PONTIFICIAE ACADEMIAE SCIENTIARVM SCRIPTA VARIA

67

THE ACTIVITY OF THE PONTIFICAL ACADEMY OF SCIENCES

1936-1986

G. B. MARINI-BETTÒLO

SECOND EDITION

PONTIFICIA
ACADEMIA
SCIENTIARVM

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

—

MCMLXXXVII

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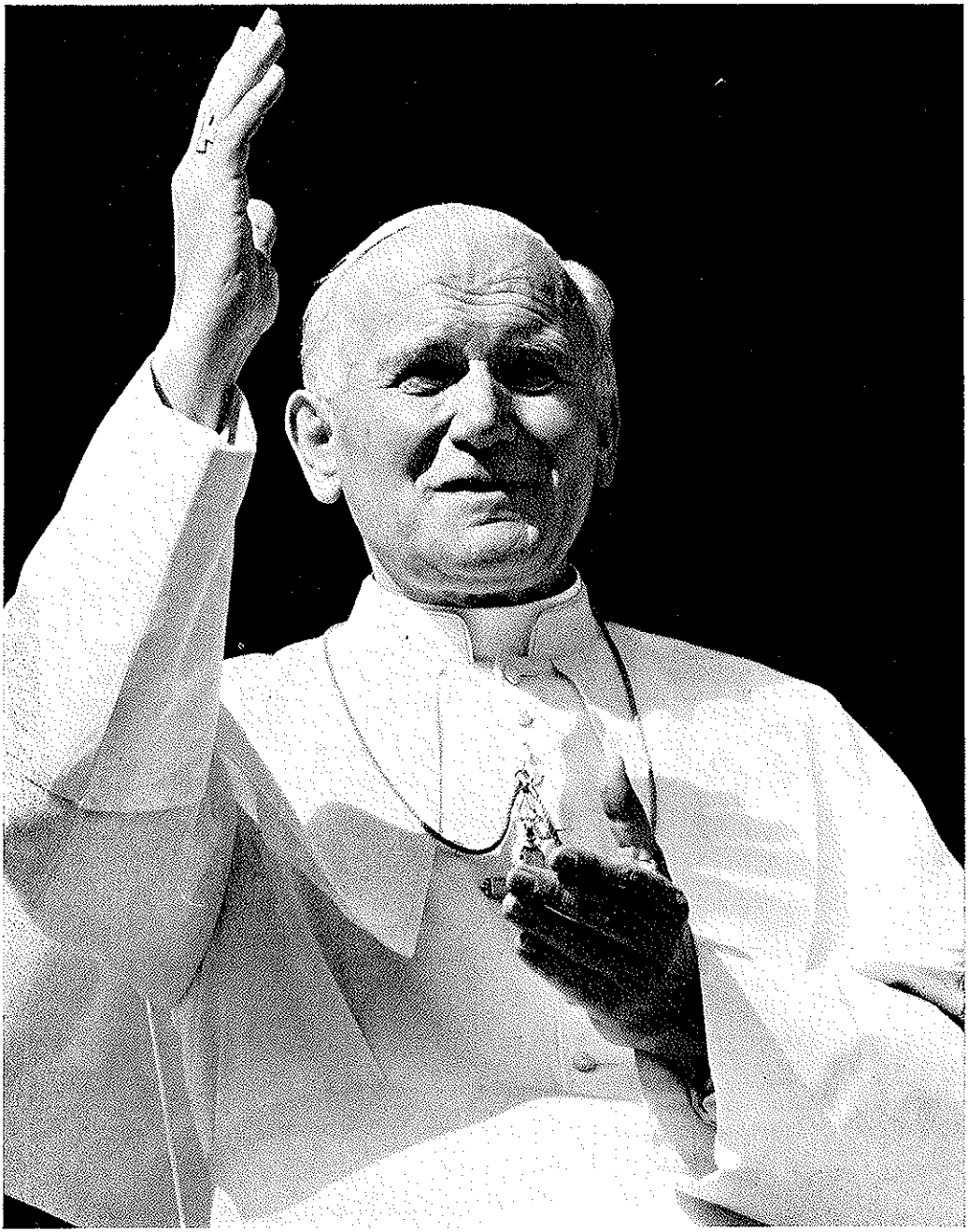


John Paul II.

PREFACE

The celebration of an anniversary, besides recalling to present generations the events or persons that have made it stand out in history, has the merit of imposing on the daily activity of individuals and institutions a moment of reflection to reexamine the time that has passed, which can be important not only as a memory or as an example, but especially as an inspiration for the future.

With the 50th anniversary of the restoration of the Pontifical Academy of Sciences conceived by Pius XI and made a reality through the work of the Presidents, Father Gianfranceschi first and then by Father Gemelli, it was considered appropriate, among the other manifestations planned for the occasion, to call attention to what the Academy has accomplished during these fifty years — that is during a period in which science — through technology — has modified our knowledge, our way of life, the behaviour and the wellbeing of man, more than all the preceding centuries in the history of humanity.

The recording of the activities of the Academy — which has always reflected the development of scientific and technical progress — had begun in 1936 in the *Acta Pontificiae Academiae Scientiarum* with a detailed description of its proceedings year by year.

However, this was interrupted in 1951. In order to present today an image of our Academy, it was proposed to commemorate, with a publication summarizing the events, the initiatives and the tendencies, the programs and the results of these fifty years of activity.

This not very simple task was assigned to Academician G.B. Marini-Bettòlo, who through a series of circumstances has been a direct witness from the very beginning of the Academy's evolution. For this purpose he has tried to describe in an organic manner — along a line respectively chronological and logical in the two parts of the volume — the many activities and initiatives of the Academy.

I believe that this volume — even if it has been written in a very short time, due to the need to appear for the Plenary Session of October 1986 — can present an almost complete picture of the essential points of the Academy's work in the promotion of science and its role in the international scientific comunity.

Moreover, it gives much documentary material which assures to the historian of science testimony and data which might otherwise be scattered or ignored. This material constitutes an important contribution to knowledge not only of the events but also of the spirit which has inspired the Academy during these years in its search for truth and through this the wellbeing of humankind.

I wish to express my hearty thanks to the author and to those who have collaborated with him, with intelligence and knowledge, but especially with enthusiasm and dedication in the realization of this work, and that is, to Father Enrico di Rovasenda, Ing. Don Renato Dardozzi, to Michelle Porcelli, Gilda Massa, Romana Costabile, Aldo Cicinelli and Marco Muzi and especially to Franco Chiorri for his fine technical skill and artistic sensitivity in accomplishing this work.

CARLOS CHAGAS

President of the Pontifical Academy of Sciences

FOREWORD

On the occasion of the fiftieth anniversary of the re-establishment of the Pontifical Academy of Sciences a number of facts, data and documents regarding its activity between 1936 and 1986 are presented in this booklet.

The aim is to give a short account of the activity of the Academy and all information which can give an idea, even approximate, of the work of the Academy. This material may be even used in the future as a starting point for drawing the history of the Academy during this period.

Although the history of the Academy from 1603 to 1936 has been described in detail by Mons. Charles Burns in his book, I wish to recall some points to make these notes more readily understandable.

In 1603 Federico Cesi established in Rome the first scientific Academy of Sciences in the World, under the name of "Accademia dei Lincei", which was the origin of the present "Pontifical Academy of Sciences".

The "Lincei" became famous for their substantial contribution to the "experimental method" and for the work of Galilei, one of his most distinguished members.

Soon after Cesi's death, in 1630, the Academy terminated its activity. The Lincei, already famous, were not however forgotten, and several scholars tried, in various periods throughout two centuries, to resume its name and its tasks.

Only in 1847 did Pius IX restore the Academy as an official body of the Pontifical States, with the name of Pontificia Accademia dei Nuovi Lincei. The scope of the Academy was not only to promote scientific research but also to advise the Government on scientific questions.

When in 1870 Rome was annexed to the Kingdom of Italy the Lincei fellows split into two parts; one formed the Royal Academy of

the Lincei, established as the national Italian Academy, the other continued with its name and statutes as Pontifical Academy.

This meant the existence of two Academies of the Lincei in the same town. As an indirect effect of the "Conciliazione" between the Holy See and the Italian State in 1929, a change in the structure and in the scopes of the Pontificia Accademia delle Scienze - Nuovi Lincei — the Academy's new name after 1930 — was envisaged by Pius XI. After a long period of study, before by Fr. Gianfranceschi and later by Fr. Gemelli, under the direct supervision of the Pope, the Academy was *renewed* on an international basis by papal *Motu proprio*, with the name of Pontificia Academia Scientiarum and the appointment of 70 new Academicians.

The present report begins from this point. It is divided in two parts. The first describes the chronology of the Academy in the scenario of the different events of this period: the Second World War, social changes, the emerging Third World, the impact of the scientific and technological progress on Society.

The second part is a brief summary of the various scientific topics debated in these years at the Academy in collaboration with scientists from all over the world. All the problems were examined in the spirit which governs the Academy, that is that science is the search for truth and also that science must operate for the benefit of humankind.

An Appendix offers some basic documents and data for the history of the Academy.

I am indebted to the chairpersons of the study weeks and working groups for preparing the summaries of the proceedings which were most useful for the preparation of the present report.

The gathering of all the data concerning fifty years of the Academy's activity and the following presentation were a rather complicated and difficult task. Therefore I apologize for any involuntary omission of facts or persons.

Rome, October 1986

G.B. MARINI-BETTÒLO

The Academy or the School of Athens by Raphael in the Vatican Palace.

In those people you will have recognised your oldest predecessors in the investigation of both matter and spirit (Pius XII, Discourse

PART I

THE ACTIVITY OF THE ACADEMY

1936 - 1986

THE EARLY DAYS

The *Motu proprio* of Pius XI, issued on the 28th October 1936 established the Pontifical Academy of Sciences. On the same day the Pope appointed seventy Academicians (1).

This event coincided with one of the most outstanding moments in the history of science. The knowledge of the physical laws and of the structure of the matter acquired through the studies of scientists in the early twenty years of our century: Planck, Einstein, Rutherford, Bohr, De Broglie, Heisenberg and Schrödinger laid the foundations for a series of extraordinary research, both on a theoretical and experimental level, which led to the discovery of the atom, of subatomic particles and their laws and thence to a new view of the material world, from the extremely small to the immensity of the Universe. New cosmological theories were developed in this period, astrophysics took on new dimensions, chemistry developed new dynamic concepts which made it possible to increase the knowledge of reaction mechanisms and paved the way for the preparation of new materials.

In the study of biological processes the morphological approach was gradually replaced by the biochemical one, which allowed the study of the reactions at molecular level, even if the techniques available were still insufficient to penetrate and explain the complex phenomena of life.

It was a time when the scientific results began to influence deeply modern society in all its activities. The applied sciences achieved extraordinary results in teletransmission; Marconi employed with success short and ultra short waves for long distance as well as for optical distance transmission. As for pharmacology we must remember the discovery of sulphonamides which made possible the defeat of bacterial diseases.

(1) See Appendix.

Structure and organization

All these tendencies were reflected in the structure of the new Academy. Its statute aimed at promoting mathematics, physics and natural sciences, but what is it that makes the Academy different from the Pontifical Academy of the New Lincei? In the statute, published in 1936, we can find the answer. The Pontifical Academy no longer depended on the authority of a "patron" Cardinal but on that of the Pope; the criterion adopted to appoint the Academicians was their high scientific value, their moral rectitude regardless of their religion and race. The candidates were appointed by the Pope after being elected by the Academicians from lists of three drawn up by the Academy Council. The Academy became international even if the number of Italian Academicians, former members of the Academy of the Nuovi Lincei, was still very large in 1936.

