains in which Lichnerowicz worked and published.

Lichnerowicz was interested in many facets of differential geometry. The relation between curvature and topology is a very natural topic in Riemannian geometry. Many papers were devoted to what may be called roughly the Bochner heritage, in particular Leplacian calculations. Lichnerowicz demonstrated his ability to make difficult calculations in a very clever way and to find formulae that described deeply fundamental properties. He was also a master of the Kähler domain, motivated in particular by the long-standing question of Elie Cartan. Among the questions in which he obtained important results were those connected with the classification of Riemannian manifolds and the use of their holonomy groups in order to obtain the answer.

Another broad field of research of Lichnerowicz was general relativity. His thesis belonged to this field. In 1939 he provided a global differential geometric point of view of general relativity. Later on, he made explicit in the appropriate general context the necessary and sufficient conditions for a metric to be a global solution of the Einsteinian equations. Lichnerowicz's methodology has been used in the construction of numerous models. He was the first person to obtain a coherent mathematical formulation of the theory of relativity. In 1970 he gave courses on hydrodynamics and relativistic magneto-hydrodynamics including thermodynamics, and obtained in particular beautiful results on shock waves. On must also cite his works on gravitational radiation, spinor fields, and the quantisation of fields on curved space-time.

On should also mention another set of important contributions to symplectic geometry and to the various manifolds which can be useful in providing the basis of convenient formulations of physical situations: Poisson manifolds, Jacobi manifolds and their geometry. A new field of research which he introduced in about 1970 was the theory of the deformation of the algebra of functions on a manifold. With his co-workers, Lichnerowicz showed that the formal deformations of the associate algebra of differential functions of a sympletic – or Poisson – manifold offered a method for the quantisation of classical Hamiltonian systems.

To close this rapid look at the works of Lichnerowicz, I would like to say that all those who attended lectures or courses given by André Lichnerowicz would agree with the opinion of Charles-Michel Marle: 'I admire his exceptional virtuosity in calculation and the perfect arrangement of difficult proofs which he always explains in a complete manner. The most admirable of his mathematical skills is the depth of his vision which permitted him to abstract key concepts of today's and tomorrow's mathematics'.

I would like to add a few observations of a more personal character to conclude this commemoration of André Lichnerowicz as a mathematician and his radiance within human culture and the human city.

I borrow the first from Jean-Pierre Bourguignon. With his wife, who was born in Peru and taught Spanish in a Paris high school, he formed an extremely interesting blend of different sensitivities. The two of them were sharp, remarkably cultivated, and open to many cultures. Nothing escaped their notice. An after-conference dinner with them (she often accompanied him on his scientific trips) was certainly an enriching experience.

The second concerns his faith. He was a believing Catholic. I may mention here two places where he expressed his thoughts. One is a paper in a collective volume entitled 'Le savant et la foi' (edited by Jean Delumeau-Flammarion and published in 1989). Its title is 'Mathématicien et chrétien' (pages 187-204). The other is an interview in a special issue of the magazine 'Sciences et Avenir' entitled 'Dieu et la Science'. As was always the case with Lichnerowicz, his thought was very clearly expressed.

Paul Germain

JAMES ROBERT MCCONNELL

James Robert McConnell was one of the most distinguished of Irish scientists of his epoch and the doyen of Irish theoretical physicists. He entered University College Dublin in 1932 and graduated four years later with a Master's Degree in mathematics which he obtained with first honors. During those studies he came under the influence of the distinguished mathematical physicist and Pontifical Academician A.W. Conway who aroused in McConnell an interest in relativity and quantum theory. From that moment Conway became his mentor.

McConnell gained the degree of Doctor of Mathematical Sciences in 1941 at the University of Rome "La Sapienza." Despite wartime difficulties, he managed to return to Dublin in 1942 and with Conway's support he was appointed Scholar at the School of Theoretical Physics of the newly founded Dublin Institute for Advanced Studies where he came under the influence and inspiration of the world-renowned physicists Erwin Schrödinger and Walter Heitler. His original researches were in nonlinear electromagnetic theory but he soon began a detailed study of the theory of the negative proton, or antiproton, whose existence was not confirmed until 1955.

In 1945 McConnell was appointed Professor of Mathematical Physics at St. Patrick's College, Maynooth, where he continued his researches into the theory of fundamental particles. Following his appointment in 1968 to a senior professorship in the School of Theoretical Physics of the Dublin Institute, his research interests changed and he took up the study of the theory of rotational Brownian motion. He was elected to membership in the Royal Irish Academy in 1949 and was granted a Doctor of Science degree by the National University of Ireland.

From 1969 to 1972 McConnell was Director of the School of Theoretical Physics of the Dublin Institute and he was secretary of the Royal Irish Academy from 1967 to 1972. He was a founding member of the European Physical Society and served on its Council from 1969 to 1971. In recognition of his contributions to science he was awarded the Boyle Medal by the Royal Dublin Society in 1986. He was appointed to the Pontifical Academy of Sciences in 1990 by Pope John Paul II. As many of us who knew him at this Academy can testify, James McConnell was a friendly, unassuming and generous man, who was full of vitality and who had an infectious enthusiasm for all that he undertook to accomplish.

George V. Coyne, S.J.

GERHARD HERZBERG

Dr. Herzberg was born in Germany and during his doctoral and post-doctoral studies in Germany he was associated with such eminent scientists as Max Born and James Franck. His early interests were in astronomy and later in atomic and molecular physics. In spite of his extraordinary accomplishments at a young age, Dr. Herzberg had to leave Germany and move to North America in 1935. He went to Canada where he wrote his classic books on spectroscopy, and later moved to the Yerkes Laboratory at the University of Chicago. After a brief stay in Chicago he went back to the National Research Council of Canada with which he was identified for the rest of his career.

Dr. Herzberg was clearly the father of modern molecular spectroscopy. The entire world of spectroscopy considered him its champion and statesman. Even spectroscopists who did not know him personally considered him their teacher because of his classic papers and books, which had a great impact. His contributions to molecular spectroscopy, in particular to the spectroscopy of molecules of astronomical interest, were truly outstanding.

Dr. Herzberg received many honours and was a member of several Academies including the Royal Society and the US National Academy of Sciences. He was awarded the Nobel prize in chemistry in 1971.

C.N.R. Rao

CARLOS CHAGAS FILHO

Prof. Carlos Chagas Filho, former President of the Pontifical Academy of Sciences, died on 16 February 2000, in Rio de Janeiro, Brazil, at the age of eighty-nine. As his name suggests, he was the son of the famous Brazilian medical doctor, Carlos Chagas, who at the beginning of the twentieth century discovered the causes of an important tropical illness which subsequently bore his name – 'Chagas Disease'.