The Academy consists of three categories:

1) 70 Academicians for life;

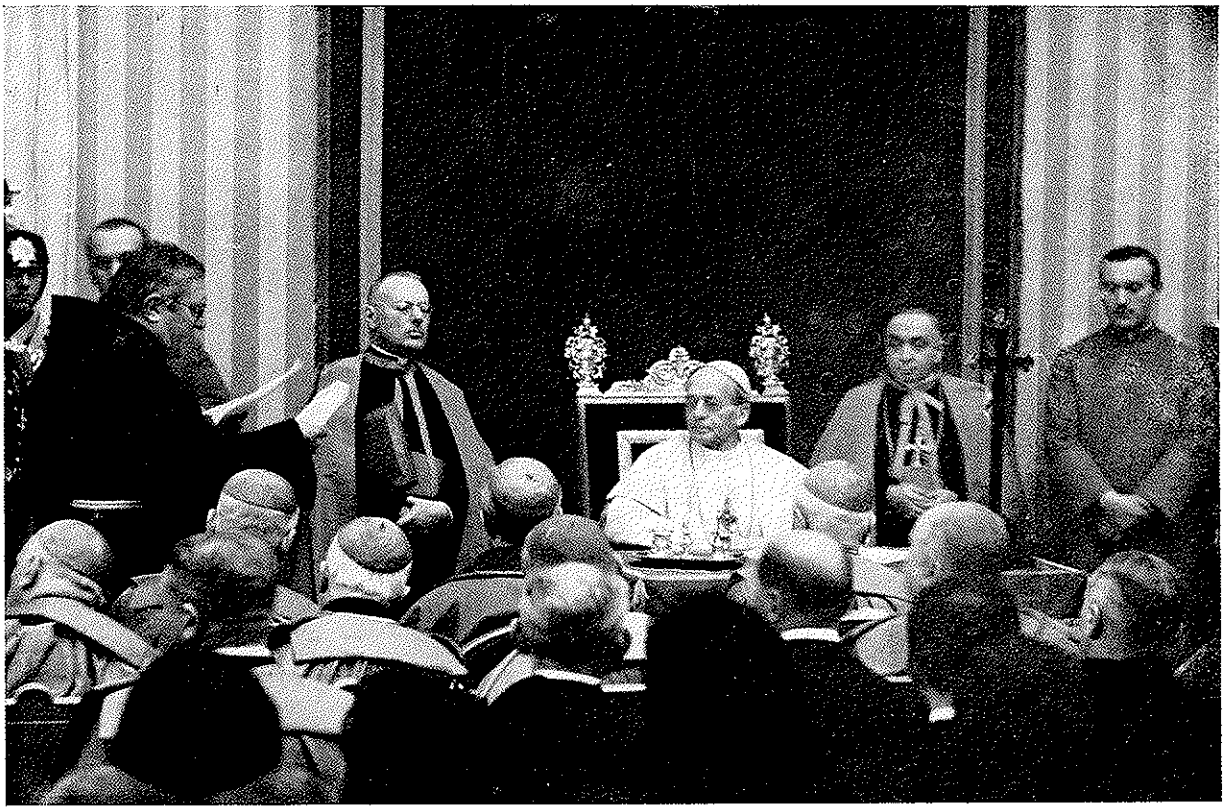
2) 5 Academicians for the term of their office: they are the Chief Librarian of the Vatican Library, the Prefect of the Secret Archives, the Director of the Astrophysics Laboratory, the Director of the Vatican Observatory and the Scientific Director of the Missionary Museum;

3) Honorary Academicians appointed among highly deserving personalities.

For its financing the Academy depends on the Holy See.

According to the Statute the Academy's management was entrusted to its President, assisted by the Academy Council. In these early days Father Agostino Gemelli, who was at the same time President of the Academy and Rector of the Catholic University of Sacro Cuore, was assisted by a Council formed by four Academicians and by the Chancellor, Prof. Pietro Salviucci. Through his office Pietro Salviucci guaranteed the activity of the Academy as far as the correspondence with its Members, the publishing of the records, the convocations of meetings, the relations with the Holy See and the contacts with the international academic world were concerned. The new Academy differs substantially in structure from the New Lincei Academy in terms of its activities because of its international character.

The foreign members were in fact 39 against 31 Italians and the Academy had to establish new rules for its management; it was no longer conceivable to hold frequent meetings in Rome for the few Academicians



Pius XI at the inauguration of the Plenary Session of the Academy during the address of the President, Father A. Gemelli.

who lived there; on the contrary it was necessary to find a way to enable the now international Academy to work efficiently according to the needs of all its members.

The residence of the Academy was the Casina Pio IV in the Vatican Gardens, already assigned in 1922 by Pope Pio XI to the Pontifical Academy of Sciences - Nuovi Lincei.

The Academicians appointed by Pius XI on October 28, 1936, were: Emil Abderhalden; Ugo Amaldi, Giuseppe Armellini, Charles Barrois, Emilio Bianchi, Georges David Birkoff, Vilhelm Friman Bjerkness, Niels Bohr, Marcello Boldrini, Filippo Bottazzi, Eduard Branly, Frederick J. Buytendiyk, Constantin Caratheodory, Alexis Carrel; Aldo Castellani, Gustavo Colonnetti, Gaetano Arturo Crocco, Lucien Cuénot, Giorgio Dal Piaz, Filippo De Filippi, Charles J. De la Vallée Poussin, Pieter J.W. Debye, Pierre Fauvel, Padre Agostino Gemelli, Father Ernesto Gherzi, Alessandro Ghigi, Gustave Gilson, Francesco Giordani, Giovanni Giorgi, Emil Godlewski, Giuseppe Gola, Ab. Victor Grégoire, Camillo Guidi, Bernardo Alberto Houssay, Wilhelmus Hendrikus Keesom, Giuseppe Lepri, Tullio Levi Civita, Luigi Lombardi, Paolo Luigioni, Guglielmo Marconi, Augusto Mendes Correa, Albert E. Michotte van den Berck, Robert A. Millikan, Thomas Hunt Morgan, Umberto Nobile, Adrian Karel Marie Noyons, Modesto Panetti, Nicola Parravano, Antonio Pensa, Ernst F. Petritsch, Emile Picard, Enrico Pistolesi, Max Planck, Franco Rasetti, Pietro Rondoni, Ernest Rutherford of Nelson, Erwin Schroedinger, Charles Sherrington, Filippo Silvestri, George Speri Sperti, Hugh Stott Taylor, Renato A. Toniolo, Armin Tschermak-Seysenegg, Giancarlo Vallauri, Francesco Vercelli, Vito Volterra, Edmund Whittaker, Peter Zeeman.

The biographies of these scientists, representing different disciplines and numerous countries all around the world, can be found in the Pontifical Academy's Yearbook ([2]).

Cardinal Gaetano Bisleti, Cardinal Francesco Marchetti Selvaggiani, Cardinal Eugenio Pacelli, Dr. Pietro De Sanctis and Prince Lodovico Chigi Albani were appointed Honorary Academicians.

Cardinal Anselmo Albareda, Father Aloys Gatterer of the Vatican Observatory, Mons. Angelo Mercati of the Vatican Secret Archives, Father Johan W. Stein of the Vatican Observatory and Father P. Wilhelm Schmidt of the Missionary Museum were appointed Academicians "perdurante munere".

([2]) Pontificia Academia, *Annuario 1936-1937*, Editio extra seriem.

Father Agostino Gemelli chairs Plenary Session; in the first row Mons. Albareda and Francesco Giordani.

Instead of holding many ordinary meetings, Father Agostino Gemelli together with Chancellor Pietro Salviucci suggested holding annual Plenary Sessions (which later became two-yearly) to which all Academicians should be invited to present and discuss their works, but above all to meet and to talk about the progress of science. Like all other Academies, the Pontifical Academy of Sciences publishes the reports of its activities, the contribution of its Members and the results of scientists presented by the Academicians. To this end, following a tradition already started by the Nuovi Lincei in 1936 the Academy published the *Acta Pontificiae Academiae Scientiarum* and later the *Commentationes*.

Aware of the importance of giving the renewed Academy functions and characteristics capable of distinguishing it from other national Scientific Academies, Father A. Gemelli asked for the opinions of some colleagues. The results of this first consultation were summarized in a circular of the 3rd September 1937 which requested all Academicians to give their suggestions.

A. Gemelli assumed in fact: "The aim of our Academy cannot and must not be only that of presenting and publishing scientific works, as it happens in most other Academies". Among the various proposals submitted to the Academicians there was that of inviting experts every year and to entrust them with the task of examining an actual and well-defined scientific question. He mentioned the possibility of collecting the results in a volume containing the ideas, doctrines and statements of those experts among whom there should be not only members of the Pontifical Academy but also external experts. Among the other possible activities there was that of bringing up-to-date scientific data in a wide-ranging synthesis and that of beginning an encyclopedic work giving a present-day picture of the scientific progress in all the sectors.

Nearly all Academicians sent suggestions and advice, most of which agreed on the benefits of gathering Academicians and Scholars every year to debate specific subjects.

The Academy's activity from 1937 to 1948

The Academy's opening session chaired by Father A. Gemelli took place on June 1st, 1937. The Cardinal Secretary of State Eugenio Pacelli took part in the meeting on behalf of Pope Pius XI who was slightly indisposed. 44 Pontifical Academicians were present ([3]). On that oc-

([3]) Acta, vol. I, n. 1, p. II (1937).

Father Agostino Gemelli, chairing a Session of the Academy and the Chancellor Pietro Salviucci.

casion Cardinal Pacelli remembered Pius XI's wish "to declare open this scientific senate conceived and created by him to foster the development of science and research".

The Cardinal thus concluded: "The Holy Father took great comfort in the institution or restitution, if you like, of this Academy to which you illustrious Academicians, give the highly desirable contribution of your reputation, your science and your works".

The opening of the second academic year took place in the presence of Pius XI in January 1938. 27 Pontifical Academicians besides the *perdurante munere* (4) were present at the meeting chaired by A. Gemelli. Vallauri, a member of the Academy, commemorated Guglielmo Marconi, whose death in July 1937 had left a great void in the world scientific community. At the end of the commemoration the Holy Father pointed out what the function of a scientist should be (5).

During the same year the Academy held two ordinary sessions in order to present some scientific works. The third Academic Year was opened in the presence of the Pope on December 18th of the same year, 1938. Twenty Academicians were present under the chairmanship of Father A. Gemelli (6).

Pius XI and the Pontifical Academy of Sciences

Nothing can express Pius XI's concept of science and scientists better than the *Motu proprio* "In multis solaciis" which establishes the new Academy. The reading of this fundamental document after 50 years shows the vital and prophetic inspiration which has given impulse and continuity to the Academy for half a century. In this document Pius XI pointed out the role played by the Pontifical Academicians in the progress of science, underlining their commitment in the search for truth.

The Pontiff reaffirmed what he had already expressed during the last session of the Academy of the New Lincei in 1936: "The Pontifical Academy represents the magisterium of Science beside the Magisterium of Faith, the Senate of Science beside the Senate of the Church". This extremely high opinion of science recurred in the speech of 1938, in which Pius XI entrusted scientists with the evangelical task of being *lux mundi*,

(4) Acta, vol. II, n. 1, p. II (1938).
(5) Acta, vol. II, n. 1, p. XXIV (1938).
(6) Acta, vol. III, n. 1, p. II e XVII (1939).

PONTIFICIA
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COMMENTATIONES

ANNO VI VOL. VI N. 22

FRANCESCO SEVERI

ULTERIORI SVILUPPI DELLA TEORIA DELLE SERIE DI EQUIVALENZA SULLE SUPERFICIE ALGEBRICHE

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

MDCCCCXXXXII

A paper by Francesco Severi printed in Commentationes during World War II.

the light of the world, a light which enlightens the world in its real progress. The Pope quoted the teaching of the Book of Wisdom: "He created all the things in *mensura, numero* et *pondere*", with measure, number and weight, an interpretative criterion of the structure of the physical world even for the scientists of today ([7]).

Pius XI died on February 10th, 1939; his pontificate was rich in events, the most important of which was the signature of the Lateran Treaty. Cardinal E. Pacelli, who took the name of Pius XII, succeeded him. His interest in scientific problems and the valid contribution he gave to the foundation of the Academy when Cardinal Secretary of State, made Pius XII a precious support for the Academy.

On January 18th, 1939 two new Academicians were appointed: the Irish physician A. Conway and the Italian mathematician E. Somigliana. Cardinals Luigi Maglione and Giuseppe Pizzardo were appointed Honorary Academicians.