Chagas Filho graduated in medicine in 1935 with great success, and from the outset of his career he directed his activities to scientific research. Chagas Filho was a privileged person: from his parents he received an excellent genetic background, an extraordinary cultural inheritance, and, to complete his success in life, he had a very happy marriage. His wife, Anah, contributed a great deal to his social life and his cultural activities.

In spite of these advantages, Chagas Filho's life was not easy. Having a famous father in the same professional area meant that he had to be very demanding with himself in a methodical and constant way. In this way he was able to achieve success in scientific production and advancement in several cultural areas at both a national and an international level.

He began his scientific career as a student of medicine at the Institute

Oswaldo Cruz in Rio de Janeiro, Brazil. After graduating in medicine he also obtained degrees in physics and mathematics. He began his research with work on the electric fish, *Electrophorus electricus*. With great success, in collaboration with colleagues and mainly with disciples and students, a series of more than one hundred important articles were published by Chagas in specialist reviews with an international circulation.

In 1936 he was appointed Full Professor of Biophysics at the Faculty of Medicine of the University of Rio de Janeiro. In 1945 he inaugurated the Institute of Biophysics at that university, an institution which was able to produce scientific knowledge and researchers of a high level. A few years later this Institute received international recognition as a Centre of Excellency, a status that it has maintained until today.

He promoted academic and educational activities of high level in Brazil and abroad. He received a Doctorate in Science from the University of Paris (1946); was President of the United Nations Committee on the Study of the Effects of Atomic Radiation (1956-62); was General Secretary of the Conference of the United Nations for the Application of Science and of Technology in Special Development, Geneva (1962-66); and was the Brazilian Permanent Ambassador at UNESCO, Paris, France (1966-70). We could mention about fifty other similar activities to be found in his curriculum. For example, he was a member of fifty-three scientific societies or Academies of Sciences. The list of decorations, medals, prizes and honorary titles that were granted to him is long indeed.

Of great importance in Chagas Filho's activities was the efficient way in which he carried out the command tasks with which he was entrusted. To give some examples mention may be made of:

a) his magnificent performance as the Director of the Institute of Biophysics, an Institute recognised internationally as much for its scientific production as for the training of outstanding researchers;

b) his presidency of the United Nations Committee on the Study of the Effects of Atomic Radiation, which under his leadership produced a series of publications of great importance and relevance at the time. These were fundamental in the drawing up of conventions and international agreements on the use of the nuclear energy;

c) how Prof. Federico Mayor, General Secretary of UNESCO, who from 1966 to 1970 worked in that institution under the leadership of Chagas, affirmed that: 'Don Carlos had the extraordinary quality of convincing his collaborators that what they did at that moment was the most important thing in their lives';

d) the magnificent performance of Chagas as President of the Pontifical Academy of Sciences. This is summed up by what he said when receiving the position, in 1972, from Pope Paul VI: "What I want in this function is very clear. I will try to change the Academy from a body of great prestige into one of great action also". This intention was expressed in important action. There was the revision of the Galileo case, an act which received universal approval, and was, without doubt, one of the landmarks of the Chagas presidency. Another important initiative, which had the support of the Academicians, Victor Weisskopf and Louis Leprince-Ringuet, was the campaign in 1981 against atomic arsenals and the production of atomic weapons. This wielded great influence on the resolutions which were subsequently passed by the United Nations. Acting in harmony with that campaign, Pope John Paul II sent letters to the governments of Washington, Moscow, Paris and London – the countries that had the atomic bomb – in which he asked them to receive a delegation from the Pontifical Academy of Sciences which would explain to them the dangers of possible nuclear conflicts for the future of the human species. These initiatives played an important role in the peace resolutions that were later approved by the governments of those countries and by the UN;

e) the excellent publications of the proceedings of the plenary sessions held during the Chagas presidency, especially those on 'the Origin of the Universe, 'the Origin of Life', and 'the Origin of Man'. These demonstrated the mutual understanding which existed between the Catholic Church and Science, something which was always propagated with enthusiasm by Carlos Chagas Filho.

Chagas Filho believed in what he was doing. That is demonstrated in an article written by Darcy Fontoura de Almeida, one of his former-students. He related how Chagas was an 'academic professor par excellence who performed his duties even in a wheel chair until December of 1999, attending the Institute of Biophysics, tracking a post-graduate course which was highly appreciated by the students'.

From another former-student, Antônio Paes de Carvalho, we have the statement: 'The owner of a special intelligence, Chagas prevailed by reason in all the forums in which he had the opportunity to act, inside and outside of the country. In science, so demanding in its methodology, Chagas's contribution was marked by the creativity of his ideas, his heady hypotheses, and the rigidity and the patience with which he knew how to lead his more immediate collaborators. We could not find a better paradigm of dignity, of intelligence, and of love for one's neighbour and of the wisdom of life'.

Chagas Filho possessed an extraordinary series of human qualities. One of the most evident was his firm and constant propensity to do what was good.

Of Chagas Filho, whom I knew for sixty years and with whom I shared numerous contacts and collaborations, I have the most valuable and honorable memories, besides an enormous admiration. He was really a great human being.

C. Pavan

HERMANN ALEXANDER BRÜCK

Hermann Brück was a member of the Pontifical Academy for forty-five years. In the course of his long, cosmopolitan life he contributed greatly to astronomy – especially to the modernisation of observatories and the improvement of observational techniques.

He was born in 1905, the only child of Hermann Heinrich Brück, an officer of the Prussian army killed in 1914 at the Battle of Lodz. He attended the Kaiserin Augusta Gymnasium in Charlottenburg. His mother would have preferred him to become a lawyer, but his uncle, a distinguished bacteriologist, argued that science could also be a respectable profession.

He started his university career in Kiel; but he found no inspiration there, and moved on after one semester. He was far more fortunate in Munich, where he completed his first degree. He was taught by the legendary, charismatic physicist Arnold Sommerfeld, in the exciting years when quantum mechanics was being formulated – indeed, he attended the colloquium where Heisenberg first presented the famous 'uncertainty principle'. He obtained his doctorate in 1928 for work on the physics of crystals. Sommerfeld then encouraged him to read Arthur Eddington's recently-published book on 'The Internal Constitution of the Stars'. Brück moved to an astronomical post at Potsdam, and within a few years became a lecturer at the University of Berlin, where luminaries like Max von Laue, Erwin Schrödinger and Albert Einstein were on the faculty.

Brück left Germany abruptly in 1936, when Nazi aggression worsened. He came for a year to the Vatican Observatory in Castel Gandolfo. This was a formative period both scientifically and spiritually. He was received into the Roman Catholic Church by Romano Guardini and Johannes Pinsk, two of the most distinguished theologians of the age: his intense commitment to the Church continued throughout his long life.