Notwithstanding its international character, in the first years the Academy found it difficult to organize its activities on an international scale. The reason lay in the serious international political situation: the *Anschluss*, the occupation of the Sudeten territory, the creation of the Bohemia and Moravia protectorate by Germany had produced a precarious and unstable climate which led to World War II in Europe in September 1939. The first scientific meeting on the subject: "The problem of the age of the Universe" should have taken place in December 1939 as can be seen from the speech that Father Gemelli gave in the ordinary session on December 3rd, 1939 ([8]); the meeting could not be held because of the state of war in Europe. Agostino Gemelli hoped, however, to hold the meeting as soon as possible.

The subjects which had to be dealt with were: the movements of the stars, the energy radiated by stars and the consequent astral evolution, the recession velocity of the extragalactic nebulae, the radioactive and intra-atomic processes observed in meteorites and in the minerals of the Earth's crust.

Eminent astronomers, mainly from U.K., U.S.A., and Sweden had guaranteed their presence: among them we must remember H.N. Russel from Princeton (U.S.A.); J. Jeans from Dorking (England), F.A. Paneth from Durham (England), K.G. Malmquist from Stockholm (Sweden).

([7]) Scripta Varia, *65*, (1986).
([8]) Acta, IV, 1, XI e XX (1940).

PONTIFICIA
ACADEMIA
SCIENTIARVM

ACTA

ANNO IV VOL. IV N. 4

TULLIO LEVI-CIVITA

NOZIONE ADIMENSIONALE DI VORTICE E SUA APPLICAZIONE ALLE ONDE TROCOIDALI DI GERSTNER

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

MDCCCCXXXX

Title-page of the Acta of a note by Tullio Levi-Civita.

Some of the proposed topics were debated in the Study Week on Cosmology and Astrophysics years later. As a matter of fact the Academy's first Study Week was held in 1949.

In 1940 Father A. Gemelli presided at three Academic Sessions. The opening of the Academic Year took place in the presence of the Holy Father in February 1940 and on that occasion Pius XI was commemorated. Most of the 21 Academicians who attended the ceremony were Italian since Europe was at war ([9]).

On April 3rd the geographer Giotto Dainelli, the biologist Umberto Pierantoni and the mathematician Francesco Severi were appointed Academicians. In June 1940 Italy too entered the war. Because of the war in 1941 the Academic Year could not be solemnly opened as tradition required. In March there was an ordinary session chaired by the Academician Francesco Giordani ([10]).

During the session the Apostolic Brief, which conferred to the Pontifical Academicians the title of Excellency, was announced. On the same occasion works and reports were presented ([11]). It was also announced that for the period 1941-1944 members of the Academy Council would be: the Academicians Ugo Amaldi, Filippo Bottazzi, Francesco Giordani, Giuseppe Lepri and the supernumerary Academician P. Don Anselmo Albareda. In 1941 Alfred Ursprung and Antonio Cardoso Fontes were appointed Pontifical Academicians. The solemn opening of the VIth Academic Year took place in November 1941 in the presence of Pius XII, who gave on that occasion an important allocution on the position of man in the Universe and before God. Twenty-five Academicians, all of them Italian except for the Swiss Ursprung ([12]), were present. In the same Academic Year A. Gemelli chaired two ordinary sessions (on February 20th, 1942 and on June 6th, 1942, respectively) attended only by Italian or foreign Academicians living in Italy ([13]).

Eight new Academicians were appointed, namely G.B. Bonino, Dante De Blasi, José Garcia-Siñeriz, Corneille Jean-F. Heymans, Domenico Marotta, Gaetano Quagliarello, Leonida Tonelli and Leopold Ruzicka.

The VIIth Academic Year was opened in February 1943 by Pius XII

([9]) Acta, IV, 1, XXVIII (1940).
([10]) Acta, V, 1, I (1941).
([11]) Acta, V, 1, III (1941).
([12]) Acta, VI, 1, II (1942).
([13]) Acta, VI, 1, XXXXV (1942); VI, 1, LIX (1942).

1. Personalien und Lebenslauf.

Ich, Max Carl Ernst Ludwig Planck, bin geboren am 23. 4. 1858 in Kiel als Sohn des damaligen Professor des Rechts Wilhelm Planck und seiner Ehefrau Emma geb. Patzig. Im Jahre 1867 folgte mein Vater einem Ruf an die Universität München. Dort absolvierte ich 1874 das humanistische Maximiliansgymnasium und widmete mich dann dem Studium der Mathematik und Physik, zuerst 3 Jahre an der Universität München, dann 1 Jahr an der Universität Berlin. Nach München zurückgekehrt machte ich dort mit dem gewöhnlichen Gang der Dinge das übliche Lehrexamen, promovierte am 28. 6. 1879 mit einer Dissertation über den zweiten Hauptsatz der Wärmetheorie und habilitierte mich 1880 an der dortigen Universität für Physik, wo ich 5 Jahre lang als Privatdozent Vorlesungen über theoretische Physik abhielt. Im Herbst 1885 erhielt meine Berufung als Professor Extraordinarius an die Universität Kiel und im Anschluss daran die Gründung meines eigenen Hausstandes durch Verheiratung mit meiner Jugendfreundin Marie geb. Merck, die mir 4 gesunde Kinder schenkte.

Max Planck's autograph curriculum vitae from the Academy's Archives.

Nach dem Tode von Gustav Kirchhoff übertrug mir die Preussische Unterrichtsverwaltung an der neugegründeten Institut für Theoretische Physik in Berlin, Zunächst im Jahre 1889 als Extraordinarius, dann, 1892, als Ordinarius. Von der Preussischen Akademie der Wissenschaften wurde ich im Jahre 1894 zum ordentlichen Mitglied, im Jahre 1912 zum Beständigen Sekretär erwählt. Nach dem 1909 erfolgten Tode meiner Frau heiratete ich diese Nichte Marganthe geb. v. Hausbrand und zeugte mit ihr einen Sohn. Am 1. 10. 1926 wurde ich unter Ernennung zu Honorarprofessor von meinen amtlichen Verpflichtungen entbunden, und am 12. 7. 1930 erwählte mich die Kaiser-Wilhelm-Gesellschaft zur Förderung der Wissenschaft zu ihrem Präsidenten.

2, Akademische Beziehungen, wichtige Orden und Ehrenzeichen

Ehrendoktorate: Dr. phil. nat. (Frankfurt) Dr. rer. techn. (München) Dr. med. (Rostock) Dr. Ing. (Berlin) Dr. of sc. (Cambridge) Dr. phil. (Graz) Dr. of sc. (London)

Korrespondierendes Mitglied der Akademien der Wissenschaften München, Leipzig, Torino, auswärtiges Mitglied der Gesellschaft der Wissenschaften in Göttingen, der Akademien der Wissenschaften in Amsterdam, Rom, Washington, der Royal Society in London, ausländisches Mitglied der Gesellschaft der Wissenschaften in Kopenhagen, Lemberg, Stockholm, Athen, Upsala, Ehrenmitglied der Akademie der Wissenschaften in Wien, Leningrad, Dublin.

Max Planck's autograph curriculum vitae from the Academy's Archives.

Ehrenmitglied der Deutschen Physikalischen Gesellschaft, der Deutschen Chemischen Gesellschaft, der Bunsengesellschaft, der American Physical Society, der Cambridge Philosophical Society, der Physical Society of London, der Franklin Institute, Philadelphia, der American Philosophical Society.

Kanzler der Orden pour le mérite für Wissenschaften und Künste, Mitglied der bayrischen Maximilians-Orden, Inhaber der Adlerschilde der Kaiser. Nobelpreis für Physik (1919), zahlreiche Medaillen.

3. Veröffentlichungen.

Das Prinzip der Erhaltung der Energie, Leipzig, B. G. Teubner.
Vorlesungen über Thermodynamik, Berlin und Leipzig, Walter de Gruyter & Co.
Vorlesungen über die Theorie der Wärmestrahlung, Leipzig, Joh. Ambr. Barth.
Acht Vorlesungen über theoretische Physik, Leipzig, S. Hirzel.
Einführung in die theoretische Physik, 5 Bände. Leipzig, S. Hirzel.
Zeitschriften, mehrere Hundert Aufsätze und Broschüren.

Max Planck's autograph curriculum vitae from the Academy's Archives.

with 23 Academicians and 4 *perdurante munere* present ([14]). On that occasion the Holy Father addressed the Academy on the subject: "The Laws which rule the world". Two ordinary sessions, held in February and in June to present notes and works, concluded the activity of that Academic Year. Because of the events which followed the armistice of the 8th of September 1943, and above all because of the German occupation of Rome and the war on the Italian territory which continued until April 1945, the Academy's public activity was interrupted apart from the editorial activities, which continued with the publication of the *Acta* and of the *Commentationes*. The suspension of the Academy's public activities continued through the early post-war years — a period when everyone was doing what he could to get over the destruction of war by re-establishing moral activities in order to create work and new perspectives for humanity.

Most of the works published by the Academy in this first period (1937-1946) were by Italian Academicians: the studies of Pistolesi, Crocco and Nobile on aerodynamics, one of the avant-garde fields of those years, those of Colonnetti on construction science, those of Filippo Silvestri on entomology and of G.B. Bonino on spectrography. Notes of foreign Academicians were also published: that of Schroedinger (1937) ([15]) on quantum physics and that of M. Tibor (1937-1939) ([16]) on astronomical observations.

Mathematics and its applications occupied an important place in these publications to which distinguished mathematicians, such as Bompiani, Fantappiè, Giorgi, Miranda, Cattaneo and Colonnetti, gave their contributions. The works of a group of Jewish mathematicians, as Tullio Levi-Civita and Vito Volterra, which in those years could not be published because of the racial laws, were published in the *Commentationes* of the Pontifical Academy of Sciences.

Jewish scientists of other disciplines, whose works had not been accepted by the Italian journals, were given the chance of issuing them through the Academy: among them we remember Giuseppe Levi, Rita Levi-Montalcini, E. Foà and G.S. Coen. Even studies of many Italian scientists, which did not have the opportunity of being published during

([14]) Acta, VII, 1, II (1943).

([15]) Commentationes, II, 321-364 (1937).

([16]) Acta, I, 10, 85-92 (1937); Commentationes, II, 4, 175-205 (1938); Commentationes, III, 5, 93-140 (1938); Commentationes IV, 2, 21-82 (1939).

Pius XII, after the Audience, receives the President Father Gemelli and the other Academicians.

the hardest years of the war, because of the state of occupation in the country, were welcomed by the Academy. We must remember among them the studies of Arturo Miolati, Franco Rasetti, A. Giacomini, A. Stefanelli and U. Bordoni. Of particular interest and importance because of their later development were Marcello Boldrini's studies in the field of statistics, ranging from those on the history of the application of statistics to biology, those on Mendel's segregation of characters (1941) to those on the typical mean (1945).

In 1946, in reward for the discovery of penicillin which led to the use of antibiotics, Alexander Fleming was appointed Academician. The Academy's public activity began again in 1948. At the opening of the XIIth Academic Year Pius XII addressed the Assembly on the immutability of natural laws and the rule of the World. Out of 28 Academicians attending the Assembly, 7 were foreigners; the international community began to reorganize itself in order to resume its course... ([17]).

During the early post-war years, when not only Italy but all Europe were engaged in recovery and the exchange of the most commonly available scientific journals was virtually impossible, the Academy swiftly began to publish the most interesting results obtained in different fields of science. The task of issuing the "*Relationes de Auctis Scientiis*", as their publication was called, was given to Academicians and scientists of outstanding reputation. The publication played an essential role in helping former enemy nations to resume scientific contacts ([18]).

SCIENCE IN THE EARLY POST-WAR YEARS

From 1939 to 1949 all the countries at war had been engaged in the production of war materials, systems and arms to use without constraint in every part of the world, as in the case of Hiroshima. Science and its applications played an important role in this period: it is sufficient to remember the use of nuclear energy, the invention of radar and the production of long-range missiles. The most important war dis-

([17]) Acta, XII, I-XXIV (1948).
([18]) Editio extra seriem 1-645 (1946), edit. by P. Salviucci.