His next move was to the Cambridge Observatories in England, in 1937. After war broke out, he was interned as an enemy alien, but within six months Eddington secured his release, and he returned to a post of greater responsibility in Cambridge. But in 1947 he received a personal invitation from Eamon de Valera, then Prime Minister of the Irish Republic, to become Director of the Dunsink Observatory and Professor of Astronomy at the new Dublin Institute for Advanced Studies, where he joined his friend Erwin Schrödinger, who had been invited to be Professor of Theoretical Physics.

After a successful decade in Ireland he moved again. On the personal initiative of Sir Edward Appleton, then Vice-Chancellor of Edinburgh University, he was invited to become Director of the Royal Observatory in Edinburgh, and Astronomer Royal for Scotland. Brück's personal scientific interests were in the physics of the interstellar medium, questions of stellar evolution and the formation of stars from diffuse interstellar material. But his impact was wider because he had a natural authority, and proved an effective innovator. During his tenure, the observatory staff numbers expanded from eight to more than a hundred. He fostered the work of Fellgett on automatic plate scanning machines, and that of Reddish on new telescopes. He thereby prepared the way for the pioneering Cosmos High-Speed Measuring Instrument, the 'Schmidt telescope' in Australia, as well as the UK Infra-Red Telescope and the James Clerk Maxwell Radio Telescope in Hawaii.

He championed the establishment of observing stations in climates better than that of Great Britain and was a prime advocate of a UK Northern Hemisphere Observatory in the Canary Islands. The Edinburgh Observatory still goes from strength to strength as a major astronomical centre, and its standing owes a great deal to Brück's far-sighted leadership.

Brück continued living near Edinburgh with his second wife, Mary, throughout his long and active retirement. (His first wife, Irma, had died in 1950.) Mary, who survives him, has herself a fine record as a professional astronomer. Hermann and Mary produced a highly readable biography of the eccentric nineteenth-century astronomer Charles Piazzi Smyth – one of Brück's predecessors in Edinburgh who pioneered stereoscopic photography but gained embarrassing notoriety through his obsession with the numerology of the Great Pyramid. The Brücks also wrote a history of astronomy in Edinburgh, tracing its emergence back to the Scottish enlightenment.

The Pontifical Academy meant a great deal to Hermann Brück. He was proud to have been elected when Georges Lemaître was President, and to have known him well. He gained special satisfaction from the memorable Study-Week which he organised on the theme 'Astrophysical Cosmology'. This took place in 1981 – a time when new links between cosmology and physics were being perceived. The meeting gathered together an outstanding group of scientists; the proceedings, beautifully edited, came out promptly and were widely influential.

He served on the Academy's Council for twenty years. And he lived long enough to be honoured for his services: on his ninetieth birthday Pope John Paul II appointed him Knight Grand Cross of the Order of St. Gregory the Great.

Those of us who were privileged to know Hermann Brück will cherish the memory of a dedicated scientist whose courteous dignity overlay a brilliant intellect and a firm faith.

Martin J. Rees

JOHANNA DÖBEREINER

Johanna Döbereiner (28/11/1924-5/10/2000) was born in Aussig, in Czechoslovakia, and lived with her family for some years in Prague, the city where her father, Paul Kubelka, was a teacher at the German University. As a youth her life was afflicted and very difficult.

At the age of seventeen, in the middle of the Second World War, she was forced to separate from her family and for a period of about four years had only occasional encounters with her parents and grandparents. She worked in several places in a broad range of activities. To begin with, she took care of children in government-sponsored colonies inside Czechoslovakia, and later she lived and worked on farms, milking cows, distributing natural fertilisers in the farms and orchards, and helping in the weeding of crops. Through these activities she was able to sustain and help her grandparents' survival.

In 1945, as a consequence of the war, together with her grandparents, she was expelled from Czechoslovakia, from which she went to Germany where she continued working in farms until 1947, in which year she was offered a place in the School of Agriculture of Munich, where, in 1950, she graduated as an agricultural engineer.

Her mother, after enduring great deprivations and even internment in concentration camps, died and was buried under a changed name, Anna, instead of Margareth Kubelka. Her widowed father and her brother Werner, with the help of foreign teachers based in Brazil and the Brazilian citizen Mário Pinto, managed in 1948 to migrate to Brazil. In 1950, Johanna, already married to Jürg Döbereiner, a University colleague, emigrated with him to Brazil. In 1956 she became a naturalized Brazilian citizen.

In 1951, in Rio de Janeiro, she was employed by the Department of Agriculture and began her work on nitrogen fixing bacteria, an area that she knew only from references to it in her agronomy course. Even without a specialised adviser, she believed so much in the importance of the subject that initially, with very few resources and a great deal of perseverance, she achieved, with students and collaborators, excellent progress in this field. Her work was abundant in practical results and publications that went beyond the borders of Brazil to receive wide international recognition.

Her work on soy-bean culture, involving the selection of bacteria which fix nitrogen from the air and pass it on through symbiosis to the plant, led to the substitution, with great advantages, of the application of artificial nitrogen fertilisers. With collaborators she produced the most efficient culture of soy-bean existent today, something which has proved to have great economical and ecological value. By planting in Brazilian soil, without the use of artificial nitrogen fertiliser, she obtained a productivity comparable to the North American cultures, which depended on artificial fertilisers and were the largest soy-bean producers per unit area in the world. These cultures are now generating great profits (hundreds of millions of dollars) for Brazilian and Argentinian farmers, and this latter group uses the same technology as that elaborated by the group of researchers led by J. Döbereiner.

In terms of the ecological aspects of soy-bean culture, it has been demonstrated in works published by the Ecological Society of America that artificial nitrogen fertiliser, used in agriculture throughout the world, is an important polluting agent of the terrestrial aquatic system and is already contaminating the sea systems. The use of nitrogen fixing bacteria is without doubt the most important alternative that exists to achieve a solution to this problem.

Of no less importance are some other achievements of the work of Döbereiner's group, in particular the discovery of several new species of nitrogen fixing bacteria associated with cereals, grasses and other non-leguminous species.

In contrast to the classical concept of rhizosphere associations, these bacteria colonise the roots, stems and leaves of wheat, rice, maize, sorghum, and a great number of other wild plant species.

Some of these species of bacteria are obligate endophytes and do not survive in the soil, and their transmission occurs within seeds or stem cuttings.

These discoveries by Döbereiner now exert a very important influence on agricultural processes involving the legume plants mentioned above and are expected to make a no less important contribution to the agriculture of non-legume plants and also to the conservation of biodiversity around the world. Their importance in the transition to sustainability is more than evident.