PIVS PP. XII

Ad perpetuam rei memoriam

Ad Apostolicae Sedis decus augendum serveriarumque disciplinarum scientiam honorandam, Motu proprio die duodevicesima octava mensis Octobris anno MCMXXXVI recol. mem. Decessor Noster Pius PP. XI "Pontificiam Academiam Scientiarum" in Civitate Nostra Vaticana constituit, atque etiam opportuna, quibus Coetus ipse regeretur, Statuta eidem tribuit. Nos autem, gravissimum sane munus considerantes perspicuis illis viris demandatum, qui ex omni loco et natione in praeclarum Coetum ipsum adlecti sunt, ut peculiari luculentoque Nostrae benevolentiae testimonio Pontificios de numero Academicos prosequamur, atque ita conspicua quoque eorum merita in optima scientiarum studia diligenda ac fovenda potioribus usque honoris significationibus publice honestentur, iisdem ex nunc titulum "Excellentiae" benigne concedimus, ita ut omnes et singuli de numero tantum Academiae Socii, non autem supranumerarii vel honorarii, tam in Actis ejusdem Academiae quam in communi humanae societatis ratione eodem "Excellentiae" titulo decorari debeant. Sed ad debitum etiam in omnibus ordinem recte servandum, statuimus quoque ut ob hujusmodi honoris titulum Academicos Pontificios, quibus conferetur, nullum "praecedentiae", quam vocant, jus tum in Hierarchia ecclesiastica tum in Aula Summi Pontificis sive ecclesiastica sive laicali competere possit; atque Academici, qui forte alicujus Ordinis vel Congregationis religiosae sint sodales, in sui ipsorum Institutis religiosis finibus memorato honoris titulo uti, frui illumve ab aliis exigere nequeant. Haec volumus, mandamus, decernentes praesentes Litteras rescque omnes in eis expressas semper ac perpetuo validas et efficaces existere et fore; suosque plenarios atque integros effectus sortiri debere; et ab omnibus ad quos spectat et spectabit inviolabiliter observari. Irritumque ex nunc et inane fieri si quidquam secus super his a quovis, auctoritate qualibet, scienter sive ignoranter contigerit attentari. Contrariis non obstantibus quibuslibet. Datum Romae, apud Sanctum Petrum, sub annulo Piscatoris, die XXV mensis Novembris, anno MCMXXXX, Pontificatus Nostri Secundo.

Mgr. Card. Maglione
a secretis Status

Brief by Pius XII establishing the title of Excellency for the Pontifical Academicians (25 November 1940).

coveries found, however, peaceful applications, as for instance: nuclear plants for energy production, launching systems to put satellites into orbit, extraordinary developments of electronics and telecommunications.

At the same time the research on the polymerization processes took a great step forward and new organic materials were developed to be used in countless fields from textile fibers to sewage systems, from prosthesis materials to containers.

Chemistry and pharmacology impelled by war conditions had rapidly broken the ground for antibiotics, bringing about a revolution in therapy. The eagerness for research, characteristic of these years, improved the choice of medicines available for preventing and treating a large number of diseases. New chemicals such as phosphoric esters and chlorinated derivatives, resulting partly from the conversion of war research, were employed in agriculture to protect crops from pests. The same products made possible the control of vectors of diseases, like malaria, which was defeated in Europe in those years thanks to the use of these pesticides. Biology recorded an increase in the research on the chemical mechanisms which regulate cell growth and development; great progress was made in the knowledge of nucleic acids.

Among drugs we must remember the realization of chemical synthesis in the field of vitamins and hormones, particularly steroidal hormones which gave medical therapy new chances thanks to the use of cortisone-anti-inflammatory drugs and of progestative, androgenic and estrogenic hormones. At the same time specific drugs for specific diseases, like tuberculosis, were discovered. Synthetic drugs, capable of interrupting neuromuscular transmission and therefore with muscle relaxing properties, revolutionized surgical techniques. Research on cosmic rays carried out by physicians in that period was made possible by the preparation of new highly sensitive photographic emulsions. In order to understand better the phenomena occurring among elementary particles the first acceleratory machines cyclotrons and betatrons were constructed — now regarded as the ancestors of those complex machines that today give us a great deal of information on the weak and strong interactions in the nucleus.

These scientific results had great social and economic consequences. The increase in life expectancy, which began in that period, was due above all to new drugs, hygiene and child welfare.

At the Academy Pietro Salviucci organized monothematic annual meetings, which had already been suggested in 1938 (see page 8)

could finally be held. During these meetings, which were called Study Weeks, Academicians and some of the most qualified scientists in the international scientific community met to discuss, with freedom of thought and speech and by means of objective debate, the most important and still unsolved aspects of problems belonging to different branches of Science (1). It was a new and original organization which had no connection with the Weeks of the New Lincei formerly organized on the basis of public lectures followed by debates. Because of the long war the first Study Week took place only 13 years after the foundation of the Academy.

In May 1948 the Spanish Professor in agricultural Science José Maria Albareda Herrera, the English astronomer Edward Victor Appleton, the Chilean biochemist Eduardo Cruz Coke, the Brazilian physiologist Aloysio de Castro, the Americans Edward A. Doisy biochemist and Herbert Sydney Langfeld psychologist were appointed Academicians.

THE ACADEMY'S ACTIVITY FROM 1949 TO 1959

With the Plenary Session held on June 7th, 1949, the Academy started its full activity again. At the same time the Academician Pietro Rondoni organized the first Study Week on the problem of cancer, which gathered scientists of different countries for the first time after the end of the war. The Plenary Session, in which 25 Pontifical Academicians took part, was opened by a short message of greeting from Pius XII.

In 1951 the Academician Vercelli organized the Study Week on microseisms attended by scientists from all the world. On that occasion Pius XII addressed the Assembly on the theme: "*The evidence of God in the light of modern Science*".

The Academy developed its activity in the publishing sector too. Many important articles were issued in the *Commentationes* and in 1942 appeared a new series of publications entitled "*Scripta Varia*" of the Study Weeks.

In the same period the Academy began to deal with problems concerning applied science starting with that of microelements in animals and

(1) See Regulations of the Study Weeks in Appendix.

plants, which was fundamental for the nutrition of plants and for the enzymatic processes in animal tissues. And in April 1955 in fact an important Study Week attended by scientists coming from every part of the world paid particular attention to the subject. At the same time the Plenary Session was held. This was the first Study Week on agricultural production. On that occasion Pius XII addressed the Academy on the problem of science in the modern world and the relation between science and philosophy. In 1954 Michael Schulien was appointed Academician *perdurante munere.* In 1955 the Academy, in order to be represented in the new emerging fields of science, appointed fourteen new Academicians: the Canadian discoverer of insulin Charles H. Best; the Scottish astrophysicist Herman Alexander Brück; the Uruguayan biologist Cesar Garcia Otero; the discoverer of nuclear fission Otto Hahn; the Nobel Laureate for his new model of the atom Werner Carl Heisenberg; the French Louis de Broglie Nobel Laureate for his contribution to quantum physics; Nobel Laureate Walter Hess, Swiss physiologist; the French Gaston Maurice Julia; the Swiss biologist Theodor Niehans; the Swedish physical-chemist Arne Tiselius who had won the Nobel Prize for his new techniques for the separation of proteins; the Finnish Nobel Laureate Artturi I. Virtanen for his research on vegetable biology, the Hungarian, naturalized American, Theodore von Karman for his research into aerodynamics; the German Max von Laue who was the first to study the chemical molecular structure by means of X-ray diffraction, and the Swiss mathematician Hermann Weyl.

The 1957 Study Week was devoted to astronomy and in particular to the problem of star constellations. It was a recognition of the great activity carried out by astronomer Academicians in the spirit of the ancient tradition of Castelgandolfo Observatory, the Specola Vaticana, and of the work of many Priest Scientists, who had given a remarkable contribution to science and to the development of astrophysics thanks to their observations.

During the audience on May 20, 1957, with the members Pius XII addressed the Academy for the last time (1). Pius XII died in fact on October 9th, 1958; Father Agostino Gemelli died a few months later on July 15th, 1959.

* * *

(1) *Discours du Saint-Père Pio XII à l'Academie Pontificale des Sciences* (20 mai 1957). Editio Extra seriem, 1-18 (1958).

Pius XII meets the Academicians after the audience on the occasion of the Plenary Session.

By appointing Father A. Gemelli President of the Pontifical Academy of Science, Pius XI knew he could rely on a worthwhile scientist, but above all he knew he could rely on a man whose main qualities were diligence and costancy in addition to that of success. The foundation and the development of the Catholic University of Sacro Cuore in Milan in an, if not hostile, at least skeptical milieu, were evidence of his executive capabilities.

Gemelli, who as a medical doctor had worked as Assistant together with Golgi, had continued his studies and research after entering the Franciscan Order of the Friars Minor and had become a famous phychologist in Italy, giving a great contribution to experimental psychology through his studies. To subject pilots of the recently established military aviation during the First World War to psychophysical tests and to structure psychosomatic and aeronautical medicine were both his ideas. Besides scientific results Father Gemelli always sought the benefit of mankind and applied new psychological techniques to identify aptitudes of industrial specialization to avoid accidents and to deepen personality studies.

He had a clear-cut idea of the unity which exists between Science and Faith; in 1951, while introducing the Academy and the participants in the Study Week on microseisms to the Pope, he stated: "There cannot be disagreement between Science and Faith because the truth is one and God himself reveals it to men in His infinite mercy through the knowledge of nature as well as through the study of man and his nature" (2).

More than an executor he was the interpreter of the Pope's instructions during the foundation of the Academy and during his twenty-year-administration. His personal ideas influenced both the Academy's organization and the Holy See's attitude toward it. His commitment to the development of his new creation, the Catholic University of Sacro Cuore, left him little time to devote to the Academy, but when difficult decisions or situations, especially during the war, required his advice he was always available.

Two famous Italian scientists, Francesco Giordani and Francesco Severi, cooperated with Father Gemelli as his councillors, backing his policy and running the Academy from 1943 to 1945 when Italy was split in two by the Allied and German Armies. Moreover Gemelli could always rely on Chancellor Pietro Salviucci's activity and presence. Since the

(2) Scripta Varia, 12, XXXVII (1952).

Pontifical Academy of the New Lincei Salviucci had devoted all his life to the Pontifical Academy of Science's growth and prosperity.

With his work and support Gemelli had laid the foundations for the new, or better, for the renewed, institution and when he died the Academy was already solid and established ([3]).

Pius XII's Magisterium

At a time when research was achieving extraordinary results on the structure of matter, on energy, cosmology, nature and on the function of cells, and new theories were rapidly developing to keep pace with scientific results, Pius XII's main concern was constantly to prove to the Academicians that there was no conflict between Science and Faith. During his pontificate from 1939 to 1957 he gave the Academy eight allocutions ([4]).

Pius XII's ideas on Science were very clear. Addressing the Academy in the Session of 1955 he said: "The duty of a scientist is to understand God's design, to interpret the Book of the Nature, to explain its contents and to draw from it consequences for the common good" ([5]).

The Pope's statement that the experimental method cannot be influenced by philosophical assumptions and that the autonomy of Science and of scientific interpretation is legitimate must be underlined. These words enlightened the Church in a field which had caused misunderstandings in the past, which had not yet completely vanished. Already in his first meeting with the Pontifical Academy of Sciences, Pius XII affirmed the freedom of scientific research: "To You noble champions of human arts and disciplines the Church acknowledges complete freedom in method and research..." ([6]).

This statement expressed a new vision of science, which Pius XII was to reaffirm in all the allocutions given during his Pontificate. Today it can be regarded as the synthesis of an important moment in the history of science and philosophy.

The secrets of the microcosm and macrocosm revealed by scientists

([3]) L'Académie Pontificale des Sciences en mémoire de son premier Président Agostino Gemelli à l'occasion du dixième anniversaire de sa mort; Scripta Varia, *34*, 1-268 (1970).
([4]) Scripta Varia, *65*, (1986).
([5]) Scripta Varia, *14*, XXIX-XXXVII (1956).
([6]) Acta, IV, X (1940).

were considered by the Pontiff as evidence of the Creation. To take into consideration only laws of statistics is a common error of our times; "such universal order is not and cannot be the result of absolute blind necessity nor even of fate or of chance ([7]) and scientists must look for a law which is established by the Mind that rules the Universe".

This was an anticipation of those points of view on the principle of casuality which was to be thoroughly developed in the 60s and put forward by some scientists as the only explanation for the Order of the whole Universe and of the origin of Life. When Pius XII got to know that the latest results of cosmological research hypothesized the existence of an initial event to explain the formation of the Universe, he said: "Creation in time and therefore a Creator and therefore God. Although still implicit and incomplete these are the words we wanted to hear from Science and that the present generation is waiting for" ([8]).

This speech had a great impact on the scientific world of the time and even today it is widely quoted in epistemology books either to accept or to deny its conclusions. It shows a renewed interest of the Church in scientific problems.

As regards scientific discoveries used as destructive weapons Pius XII, addressing the Pontifical Academy of Sciences in 1941, at the time when "the war tears the world to pieces and employs all available technological resources to destroy", reminded those present that in the hands of man science can become a double-edged weapon capable of curing and killing. In this period the Pontiff attentively followed "the incredible adventure of man involved in research into nuclear energy and nuclear transformations" through personal contacts with scientists and the reading of scientific works.

Already in 1943 referring to a speech on the progress of nuclear research submitted to him by the Pontifical Academician Max Planck, Pius XII thus addressed the Academy: "Although it is still unconceivable to take technical advantage of such an unforeseen achievement, it does break the ground for multitudes of possibilities which make the setting-up of uranium reactor no longer a utopia. It is, however, essential to prevent the process from taking place as an explosion because otherwise

([7]) Acta, VII, IV (1943).
([8]) Scripta Varia, *12*, XXXV (1952).

Mons. Montini meet the Council of the Academy (from the left: P. Salviucci, F. Severi, Mons. Montini, Fr. Gemelli, G. Quagliariello).

the consequence could be catastrophic not only in itself but for the whole Planet" ([9]).

Unfortunately the United States had already overcome the experimental stage and two years later the first nuclear bomb exploded over Hiroshima.

In 1948 Pius XII admitted sadly that nuclear energy had been employed for destruction and death: "The nuclear bomb, the most terrible weapon that the human mind has ever conceived". The tragedy of Hiroshima made him realize that a future conflict, to which science would give its contribution, would be fatal to the world: "What calamities a future conflict would hold in store for mankind, if it proved impossible to stop or slow down the use of every newer and sophisticated scientific invention" ([10]). And here comes the appeal: "We should mistrust the science whose main objective is not love".

He was not just thinking of nuclear weapons, but also of the whole arsenal of sophisticated systems, from missiles to chemical, biological and conventional weapons which are the result of the use and development of scientific research. However he did not want to give in and declared: "Each branch of science governed by Scientists worthy of the name and You in particular tends towards the realization of love for Your fellow-men" ([11]). Taken in itself each science leads to love — he said in Marconi's day — and added: "As regards practical applications, it shows for our fellow-men at whose service it places itself to provide them with every kind of good things" ([12]).

His concerns about nuclear energy as a war weapon increased especially after its use against Japan. For this reason he repeated that it is possible to make an immoral and barbaric use of the most beautiful achievements of science ([13]).

([9]) Acta, VII, IX.
([10]) Acta, XII, V-VI.
([11]) Pius XII's Discorsi, Tip. Vaticana, 9, 266 (1974).
([12]) Ibidem, 9, 263 (1947).
([13]) Ibidem, 9, 267 (1947).

SCIENCE AND TECHNOLOGY IN THE 60S.

Around 1960 extraordinary scientific and technological progress has to be recorded, such as the development of electronics and the conquest of space indicate.

The conquest of space is the result of a huge technological effort ranging from chemistry to the development of spacecraft materials to propellants, from applied mathematics to calculating satellites' routes, to telecommunication, computers and sensors of all kinds.

From the first *Soyuz* voyage in 1956 until the conquest of the moon with the Apollo mission in 1969 there has been a rapid succession of exceptional ventures which were followed live through audio-visual media, further evidence of the incredible advance of science and technology.

In electronics the realization of transistors and miniaturized computers allows new computers as wells industrial automation technologies.

All these technological achievements were made possible by the results reached in basic scientific research, such as the discovery of solid state properties. Increasingly sophisticated transistors were manufactured. This had a great effect on society and was held to be the main factor of the third industrial revolution.

While the first two industrial revolutions, based on the use of thermic and electric energy, permitted the reduction of manual labour and the development of large industry, electronics has freed the man from repetitive work and made possible industrial automation and remote control, spacecraft and missile guidance as well as telecontrol.

Although industrial automation freed workers from manual labour, at the same time it posed a series of social problems which were quite difficult to solve and which involved a slow and often difficult reconversion of labour.

The international conferences on the theme of "Atoms for Peace" showed new ways for the peaceful use of nuclear energy. By applying different principles and technologies new nuclear plants were designed to face the problems deriving from a total dependence on oil.

The extraordinary results achieved by science in almost all its branches are due to the discoveries of basic science; the knowledge of the information and transcription mechanisms of genetic codes, cell reproduction and memory are in fact the result of progress made in the

field of chemical and biological methodologies. In astrophysics new sensors such as radioastronomy paved the way for a new interpretation of the Universe. Satellites, the most advanced expression of modern technologies, on one hand break the ground for a better knowledge of our planetary system and on the other hand serve as observation points for collection of information about the Earth's resources.

If theoretical physics aimed at understanding the nature of inter-nuclear forces, experimental physics concentrated on the study of condensed states, preparing the way for the development of new materials.

Thanks to the progress recorded by plant genetics in India and in southern Asia a "green" revolution was undertaken to provide enough food for the populations.

Molecular biology and its extraordinary research on the gene, whose properties were by then interpreted in chemical and thus molecular terms, took the main share.

On the basis of scientific results new technologies developed, which were not always properly used. Badly regulated industrialization may jeopardize the environment and nature. It was science, therefore, that had to face these problems in order to protect citizens.

Although the discoveries of chemistry applied to industry were able to produce great economic benefits, they were equally capable of causing an environmental deterioration due to uncontrolled storage and discharge of wastes that polluted soil and water, causing damage to people, plants and things. In the same way nuclear energy, by bringing to mind memories of Hiroshima, which could not be completely wiped out, was opposed by many countries even in its peaceful utilizations.

A movement against science, which saw only the negative aspect of scientific progress and ignored the fact it had improved the standard of living such as the increase in life expectancy shows, took shape in these years in general public opinion.

THE ACADEMY FROM 1958 TO 1963

Cardinal Angelo Roncalli was elected Pontiff taking the name of John XXIII in 1958. But a number of months elapsed until later, on March 23rd, 1960, George Lemaître, member of the Academy since its foundation, was appointed President.

John XXIII meets the Academy after the pontifical audience in 1961.

Lemaître was born in Belgium, where he attended courses of physics and mathematics at the University of Louvain. After World War II, in which he had fought as a volunteer to defend his country from the German invasion, he took Holy Orders continuing however his studies and becoming Professor of physicomathematics at the University of Louvain.

Today Georges Lemaître, who was President of the Academy from 1960 to his death in 1966, is regarded as one of the most important scientific figures of our century. He undoubtedly left his mark on a period of the history not only of the Academy but also of modern science. In order to explain the beginning of the relationship time/space, in 1931 Lemaître put forward the hypothesis of a *singleness* which he called the positive Atom. This represented the basis for what is known as the "Big Bang" theory, according to which the beginning of the Universe is due to only one event.

Monsignor Lemaître always considered faith, religion and science as distinct sectors. His points of view were clear and explicit, as he wrote in one of his books: "I think that this theory must not be mixed up with metaphysical or religious questions. It leaves the materialist free to deny any supreme Being and to have the same attitude towards the notion of space and time which he has to events which occur in non-specific places in time/space. It does not include any familiarity with God on the part of the believer, which matches Isaiah's words when he spoke of the 'hidden God' even from the beginning of creation".

Lemaître's scientific approach was that of the search for truth. He said: "The most noble of human truths is the search for truth", a concept which often recurs in his writings. In all his works the distinction between Science and Faith is clear-cut; in his scientific publications, in fact, he never refers to problems of faith, and even less to the theories on Creation.

In those years not only did he go on with his studies and research, but also contributed to the development of the Academy's activity. Personally engaged in cosmological research he promoted a Study Week, in which he could not take part, the theme of which was the study of nature and the importance of cosmic radiation in particular.

The *Pius XI Gold Medal*, to be awarded to young scientists for scientific works of a high standard, was instituted on Lemaître's initiative during his chairmanship.

In 1961 the Pontifical Academy organized a Study Week on macro-

President Georges Lemaître

PONTIFICIA
ACADEMIA
SCIENTIARVM

IL PRESIDENTE

CITTÀ DEL VATICANO, *9. III. 1961.*

Excellence!

Le Souverain Pontife a institué une « Medaille d'or de l'Académie Pontificale des Sciences » qui portera le nom du Fondateur de l'Académie: Médaille Pie XI.

Le Conseil de l'Académie a decidé de couronner cette année, par cette Médaille, un savant rélativement jeune qui ait déjà atteint ou qui soit consideré comme étant susceptible d'atteindre bientôt une réputation internationale.

Nous vous demandons donc de nous proposer un candidat à ce Prix en tenant compte des conditions suivantes.

1) *qu'il soit d'une nationalité differente de la votre;*

2) *qu'il n'ait pas atteint au premier janvier* 1961 *l'age de quarante ans accomplis;*

3) *que vous l'estimiez être de classe internationale.*

Nous vous serions reconnaissants de nous faire parvenir les renseignements capables d'éclairer le jury.

Le Prix sera attribué par le Conseil de l'Académie qui se fera aider éventuellement par des spécialistes.

Les propositions seront reçus jusqu'au premier juin 1961.

Cette matière sera naturellement traitée confidentiellement. Seuls seront publiés les noms des Académiciens qui ont présenté le lauréat et les noms des personnalités auxquels le Conseil de l'Académie aurait éventuellement fait appel pour prendre sa décision.

Je vous remercie de votre précieuse collaboration et je Vous prie d'agréer, Excellence et cher Collègue, les sentiments de ma haute consideration.

LE PRESIDENT

Letter of President Lemaître announcing the establishment of the Pius XI Gold Medal.

molecules of biological interest and nucleoproteins in particular, which constitute the most important subject in science in these years, in order to explain the function of cells and their mechanisms of reproduction.

On that occasion John XXIII spoke to the participants of the cultural and educational mission carried on by the Church and recalled the role played by scientific progress in fulfilment of man's potential. On that occasion Professor R. Woodward of the Massachusetts Institute of Technology, who had carried out the synthesis of molecules of great biological interest, such as quinine and chlorophyl, by using avant-garde synthesis methods, was the first to be awarded the Pius XI Gold Medal (1).

In September of 1961, 19 new pontifical Academicians were named; they were: the Portuguese anthropologist A. De Almeida, the Australian physiologist Sir John Eccles who had won the Nobel Prize for physiology and medicine for his studies on the brain; the Brazilian biophysicist Carlos Chagas for his research on animal electricity and neuromuscular transmission; the Nobel Laureate for physics and one of the greatest scientists in our times P. A. M. Dirac; the British chemist Sir Cyril Hinshewood; the Swedish botanist S.O. Horstadius; the Austrian physicist Victor Hess, discoverer of cosmic radiation; the Peruvian physiologist Alberto Hurtado, the French physicist Louis Leprince-Ringuet; the Japanese chemist S.P. Mizushima; the Dutch astronomer J.K. Ort; the Nobel Laureate G.C. de Hevesy of the University of Stockholm for his research concerning the use of radio-isotopes in the study of biochemical reactions; the Italian professor of pharmaceutical chemistry at the University of Rome Giordano Giacomello, known for his crystallographic studies on compounds of biological interest, the biochemist E.J. Conway from the University of Dublin; the Indian physicist Sir Chandrasekhara Venkata Rahman, who had won the Nobel Prize for the discovery of the effect named after him; the British Nobel Prize-winner and discoverer of the neutron Sir James Chadwick; the theoretical physicist Manuel Sandoval-Vallarta of the University of Mexico; the Japanese theoretical physicist Hideki Yukawa Nobel Laureate for his theories on strong interactions (2).