This outstanding scientist received several prizes, including the Bernard Houssay Prize of the OEA (1979); the Prize for Science of UNESCO (1989); the Mexican Prize for Science and Technology (1992), and others. She belonged to the Brazilian Academy of Sciences (1977), to the Pontifical Academy of Sciences (1978), and was a Founding Member of the Third World Academy of Sciences (1981).

The list of her publications includes over 370 papers published in international scientific journals. In a survey carried out in 1997 by the ' Folha de São Paulo', a major Brazilian daily newspaper, she was classified as the most cited (Citation Index International) of Brazilian female scientists and belonged to the top 10% of both male and female cited scientists.

Apart from losing a great researcher, the Brazilian scientific community, and especially myself, have lost a very dear and esteemed friend whose memory will be cherished by us all.

C. Pavan

SELF-PRESENTATIONS

TE-TZU CHANG

I am a Chinese national and my name, if Romanised, reads as Chang Te-Tzu. For the convenience of colleagues and friends, I generally use the abbreviated form, T.T. Chang. You are welcome to call me 'T.T.'

I completed my education at the college level in China. My graduate studies were then pursued in the USA.

My major area of research is plant genetics and its application to crop improvement, germplasm conservation, and crop evolution.

During my professional career I have served two institutions: the Sino-U.S. Joint Commission on Rural Reconstruction (JCRR) in Taiwan and the International Rice Research Institute (IRRI) in the Philippines. Both institutions have earned world-wide fame for enhancing the livelihood of underprivileged farmers and low-income consumers through the achievement of increased food production and more equitable distribution.

My contributions at the level of research and technology transfer have been:

1) the introduction of the potent semidwarfing gene in Taiwan's lane races into tropical rice. This greatly raised yield potential and led to the 'Green Revolution' in rice; and

2) the conservation of the diminishing land races, thus reducing the perils of genetic uniformity in improved cultivars. Through international collaboration we were able to save endangered gene-pools and preserve their seeds at the IRRI. Many land races and their wild relatives are no longer found in their old habitats. I also shared my expertise and experience in seed storage with national and international agricultural research centres by helping China, India, Taiwan and others in constructing modern genebanks.

In recognition of these activities, many awards and honours have been bestowed on me. Nevertheless, I highly value my membership of the

Pontifical Academy of Sciences. Actually, I began my collaboration with this Academy in 1998 with the Study-Week on the 'Food Needs of the Developing World in the Early Twenty-First Century'. Its proceedings have just been published.

I am both honoured and pleased to be present at this Assembly and to join many eminent scientists in discussing the role of science and the future of mankind.

Thank you.

CLAUDE COHEN-TANNOUDJI

I was born on April 1, 1933, in Constantine, Algeria, which was then part of France. My family, originally from Tangiers, settled in Tunisia and then in Algeria after having fled Spain during the Inquisition. In fact, my name, Cohen-Tannoudji, means simply the Cohen family from Tangiers.

I completed my primary and secondary school education in Algiers and left Algiers for Paris in 1953, before the war in Algeria and the stormy period that preceded independence.

I came to Paris because I was admitted to the Ecole Normale Supérieure. The four years I spent at this school were a unique experience. Being fascinated by Alfred Kastler's lectures in physics, I decided to join his group to do my "diploma" work and I think that what I learned during that period was essential for my subsequent research work. After the final "Agregation" examination, I left Ecole Normale as a student. In 1960, I returned as a researcher and submitted my Ph.D. in December 1962. Shortly after, I was appointed to a position at the University of Paris.

Understanding atom-photon interactions was one of the main goals of our research group and led us to develop a new approach, the so-called "dressed atom approach", which turned out to be very useful in providing new insights into atom-photon interactions.

Another important event in my scientific life was my appointment as a Professor at the Collège de France in 1973. In the early 1980s, I chose to lecture on radiative forces, a field which was very new at that time and I formed a new experimental research group on laser cooling and trapping with Alain Aspect, Jean Dalibard, and Christophe Salomon. We began to investigate new cooling mechanisms suggested by the dressed atom approach. Our work was devoted to the understanding of the mechanical effects of light and to the investigation of possible applications of these effects.

In 1997, I was awarded the Nobel Prize in Physics jointly with Bill Phillips and Steven Chu for the development of methods to cool and trap atoms with laser light. This research field has considerably expanded during the last few years and I will try to describe a few recent developments and applications in the paper which follows this self-presentation.

RAFFAELE FARINA, S.D.B.

As the Prefect of the Vatican Library I was appointed a 'perdurante munere' member of the Pontifical Academy of Sciences on 24 May 1997.

I obtained my doctorate in ecclesiastical history at the Gregorian University of Rome. I was Professor of the History of the Ancient Church at the Salesian Pontifical University of Rome from 1965 to1997 and was Rector of the same university from 1977 to 1983 and from 1992 to 1997. I was also for a period President of the Committee of the Pontifical Universities of Rome. Within the Roman Curia I was Under-Secretary of the Pontifical Council for Culture from 1986 to 1992 and Secretary of the Pontifical Committee for Historical Sciences from 1980 to 1992.

NICOLE LE DOUARIN

Nicole Le Douarin started her research carrier in 1958 under the sponsorship of Prof. Etienne Wolff who was the Director of the Institut d'Embryologie Expérimentale et de Tératologie du Centre National de la Recherche Scientifique et du Collège de France in Nogent-sur-Marne. For two years she worked in the laboratory only part time since, from 1954, she was teaching in a lycee. She became full time researcher in 1960 and submitted a thesis for the "Doctorat d'Etat" in 1964. Her thesis was entitled "Etude expérimentale de l'organogenèse du tube digestif et du foie chez l'embryon de Poulet". She was appointed as Maitre de Conférences first in the Faculté des Sciences of Clermont-Ferrand in 1965-1966, then in the Faculté des Sciences of Nantes where she became Professor in 1971. She was responsible for teaching developmental biology and had the opportunity of setting up a Developmental Biology Research Unit with the support of the CNRS.

In 1975, when Prof. Etienne Wolff retired, she was invited to take over the Directorship of the Institut d'Embryologie du Collège de France et du CNRS at Nogent-sur-Marne. She was appointed Professor at the Collège de France in the Chair of "Embryologie cellulaire et moléculaire" in 1989, a position that she occupied until September 2000. She was elected a member of the French Académie des Sciences in 1982, of the American Academy of Arts and Sciences in 1984, of the National Academy of the United States America in 1989, and of the Royal Society of the United Kingdom in 1990. She received the Kyoto Prize in Advanced Technology in 1986, the Gold Medal of the CNRS in 1986, the Jeantet Price for Medicine in 1990, the Luisa Gross Horwitz Price of Columbia University in New York in 1993, and the Grand Prix de la Fondation pour la Rercherche Médicale Française in 1999. She has been elected as the "Secrétaire Perpétuelle" of the Académie des Sciences de l'Institut de France from January 1st, 2001 and she continues to do research part time at the Institut d'Embryologie Cellulaire et Moléculaire du Collège de France et du CNRS.

MARIO J. MOLINA

I was born in Mexico City. I obtained a degree in chemical engineering from the Universidad Nacional Autónoma de México (UNAM) in 1965, and a Ph.D. in physical chemistry from the University of California, Berkeley in 1972. I came to MIT in 1989 with a joint appointment in the Department of Earth, Atmospheric and Planetary Sciences and the Department of Chemistry, and became MIT Institute Professor in 1997. Prior to joining MIT, I held teaching and research positions at UNAM, at the University of California, Irvine, and at the Jet Propulsion Laboratory of the California Institute of Technology.

My main work involves laboratory studies of chemical systems of importance in the atmosphere. In particular, I have conducted research on the chemistry of the stratospheric ozone layer and its susceptibility to human-made perturbations. In 1974 I published together with F. S. Rowland an article in the British magazine 'Nature' describing our research on the threat to the ozone layer from chlorofluorocarbon (CFC) gases that were being used as propellants in spray cans, as refrigerants, as solvents, etc. As a consequence, the production of these gases was eventually banned in developed countries.

More recently I have also been involved with the chemistry of the lower atmosphere, pursuing interdisciplinary work on urban and regional air pollution issues and working with colleagues from several disciplines on the problem of rapidly growing cities with severe air quality problems. I am currently heading a collaborative research and education program based at MIT aimed at addressing the complex and interrelated environmental issues spawned by the world's rapidly growing mega-cities and their impact on the global environment. Mexico City serves as the initial case-study for this program's research and educational activities.

JOSEPH E. MURRAY

Surgery as Science – Surgery as Humanism

My professional life has been primarily spent caring for patients. Teaching and research have also been prominent.

After graduating from medical school during World War II, I was randomly assigned to a military hospital in the United States that cared for battle casualties from the European, African and Pacific theatres.

Treating a young aviator burned in a crash flying from Burma to China (when the U.S. was helping China in the war against Japan) gave me my first experience in using tissues from a dead person as a life-saving measure. This experience directed my professional activities.

After three years of Army surgery, I joined a group of physicians studying kidney transplantation at Harvard Medical School. Working in the surgical research lab, I developed techniques of transplantation in mice, rabbits and dogs. In 1954, we performed the world's first successful human kidney transplant between identical twins. Five years later, in 1959, we successfully transplanted a human kidney from a cadaver. Our team consisted of clinicians and basic scientists working toward a common goal. For this, I was recognized by the Nobel Committee and awarded the Nobel Prize in Medicine in 1990.

Transplantation of other organs by other investigators rapidly followed (i.e. liver, heart, pancreas, lung, heart/lung, and intestines). By the early

1970's, transplantation was being performed worldwide. At that time, I decided to move away from transplantation and, instead, concentrated on my original surgical passion – reconstructive surgery. This included craniofacial problems (congenital, traumatic or neo-plastic) in children and adults. Just as organ transplantation required knowledge of biochemistry and immunology, craniofacial problems required interaction with basic genetics and embryology.

During my surgical career of over 50 years, surgery has evolved from excision, reconstruction and transplantation to inductive surgery. These advances required the understanding and contributions of both basic scientists and clinical scientists, confirming Pasteur's dictum, "There is only one science. Basic and clinical science are closely joined as the trunk of a tree is to its branches."

SERGIO PAGANO

Né à Gênes le 6 novembre 1948, il est entré dans la Congrégation des Barnabites en 1966. Il a étudié la philosophie et la théologie à Rome, où il a été ordonné prêtre en 1978. La même année il obtient la maîtrise en théologie avec spécialisation en Liturgie, le diplôme de Paléographe Archiviste auprès de l'École Vaticane de Paléographie, Diplomatique et Archivistique, puis il est nommé "Scriptor" des Archives Secrètes Vaticanes. Actuellement, il est professeur de diplomatique pontificale dans cette École. Membre de l'Académie San Carlo de Milan, représentant des Archives Secrètes au Comité International d'Archivistique, consulteur historique de la Congrégation pour les Causes des Saints depuis mai 1985, il est nommé Vice Préfet des Archives Secrètes Vaticanes par Jean-Paul II le 30 janvier 1995. Quelques jours plus tard, il reçoit la charge de Vice Directeur de l'École Vaticane de Paléographie, Diplomatique et Archivistique. Depuis 1989, il est Supérieur du Centre d'Études historiques des Pères Barnabites de Rome. Le 7 janvier 1997, il est nommé Préfet des Archives Secrètes Vaticanes et Directeur de l'École Vaticane de Paléographie, Diplomatique et Archivistique. Il est membre de droit "perdurante munere" de l'Académie Pontificale des Sciences et du Comité Pontifical des Sciences Historiques. Depuis Mars 2000, il est membre correspondant des *Monumenta Germaniae Historica* et depuis juillet 2000, il est membre de la Société Romaine d'Histoire de la Patrie.

FRANK PRESS

I have found it challenging and rejuvenating to change positions every 5 to 10 years. In this way I have had the opportunity to serve as teacher and researcher at three great research universities – Columbia, Caltech, and MIT. The face to face discourse with students and faculty, the laboratory, library, and computational resources, the air of imminent discovery at these places provide an ideal environment for a scientist to be creative and fulfilled.

After some 25 years so occupied, I received a call from President Jimmy Carter to become his Science Adviser. Although the work during the four year term was taxing and stressful, not particularly enjoyable, and ended my life as a bench scientist it was an experience not to be missed. Other than learning on the job, there is no way to prepare oneself for the turbulent world of politics and its intersection with science and technology (which includes most issues faced by a nation's chief executive). I had to prove myself all over again in a new environment where credentials and publications meant little and contributing to the success of a political administration meant everything. Perhaps I had it a bit easier than other Science Advisers because President Carter was trained as an engineer, was conversant in science, and most importantly, I agreed with his goals.

In 1981 I was elected to the Presidency of the U.S. National Academy of Sciences (NAS) and served for 12 years. I took less interest in the honorific aspects of the Academy than in its unique role as one of the most influential advisory bodies to any government. I was well prepared for this position because of my earlier academic and government position. Although advising the government as president of a private organization is not the same as being on site in the White House, I am proud of the many ways in which the NAS helped the government to address issues ranging from the AIDS epidemic, to arms control, science budgets and industrial productivity.

As I look back on my career (hopefully, it is not yet over), I am proud of my discoveries as a scientist in partnership with my graduate students and colleagues. But most of all I take particular pleasure in my undergraduate textbooks *Earth* and *Understanding Earth*, co-authored with Professor Raymond Siever of Harvard, which from 1974 to 2000 have introduced a million or so students to the planet on which they live.