With the appointments of these new members the Academy underwent a remarkable transformation. With the regulations of 1962 the

(1) *R. Woodward, Médaille d'or Pie XI-1961.* Editio extra seriem, 1-28 (1961).

(2) *Viginti doctorum virorum vitae et operum notitia.* Pontificia Academia Scientiarum. Edit. by P. Salviucci. *Editio extra seriem*, 1-180 (1961).

Study Weeks took on a particular character which distinguished them from other scientific congresses; their main target was that of debating those scientific subjects on which there was no agreement, in order to draw conclusions which later permitted to establish the best way to solve that problem.

The second Study Week on astronomy dealt with the problem of cosmic radiation in space and was held in 1962 on the occasion of the plenary session. The scientists of that time were fascinated by the subject and Mons. Lemaître himself spoke on the subject, demonstrating his great experience in the field. Welcoming Academicians and other scientists, the Pontiff awarded the Pius XI Gold Medal to the Swedish physiologist Bengt Andersson for his studies on thirst and hunger mechanisms ([3]).

* * *

John XXIII's teaching to the Pontifical Academy of Science is summed up in the allocution given at the Plenary Session and in the Study Week on the structure of macromolecules of biological interest. The Pope reaffirmed the position of the Church and its contribution to the development of culture ([4]): "Because of your different origins and because of the range of your interests you are a truthful reflection of the modern scientific world and proof of the complete harmony existing between the Church and Science".

John XXIII also recalled that science aims above all at the development of human character and at the glorification of God. "In fact far from fearing the most daring discoveries of men, the Church believes that any progress in the possession of truth entails an inner development and represents a step forward to the first Truth, the glorification of the Creation of God".

Pope John XXIII died in June 1963. The Conclave elected Cardinal G.B. Montini who became Pope taking the name of Paul VI.

* * *

Paul VI met the Academicians, gathered in plenary session under the chairmanship of Mons. Lemaître, and those participating in the Study Week on Econometrics for the first time in October 1963.

([3]) *Bengt Eric Andersson, Médaille d'or Pio XI-1962.* Editio extra seriem, 1-28 (1962).
([4]) Scripta Varia, *22* (1962).

Academician Mizushima addressing the Assembly during the Plenary Session in October 1962.

In his speech the Pontiff recalled Father Agostino Gemelli's activity and invited scientists to remain faithful to the law of Truth. While conferring the Pius XI Gold Medal on the Danish scientist Aage Bohr for his research on atomic structure, Paul VI made an earnest call for the abolition of nuclear weapons: "May this reward be a cordial invitation to all responsible people not to make science and in particular nuclear science a menace, nightmare, a weapon for the destruction of human life" ([5]).

In these years the Academy remarkably increased both publications and meetings. The Miscellanea Galileiana by Mons. Paschini, Professor of History at the Lateran University, was published in 1964. It represented an important contribution to our knowledge of such a significant period in the history of Science and was an objective reassessment of Galileo's works which paved the way for the review of the whole Galileo case and which was to culminate in John Paul II's speech of 1979.

This work, that Father Gemelli wanted to be published in 1942 on the third centenary of Galileo's death, appeared in 1964 in the Pontifical Academy's collection *Scripta Varia* edited by Father Lamalle S.J. The Vatican Council, held in the same year, referred to it explicitly in the Constitution "Gaudium and Spes" when it speaks of (n. 36); "the legitimate autonomy of science" ([6]).

In October 1964 the Academician Eccles organized a Study Week on a very delicate matter because of its philosophical and moral implications; the title of the debate was in fact: "Brain and conscious experience". In 1964 the French biologist François Gros was awarded the Pius XI Gold Medal for his studies on the mode of action of antibiotics. His appointment as Director of the Pasteur Institute of Paris won him further fame in the scientific community ([7]).

The Academy went on with its activities gaining an increasingly international character and dealing with problems of fundamental interest. The Study Week on molecular forces in 1966 was prepared and organized by the Academician and Nobel Prize-laureate for chemistry Debye but chaired by the Academician Mizushima since Debye had fallen seriously ill in the meantime. At the end of the Plenary Session Paul VI awarded the

([5]) Scripta Varia, *28* JERCL); *Aage Bohr, Médaille d'or Pie XI-1963.* Editio extra seriem, 1-24 (1963).

([6]) PASCHINI P., *Vita e opera di Galileo Galilei.* Scripta Varia, 27, I-II, 1-728 (1964).

([7]) *F. Gros, Médaille d'or Pio XI-1964.* Editio extra seriem, 1-32 (1964).

Pius XI Golden Medal awarded to Aage Bohr.

Pius XI Gold Medal to the astronomer Prof. Sandage for his basic research on the development of new techniques for establishing the distance between galaxies ([8]). On that occasion Paul VI pointed out the importance of scientific research and the mission of scientists.

The Pontifical Academicians named by Paul VI in 1964 were: the Irish astronomer and Director of the Vatican Observatory Father Daniel O'Connell; the Canadian Nobel Laureate for physics G. Herzberg, the French biologist P. Lépine of the Pasteur Institute of Paris; the Spanish organic chemist M. Lora-Tamayo; the American astronomer W.W. Morgan; the Pakistani chemist Salimuzzan Siddiqui; the Finnish geophysicist Heiskanen; the Dutch geophysicist Vening Meinsz; the French physical chemist Lecomte ([9]).

The Academy's international character became even more marked and its scientific fields as well as its sphere of action widened with the addition of the new specific disciplines of the single Academicians.

* * *

President Mons. Lemaître died on June 20th, 1966 but only on January 15th, 1968, Father Daniel O'Connell was appointed as his successor. The delay in the appointment was probably due to perplexities concerning a possible reorganization of the Pontifical Academies.

As Director of the Vatican Observatory and thus as Academician *perdurante munere* the Irish Jesuit Father Daniel O'Connell had already taken part in the Academy's activity and in 1964 he had been elected Academician for life.

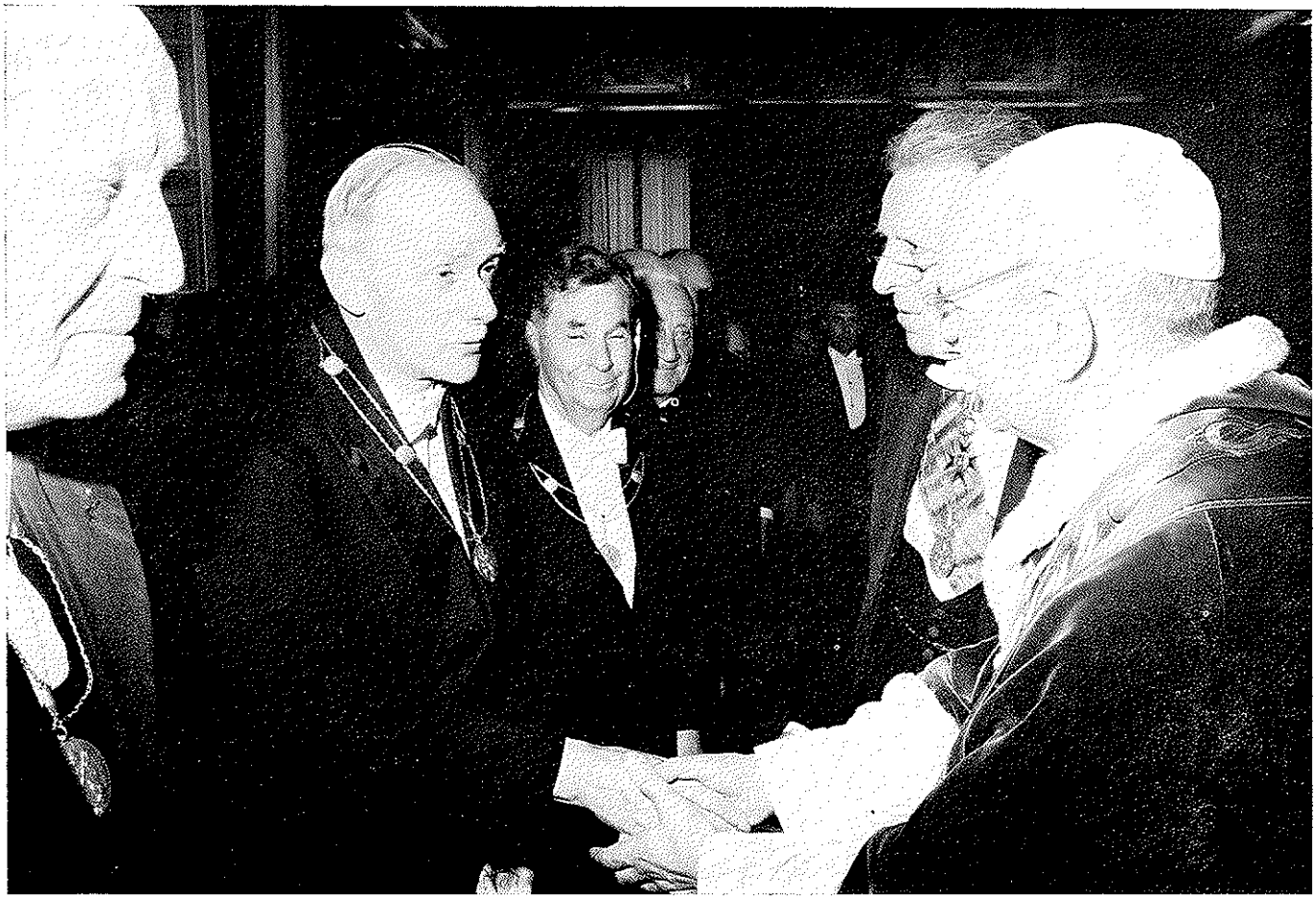
An astronomer of great merit and deeply involved in scientific research he had worked first in Ireland and then in Australia establishing friendly relationships with the most important contemporary astronomers, with whom he had cooperated in the preparation of the Star Atlas.

Shy and introvert by nature but at the same time tenacious, Father O'Connell succeeded Mons. Lemaître just when new horizons for science and technology were opening up especially as far as molecular biology, electronics and missile technology were concerned. The organization of the Study Week on astrophysics and on galaxies' nuclei was carried out