RAFAEL VICUÑA

First of all, I would like to express my profound gratitude to His Holiness John Paul II for appointing me a new member of the Pontifical Academy of Sciences. I receive this appointment with the greatest honour and I wish to declare my commitment, dedication and faithfulness to the aims of this highly prestigious institution.

I would also like to thank the members of the Academy for their support and I confirm my intention to actively contribute with the highest interest and motivation to those activities where the Academy may feel my input would be helpful.

Science represents one of the most prominent endeavours of humankind. For several centuries it has demonstrated that it is the most reliable tool that exists for unlocking the secrets of nature. From this perspective, it represents one of the fundamental supports of our cultural progress. At the same time, science has led to the development of new technologies which have had a dramatic impact on agriculture, industry, and medicine, as well as on everyday life, thereby bringing about the social progress of humanity.

Nowadays science advances so fast that we are increasingly confronted with scenarios that could not have been foreseen some years ago. Unfortunately, we do not seem to dedicate enough time to reflecting about the implications of the new discoveries, or even about the new capabilities, acquired by scientists in their laboratories. For example, the ability to manipulate cells and genes has opened up new horizons in agriculture and human reproduction. At times, some of these advances challenge our consciences and provoke dilemmas – we are faced with what we technically able to do *versus* doing what are we morally obliged to do. Therefore, institutions such as this Academy, which are devoted to deep reflection about the consequences of new knowledge, are more essential than ever in the provision of guidelines to the scientific community and society as a whole.

I will now say a few words about my academic career in the hope that this may help you to envisage how I might better serve this Academy. I have been attached to science ever since I finished high school thirty-four years ago. This has been not an easy engagement, since scientific research has very seldom been considered a worthwhile activity in Latin American countries. However, I strongly believe that scientific research is necessary to reach both intellectual autonomy and economic progress. Guided by this conviction, throughout this period I have been involved in various activities directed towards the strengthening of science in Chile. At the national level, I have participated several times in committees appointed by the government to discuss science programmes. I have also frequently served as an advisor to Congress in the analysis of legislation involving scientific issues. At the Pontifical Catholic University of Chile, the place where I work full time, I have served as dean of research and as vice-president for academic affairs, being responsible for the co-ordination of the research activities of our sixteen different Faculties. In the accomplishment of these duties I have gained some experience in the drawing up and administration of science policies.

With respect to the research fields that I have explored, during my Ph.D. studies in New York I worked on DNA replication in bacteria, which I continued to do for some years after my return to Santiago in 1978. Thereafter, I moved to the realm of thermophilic bacteria, being attracted by the amazing capability of these micro-organisms to thrive at temperatures around 80 ºC. My work encompassed the characterisation of some extrachromosomal DNA elements and also some enzymes involved in the metabolism of DNA in thermophilic bacteria. Fifteen years ago, after sabbatical leave supported by a Guggenheim fellowship in Madison, Wisconsin, I switched to my present field of interest, which is the biodegradation of lignin. Lignin is the second most abundant deposit of organic carbon in the biosphere and therefore its metabolism is a key component of the carbon cycle on earth. This macromolecule is closely associated with cellulose in the plant cell wall, providing plant tissues with mechanical strength and protecting them against microbial attack. Lignin is an insoluble polymer with a highly irregular structure, properties that make its biodegradation a very special biochemical process. My laboratory is approaching this fascinating problem by studying the ligninolytic system of a fungus which is particularly aggressive towards lignin in natural environments. We are characterising the enzymes that attack the polymer and studying both the structure and expression of the genes encoding them. Although our research can be considered as basic, it has some biotechnological connotations. One of its main applications is in the pulp and paper industry, the major process of which involves the removal of lignin from the wood and thus the release of the cellulose fibres. We have already worked with local companies with the end result of making their processes more efficient and environment-friendly.

Although, as I have just mentioned, my research in the laboratory deals with lignin biodegradation, I also manage to find the time to follow other subjects with great enthusiasm. One of them is the origin of life on earth. I had the privilege of attending a meeting on this subject which was held in Trieste last September. I also have a special interest in the subject of human evolution, which occupies much of my social reading. In addition, the Human Genome Project and its ethical and social implications have also commanded a great deal of my attention, especially during the current year.

Once again, I sincerely thank you all for your support and I restate my intention to dedicate my best efforts to serving the Pontifical Academy of Sciences with loyalty and responsibility.

CHEN NING YANG

I am Chen Ning Yang. I was born in China and went to the United States of America in 1945 to engage in post-graduate studies. After my Ph.D. at the University of Chicago, I spent seventeen years at the Institute for Advanced Study in Princeton and then joined the State University at Stony Brook where I was a professor for thirty-four years until my retirement one and a half years ago. I am now Distinguished Professor-at-Large at the Chinese University of Hong Kong. I am delighted to have been elected a member of the Pontifical Academy, in particular because my teacher, the great Enrico Fermi, was a professor in Rome and created modern physics research in Italy during his period in Rome.

AHMED H. ZEWAIL

On the banks of the Nile, the Rosetta Branch, I lived an enjoyable childhood. I was born in Egypt in Damanhour, the “City of Horous”, only 60 km from Alexandria. In retrospect, it is remarkable that my childhood origins were flanked by two great places – Rosetta, the city where the famous Stone was discovered, and Alexandria, the home of ancient learning.

I graduated from the University of Alexandria in 1967 with a B.S. degree, and shortly thereafter, in 8 months, with a Master’s degree. From the University of Pennsylvania in Philadelphia, USA, I received my Ph.D. degree, and at the University of California at Berkeley I completed two years of a postdoctoral fellowship. In 1976, I joined the faculty of the California Institute of Technology (Caltech) and I am currently the Linus

Pauling Chair Professor of Chemistry and Professor of Physics, and the Director of the NSF Laboratory for Molecular Sciences.

At Caltech, our research efforts have been devoted to developments of ultrafast lasers and electrons for studies of molecular dynamics with atomic-scale resolution. In the field of femtochemistry, developed by the Caltech group, and for which the 1999 Nobel Prize in Chemistry was awarded, the focus is on the fundamental femtosecond processes in chemistry and in related fields of physics and biology.

I have had the fortune of a wonderful family and the friendship of my wife, Dr. Dema Faham, who is here today. Currently we live in San Marino, California. Two of my children, Maha and Amani, are doing well in science and have graduated from Caltech and Berkeley, respectively. The two younger sons, Nabeel and Hani, have not yet reached this stage of college education, but the trajectory is clear! My scientific family over the past 20 years consists of some 150 postdoctoral research fellows, graduate students and visiting associates.

It is a pleasure to be inducted into this distinguished and historic academy.

ANTONINO ZICHICHI

My field of activity is subnuclear physics and is directed towards what is termed 'the Standard Model'. This is the greatest synthesis of all times in understanding the basic Logic of Nature. Some major issues in subnuclear physics have attracted my interest. The following five points have been my contribution – during these four decades – to the building up of the Standard Model.

1. *The Third Lepton*

The problem of divergences in electro-weak interactions and the third lepton. Physics results are finite: why then do theoretical calculations, for example in Quantum Electro-Dynamics (QED), give rise to divergent quantities? High precision measurements in QED and in weak interactions attracted my interest. In fact, for example, the contributions of virtual weak processes in the elementary properties of the muon should produce divergent results. The cure for divergences was called, by theorists, renormalization. My career started with the first high precision measurements of the muon electromagnetic and weak basic properties, i.e. its anomalous magnetic moment (measured with ± 5 x 10^{-3} accuracy), and its weak charge (measured with ± 5 x 10^{-4} accuracy). The invention of new technologies for the detection of electrons and muons allowed me to start searching for a new lepton and to make a series of high precision QED tests. This activity culminated in the discovery by others of the third lepton (now called *t*) to which I have devoted ten years of my life.

2. *Matter-Antimatter Symmetry*

The violation of the symmetry operators (C, P, T, CP) and Matter-Antimatter Symmetry. I was very much intrigued by the great crisis arising from the discovery that the basic invariance laws (charge conjugation C, parity P, time reversal T) were not valid in some elementary processes. Together with the successes of the S-matrix and the proliferation of 'elementary' particles, the powerful formalism called Relativistic Quantum Field Theory (RQFT) appeared to be in trouble. These were the years when the RQFTs were only Abelian and no one was able to understand the nature of the strong forces. The discovery of CP breaking gave a new impetus to the search for the first example of nuclear antimatter: in fact the antideuteron had been searched for and found not to be produced at the 10^{-7} level. The order of magnitude of its production rate was unknown and finally found to be 10^{-8}. This level of detection was reached by my group thanks to the construction, at CERN, of the most intensive negative beam and of the most precise time-of-flight detector.

3. *Mesons Mixings*

The mixing in the pseudoscalar and vector mesons: the physics of Instantons. Another field thoroughly investigated by me is the mixing properties of the pseudoscalar and of the vector mesons, realized through the study of their rare decay modes. This could be accomplished thanks to the invention of a new detector, the neutron missing mass spectrometer. The physics issues could probably be synthetized in terms of the U(1) problem. In other words, why do the vector mesons not mix while the pseudoscalar mesons mix so much? This issue found – after many decades – a satisfactory answer when G. 't Hooft discovered how Instantons interact with the Dirac sea.

4. *Effective Energy*

The non-Abelian nature of the Interaction describing quarks, gluons and Effective Energy. Another puzzle to me was the enormous variety of multihadronic final states produced in strong, electromagnetic and weak interactions. Why are these final states all different? This appeared to be in contrast with the order of magnitude reduction in the number of mesons and baryons obtained, first with the eightfold way by Gell-Mann and Ne'eman and then with the quark proposal by Gell-Mann and Zweig. The discovery of Scaling at SLAC and the non-existence of quarks found by us at CERN using the ISR was finally understood in terms of quarks, gluons, and their non-Abelian interaction. With the advent of quarks and gluons, the puzzle became even more intriguing since the multihadronic final states had to have the same origin. The introduction of the new quantity, 'Effective Energy', allowed the discovery of the Universality Features in the multihadronic final states produced in strong, electromagnetic and weak interaction, thus solving the puzzle. It is remarkable that the quantitative QCD description of 'Effective Energy' is still missing, since it is a non-perturbative QCD effect.

5. *The Supersymmetry Threshold and its Problems*

As early as in 1979, I pointed out the relevance of this new degree of freedom for the convergence of the three gauge couplings. More than a decade later (1991), I realised that a serious effort was needed to put order and rigour into this field where unjustified claims on the Supersymmetry threshold became very popular despite their total lack of validity. For example, no one had ever computed the effect of the Evolution of the Gaugino Masses (EGM), not only on the convergence of the gauge couplings but, and more importantly, on the Supersymmetry threshold. The EGM effect brought down the Supersymmetry threshold by nearly three orders of magnitude.

A Note Concerning Projects and Technological Developments

My physics interests made me very much concerned about the future of subnuclear physics. This concern lies at the origin of my activity devoted to the implementation of new projects: the Erice Centre for the implementation of a genuine scientific culture; the Gran Sasso project, now the largest and most powerful underground laboratory in the world; the LEP-white-book which allowed this great European venture to overcome the many difficulties that had blocked its implementation for many years; the HERA collider, now successfully running; the roots of LHC (the new CERN collider) i.e. the 5 metre diameter for the LEP tunnel, and the LAA-R&D project, implemented to find the original detector technologies needed for the new colliders.

THE PIUS XI GOLD MEDAL AWARD

MARK M. DAVIS

Summary of Scientific Activity

I received my first exposure to serious laboratory work in synthetic organic chemistry in the laboratory of P.Y. Johnson as an undergraduate at Johns Hopkins University. In my last year, I was exposed to the mysteries of DNA chemistry by Michael Beer in the Biophysics department and I believe it was this (and having read "The Double Helix" a few years earlier) that inclined me towards working with this substance over the next twentysome years. As a graduate student at the California Institute of Technology, starting in 1974, I had the good fortune to work with DNA and RNA in two separate laboratories – first with Eric Davidson on hybridization analysis and "gene counting" strategies and then with Leroy Hood in using molecular cloning techniques to isolate and characterize rearrangements in immunoglobulin heavy chain genes. In 1980 I finished my Ph.D. and began working with William Paul at the National Institutes of Health (NIH). As work with antibody genes was winding down I thought that it would be interesting to combine what could be done with nucleic acid hybridization with the search for interesting genes in the immune system. This could be done by exhaustively hybridizing complementary DNA (cDNA) from one messenger RNA population with RNA from another. Previously, this had only been attempted with very different types of cells and tissues (liver versus kidney etc.) and large differences in gene expression had been seen, equivalent to thousands of different genes. From the natural history of lymphocytes, however, it seemed that they shared a similar origin and morphology such that I thought that T and B cells might differ by only a few genes, making the isolation of these relatively easy. After a few months of work at NIH, I was able to show that T and B cells indeed shared 98% of their gene expression and thus only 100-200 genes were expressed in one and not the other. With tremendous support and encouragement from Dr. Paul, I built up a small laboratory at NIH and set out to use these findings to isolate important genes in the immune system, particularly the T cell receptor for antigen, the equivalent of the antibody molecule for T lymphocytes. In 1983, we were successful in isolating the first of what later turned out to be four T cell receptor genes, just at the time that my wife, Yueh-hsiu Chien, also a scientist and I moved to take a faculty position at Stanford. We published the first T cell receptor paper in early 1984, in a dead heat with Tak Mak who had the human equivalent, and later that same year, mostly through the efforts of Chien, we published a paper describing the second chain of the heterodimer, this time in a photo-finish with Susumu Tonagawa, who had joined the fray.