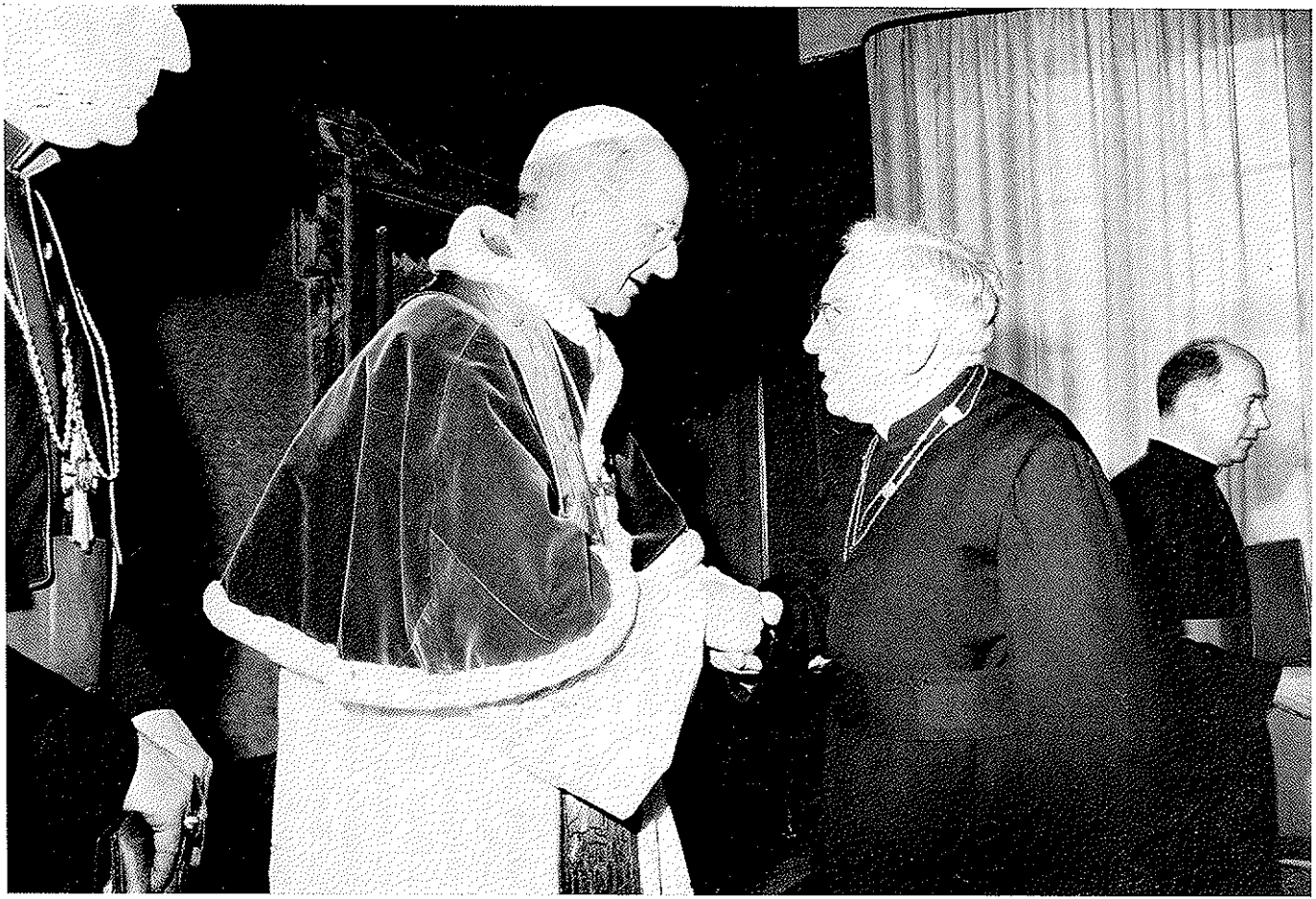
([8]) *Allan Rex Sandage, Médaille d'or Pie XI-1966*. Edition extra seriem, 1-32 (1966).

([9]) *Novem virorum vitae et operum notitia*, Pontificia Academia Scientiarum. Edit. by P. Salviucci. Editio extra seriem, 1-172 (1964).

Paul VI after the Audience meets the Academicians (15 April 1972).



Paul VI congratulates with P.A.M. Dirac on the occasion of his appointment to the Academy



Paul VI thanks President O'Connell after the Pontifical Audience (April 18th 1970).

thanks to his initiative and activity. As president and Member of the Council he worked very hard both in the Academy and in the Observatory giving an important contribution in terms of wisdom and science. He continued to see his colleagues to give them advice and suggestions, up to his last days even when a serious illness prevented him from taking part in the sessions.

* * *

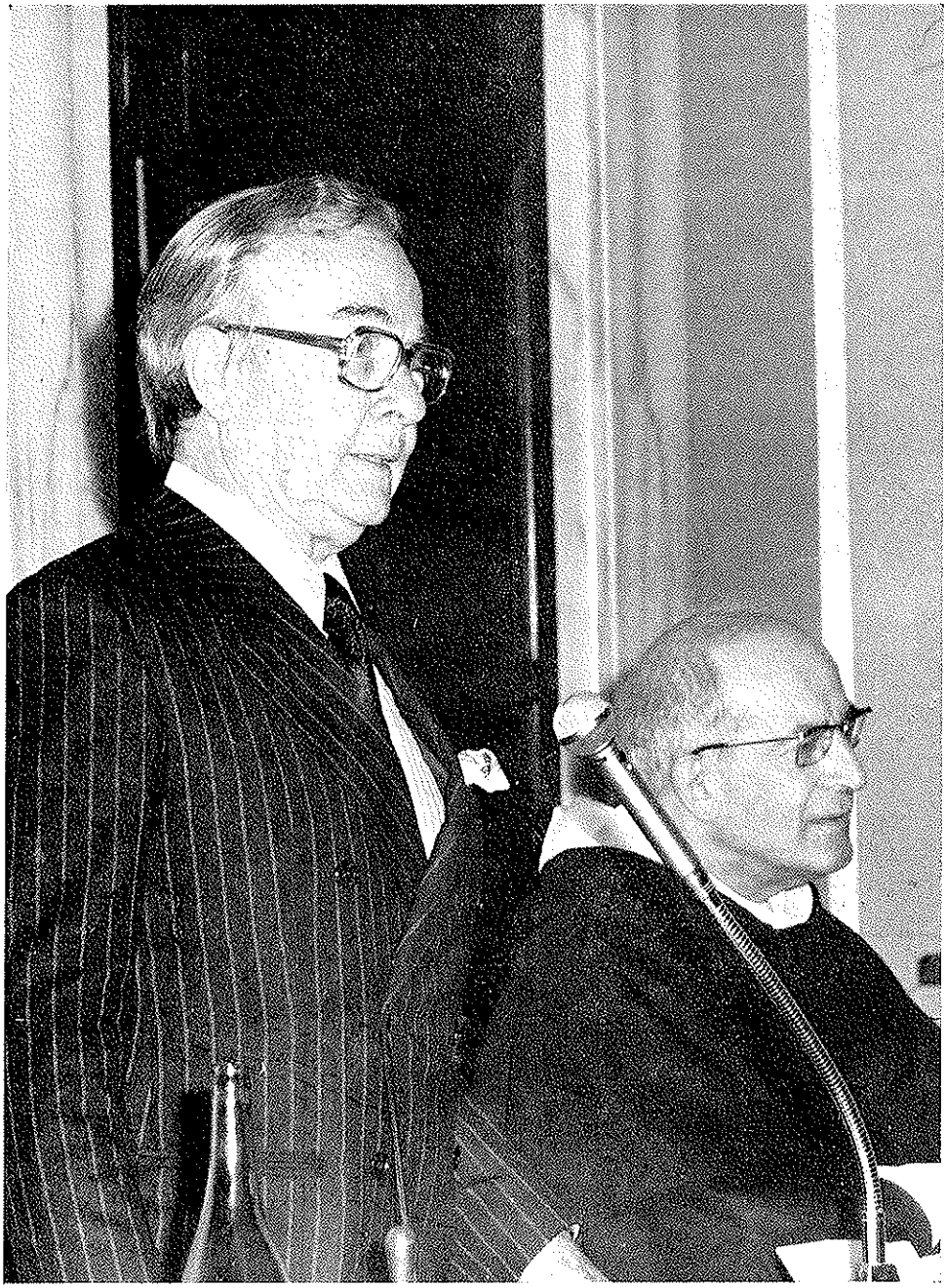
The Academy now held Plenary Sessions and Study Weeks every two years because of the difficulties in gathering scientists coming from all the continents more frequently. The Academy's composition had in fact completely changed with respect to that of its early days: out of 70 Academicians only 7 were Italian.

1967 was an important year in the history of the Church. The Encyclical "Populorum Progressio" focused attention once more on all those problems regarding the Third World and its development and urged aid and cooperation for the developing countries. This exhortation held good for the Academy as well: it was necessary to initiate forms of collaboration with scientists of the Third World at an international level. The Academy soon conformed to this policy: the members who came from those countries brought their problems and programs to the notice of the Academy.

In April 1968 the Plenary Session and the Study Week on the subject "*Organic matter and soil fertility*", chosen to continue the debate on how to apply science to agriculture production and thus solve the problems of hunger in the world, were held at the same time. During an audience granted to Academicians and other scientists Paul VI praised the attitude of the Church towards scientific research, at the same time its complete freedom of activity. He also appreciated the subject chosen by the Academicians for the Study Week, in that it proved how Science can serve mankind and especially the poorest countries.

In 1968 the Australian geologist Bullen; the English physiologist A.L. Hodgkin and the Argentinian Biochemist Luis Leloir, both Nobel Laureates; the Italian chemist G.B. Marini-Bettòlo; the eminent Polish mathematician Sierpinski and the English chemist A.R. Ubbelhode were named Academicians ([10]). The Study Week of 1970 was devoted

([10]) *Sex doctorum virorum vitae et operum notitia. Pontificia Academia Scientiarum.* Edit. by P. Salviucci. Editio extra seriem, 1-148 (1968).



President Carlos Chagas and Father Enrico di Rovasenda, Director of the Chancellery, during a Session of the Academy.

to a subject of basic science, astrophysics. Its title was: "The nuclei of Galaxies". In the Plenary Session held in April of the same year Paul VI awarded the Pius XI Gold Medal to the Japanese scientist Haruo Kanatani for his research in the field of sea biology ([11]). On that occasion the Holy Father spoke of the moment of contact between human reality and reality of the spirit, making specific mention of the outstanding achievement when man conquered a new dimension of the Universe by means of interplanetary exploration.

During the session the Academy welcomed its new members: the Belgian biologist De Duve, Laureate for his studies on cellular biology; the English malariologist P.C.C. Garnham; the German physicist and Nobel Laureate for physics Mössbauer; the Venezuelan biologist and epistemologist Marcel Roche; the Hungarian Nobel Laureate for biochemistry, A. Szent-György; the Austrian biochemist Hans Tuppy; the eminent Italian mathematician Mauro Picone; the English astronomer R. Stoneley; the French chemist G. Chaudron and the Director of the Vatican Observatory, the astronomer Father Treanor ([12]).

Science in the Seventies

As a consequence of the progress made in the various fields of chemistry (phase-separation, spectroscopic and X-ray diffraction analysis), as well as in physics and mathematics, many hitherto inaccessible problems began to be tackled in the area of biological macro-molecules, proteins and nucleic acids, in order to establish their three-dimensional structures, and at the same time making possible the interpretation of their working mechanisms and in particular their role in vital processes.

Thus the discipline of molecular biology came into being, characterized by its interdisciplinary nature which is the product of the concerted efforts of scientists of different academic formation, ranging from physicists to crystallographers, from cytologists to biochemists, from spectroscopists to immunologists and from geneticists to biologists. This discipline formed the basis for a rational knowledge of the major aspects of living organisms, both physiological and pathological. It laid the foundations for a rational approach to the control of diseases, such as tumours;

([11]) *Haruo Kanatani, Médaille d'or Pie XI-1970.* Editio extra seriem, 1-36 (1970).

([12]) *Duodecim doctorum virorum vitae et operum notitia.* Pontificia Academia Scientiarum. Edit. by P. Salviucci. Editio extra seriem, 1-190 (1970).

Plenary Session at the Academy: among others in the first row P. Dirac, H. Croxatto, R. Levi-Montalcini, S. Siddiqui; in the second:

a real revolution in the knowledge of the basic mechanisms governing molecular interactions and the consequent conformational and energy processes in animal and vegetable cells still under way.

The various methodologies involved cover our knowledge of all the living world, from bacteria to insects, from the animal to the vegetable kingdom. In this latter case the results of bio-synthetic research led to the creation, by means of genetic-engineering techniques, of new strains of micro-organisms capable of producing specific substances, such as Insulin.