Since the mid-eighties, my work has gradually shifted its focus from nucleic acid chemistry and characterization, to protein structure and biochemistry, cell biology and even to medical issues involving T lymphocytes. In this first area we were able to demonstrate direct T cell receptor binding to its peptide/MHC ligands and to link the strength of binding to the density of cell-surface clustering (with Michael Dustin). I also became curious about the high degree of sequence diversity in the center of the T cell receptor molecules and we were able to show that this region (the CDR3 loops) is the driving force behind peptide specificity. More recently we have also shown this to be true with immunoglobulins. An unexpected byproduct of our biochemical efforts was the realization that while T cell receptor binding was very weak in the micromolar range, it was nonetheless highly specific. This suggested that labeled multimers of peptide/MHC might be good "tags" for T cells with interesting specificities. After a few false starts, we made "tetramers" of peptide/MHC and these are able to stain T cells of just about any degree of specificity. This technique is becoming quite useful for clinical applications, allowing physicians to "follow" specific T cells responses to viral, cancer or autoimmune antigens quickly and easily.

More recently, we have used this approach to show that while tumor specific T cells do arise, sometimes in large numbers in patients with Melanoma, they seem almost completely non-functional compared with T cells of other specificities in the same patients.

The major interest in the lab currently is to follow the fate of labeled membrane proteins on live T cells during the recognition process, in order to discern the underlying chemistry. Interesting facts have emerged from this work about the nature of co-stimulation and the formation of what has been called "the immunological synapse".

GILLIAN PATRICIA BATES

Summary of Scientific Activity

I first started to work on Huntington's disease (HD) in 1987 when I became a postdoctoral fellow in Hans Lehrachs' research group at the Imperial Cancer Research Fund in London. The HD gene had been mapped to the short arm of chromosome 4 three years previously by Jim Gusella. In order to isolate the gene itself, a collaborative group of scientists had been brought together by Dr. Nancy Wexler, President of the Hereditary Disease Foundation (HDF). This included six research groups in the USA and UK headed by Jim Gusella, Hans Lehrach, David Housman, John Wasmuth, Francis Collins and Peter Harper. Over the next six years we worked together to generate the necessary resources and develop the required technology to pinpoint the HD gene. This was an extraordinary training. Hans' laboratory was a leading light in developing technologies for both the positional cloning of genes and also the genome project. The HDF provided the opportunity to interact regularly in an informal setting with a group of extremely talented and gifted scientists. The collaborative group published the identification of the HD gene in 1993. It was found that the only difference between the DNA sequence of this gene in people that do not develop HD and those that become affected is the length of a repeated DNA sequence (CAGCAGCAG), very close to the beginning of the gene.

At the beginning of 1994, I became a Senior Lecturer at what is now the GKT School of Medicine, King's College and initiated my independent research programme. An understanding of the HD mutation made it possible for the first time to generate a mouse model of HD. This was extremely important, as an accurate mouse model would allow us to uncover the very early molecular events in the disease course and to test possible therapies. Initially, I focussed my work in this direction and we published the first mouse model of HD in 1996. One of these transgenic lines, known as R6/2 has an early age of onset and has proved to be particularly useful as it has been possible to carry out an extensive characterisation of these mice in a very short time. Dr. Stephen Davies carried out a neuropathological analysis of these mouse brains and made the first major insight that arose from their study. He found that the transgene protein (made from the HD mutation that we had inserted into the mouse DNA) formed aggregates in the nuclei of nerve cells (neuronal intranuclear inclusions) in the transgenic mouse brains. The significance of these structures was not immediately apparent, as protein deposits had never been described in

Huntington's disease. However, since their identification in the mice, polyglutamine aggregates have been widely reported in HD post mortem patient brains. Max Perutz in Cambridge, UK and Erich Wanker, working with Hans Lehrach at the Max Planck Institute for Molecular Genetics in Berlin showed that these fibres have a cross-β-sheet structure more commonly known as amyloid.

For the past three and a half years, the R6/2 mice have been distributed to the research community either by my own lab or by the Jackson Laboratory in the USA. There are already around forty publications describing research that has been conducted on these mice by many groups. Insights into the early molecular stages of HD are arising. Polyglutamine aggregates form very early in some brain regions, before the onset of symptoms. Work initiated with Jang Ho Cha and Anne Young and MGH, Boston, showed that selective genes, many known to be important for nerve cell function, are turned down early in the transgenic mouse brains. Finally, the mice have been used for testing pharmaceutical compounds and two drugs are already entering the early stages of clinical trials in the UK and USA. The mouse model has revolutionised our knowledge of this disease and in the space of only four years is already beginning to have an impact on the treatment of HD.

STEPHEN WHITWORTH DAVIES

Research Interests

My laboratory has a long standing interest in molecular mechanisms of transcriptional regulation in the striatum following neuronal injury

I am currently focussing on the mechanism of neurodegeneration in Huntington's disease and other diseases caused by trinucleotide repeat expansions. These studies are in collaboration with Dr. Gillian Bates (UMDS). Current research projects are: immunocytochemical characterisation of neuropathological changes in Huntington's disease, post-mortem brain and transgenic mouse models of HD (Barbara Cozens and Elizabeth Slavik-Smith), ultrastructural and biochemical characterisation of *in vitro* and *in vivo* fibrous aggregates of Huntington's disease (Aysha Raza), transcriptional regulation in transgenic mouse models of Huntington's disease, and ultrastructural and molecular characterisation of sub-domains within the neuronal nucleus (Dr. Michael Gilder), ultrastructural and molecular characterisation of cell death in HD transgenic mouse models (Mark Turmaine and Lee-Jay Bannister), and a detailed analysis of the ultrastructure and molecular properties of the Cajal Body, Gemmini body, PML bodies and the nucleolus (Dr. Michael Gilder, Elizabeth Slavik-Smith and Cheryl Jones).

I am expanding these investigations to encompass neurodegeneration within the CNS of transgenic mouse models of Parkinson's disease and MSA (Rushee Jolly in collaboration with Dr Michel Goedert, LMB Cambridge), investigating the role of a-synuclein in the formation of neuropathological inclusions and in a transgenic mouse model of spinal muscular atrophy (SMA) in collaboration with Dr Arthur Burghes (Columbus, Ohio).