* * *

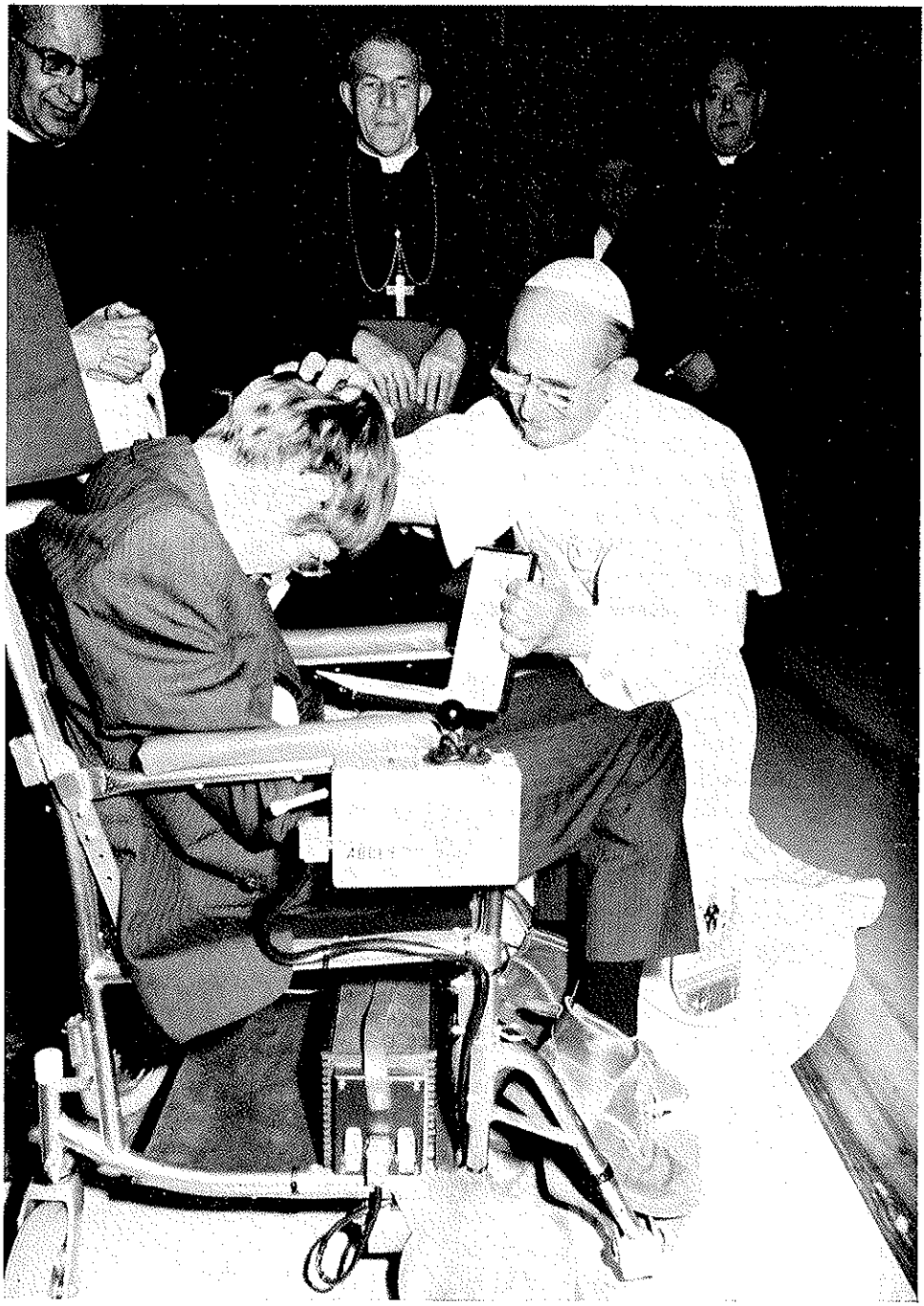
It was during this period that the Academy elected several outstanding scientists who had made important contributions to the development of the study of life, disciplines representing the traditional basic sciences: Physics, Chemistry, Mathematics, Biology, the Earth Sciences and Astronomy. Having at its disposal such high-ranking authorities, the Academy was in a position to make pronouncements on and contributions to advanced interdisciplinary fields. During this period scientific progress moved rapidly in several directions — e.g., the Physics of Condensed States which lies at the basis of modern electronics. New systems such as lasers were developed, our knowledge of subatomic particles increased and with it our understanding of Astrophysics. Physical Science brought new developments in Telecommunications (e.g., optical fibres), and in Computer Science.

By regularly electing new academicians, the Academy maintained its position at the forefront of scientific progress. In April 1972, on the occasion of the plenary session and the Study Week on Soil Fertilization, Paul VI received those attending and reminded them of the need to combat world hunger ([13]).

The Pius XI medal was conferred on the Hungarian chemist, George Nemethy in recognition of his research into the nature of intermolecular forces ([14]).

([13]) The plenary session, chaired by Father D. O'Connell was attended by 29 Academicians. Chaudron, Dirac, Herzberg and Roche gave plenary lectures. The Academicians Castellani, Ghigi, Houssay and Tiselius were commemorated and a number of scientific papers were presented.

([14]) *G. Nemethy, Médaille d'or Pie XI-1972.* Editio extra seriem, 1972.



Paul VI awards Pius XI Medal to Professor Stephen Hawking (April 19th, 1975).

THE ACADEMY'S ACTIVITIES IN THE YEARS 1972-1977

In 1972, on the occasion of the fourth anniversary of his presidency and in accordance with the new age-limits established by the Holy See for those holding Pontifical offices, Father O'Connell resigned his position, he was then appointed President Emeritus and life member of the Council.

The academician Carlos Chagas, the Brazilian biophysicist of outstanding international fame, was invited to succeed him.

This was the first time in the history of the Academy that a layman had been appointed President. Carlos Chagas' presidency also coincided with a decisive moment in the evolution of the Academy's task of elaborating its public image. All the western Academies belonged to an elite far removed from the public's power of understanding. Even the Pontifical Academy of Sciences shared this image in that it met only sporadically and addressed its activities in the field of promotion of the sciences to academic and university circles only.

Meanwhile in contemporary society the direct or indirect influence of science was making itself increasingly felt in daily life. At the same time the problems threatening human existence — the food problem, new energy needs for a growing world population, the risk of nuclear conflict, the profound revolution caused by the new electronic technologies, computer science, telematics — were becoming more and more urgent and produced the post industrial society which suffer from grave social and economic problems.

The urgent problems of the developing countries were calling out for immediate attention, and in particular on the part of scientists with the responsibility to guarantee social justice and peace in the world. In this connection, mention must be made of the heartfelt appeal made by Paul VI in his Encyclical *Populorum Progressio*.

It was this general context that made it imperative for the Pontifical Academy of Sciences to project a new image, bolstered by new aims. Its outstanding scientific prestige was no longer sufficient to meet the challenge presented by life in the modern world. A new solution needed to be found in order to solve the pressing and serious problems concerning information, research and initiative.

Carlos Chagas, who had already experienced in his own country those problems associated with development, poverty and the struggle

against endemic illnesses recognized that science had a fundamental rôle to play in social and economic growth as well as in the education of young specialists. Being an experienced scientist and researcher, with a profound knowledge of scientific and technological problems at an international level, and, thanks to the experience he had acquired in the United Nations, in particular as Secretary General in the organization of the first U.N. Conference on Science and Technology for Development, he had all the qualities needed to direct the Academy on its new course: to transform it into an active centre of interaction between the academicians and the international scientific community, capable of facing scientific problems and of applying the resulting solutions to the problems of the modern world.

Thus the Academy, guided by Carlos Chagas who interpreted the Pope's intentions, undertook the role of an Academy of action whilst at the same time preserving its prestige derived from the character and skills of its members who contributed to scientific progress in the world.

Another characteristic of this period was the growing involvement of the Academy in highly advanced sectors of scientific research, both by inviting new members to participate in its activities and by elaborating a long-term plan for organizing such activities. This trend was reflected in the new Statute (1).

In order to ensure that the Academy would continue on this course in the future, President Chagas suggested that *working groups* composed of a small number of academicians and experts should be formed and should meet regularly to study and deal with specific topics.

The present composition of the Academy had a profound effect determining the guidelines of the discussions held during the plenary sessions which touched on general interdisciplinary themes, as well as on problems of scientific policy such as the relationship between *Science and the Modern World*, and *Science and Peace*. As a result, many high level meetings were held, meetings of great interest to the international scientific community.

* * *

In 1974 Pietro Salviucci retired from his position, in accordance with the new age regulations, and Fr. Enrico de Rovasenda already Co-Director was appointed Director of the Chancellery. This exemplary and

(1) See Appendix.

highly cultured priest became the direct collaborator of the President on account of his scientific and philosophical knowledge as well as of his practical skills. He was also the Academy's internal coordinator and the right person qualified to maintain a link with the Holy See. With the assistance of his small but efficient staff of the Chancellery, Mrs. Michelle Porcelli and Silvio Devoto, he ensured the running of the Academy's various activities, and at the same time his knowledge and advice and wisdom were indispensable when facing problems containing ethical and moral aspects, as did many of those which increasingly attracted the Academy's attention during this period.

* * *

It would be impossible to write about the Pontifical Academy of Sciences without recalling the person and activities of Pietro Salviucci, the intelligent collaborator of all the Presidents from Fr. Gemelli to Carlos Chagas (in the first two years of his mandate), and the executor of the Academy's various activities and initiatives from its foundation up until the moment he left it. Salviucci had assisted Fr. Gianfranceschi, as Chancellor of the Pontifical Academy of Sciences - Nuovi Lincei during the period of renewal there, and afterwards during the period of organization of the new Academy.

During his office he gave solid and expert assistance to all the Presidents, maintained contacts with the academicians, and was the natural link with the Holy See.

His philosophical training, together with his basic grounding in mathematics, gave him great insight into scientific problems, and his critical spirit allowed him to move with ease in the various and disparate fields of activity of the Academy.

Being highly interested in Latin and the graphic arts, he took charge of the Academy's publications in a loving and competent way, taking great pride in his summaries of scientific works in the Latin language. During many years he was assisted in his tasks by his son Dr. Francesco Salviucci with great enthusiasm and capacity.

Pietro Salviucci was deeply attached to the Academy, which was his major and only passion in life, and it is thanks to him that the Academy was able to survive the difficult period of the Second World War.

It was he who proposed the original idea of Study Weeks as a means of finding a point of contact between the Academy and the world-wide scientific community; an idea which enjoyed, and still enjoys, great

success. The strict and rigorous way such meetings were conducted became an original model for scientific meetings with the special aim of solving current controversial problems. In Pietro Salviucci's view the Academy was to be above all, though not exclusively, an Academy of prestige — he did not accept the need to transform it into a dynamic forum and tool for the Holy See's activities in the scientific field, as the times seemed to suggest.

He was a profoundly religious man, with deeply held convictions which he tenaciously defended, sometimes in the face of opposition, in order to protect the work, dignity and position of the Academy. His contribution was fundamental in giving the renewed Academy character and style, in the line of the century-old tradition of the "Lincei".

* * *

In June 1974 the following were elected as academicians: the French biologist, Jérôme Lejeune; the neurobiologist, Rita Levi Montalcini, the Nobel Laureate Marshall Nirenberg (USA), and Severo Ochoa (USA, Spain), who made major contributions to our knowledge of the structure and mechanisms of DNA; Thomas Lambo, the Nigerian psychologist, Deputy Director of the World Health Organization and, finally, the English chemist, Sir George Porter, Nobel Laureate in Chemistry, for his fundamental work in the field of photochemistry ([2]).

The culmination of the Academy's public activities in 1974 was the solemn celebration of the centenary of the birth of Guglielmo Marconi, in the Synod room in the presence of Paul VI and various Cardinals, academicians and scientists. The Academician Marini-Bettòlo gave the commemorative lecture and the Holy Father pointed out how Marconi dedicated all his efforts as a scientist and as a Christian, to the benefit of mankind ([3]).

In 1975, at the same time as the plenary session ([4]), a Study Week

([2]) *Sex Doctorum virorum vitae et operum notitia.* Pontificia Academia Scientiarum. Editio extra seriem, 1-106 (1974).

([3]) Commentarii, III, 3, 1-44 (1975).

([4]) The plenary session of April 17-19th, 1975, was attended, under the chairmanship of Carlos Chagas, by 25 Academicians. Plenary lectures were given by S. Ochoa "Molecular basis of heredity and evolution" and by Professor Giampietro Puppi "Scientifical and technical aspects for the protection of Venice". James Chadwick was commemorated by P. Dirac, and D. Marotta by G.B. Marini-Bettòlo. The new Academicians presented themselves illustrating the main features of their scientific work.

was held on the subject of biological and artificial membranes and also on the purification of salt-water: a particularly important subject, given the scarcity of water in many areas of the globe and the need to apply new technology to purify salt-water for use in agriculture, as well as for human and livestock requirements.

During his reception of the academicians on April 19th, 1975, Paul VI conferred the Pius XI Gold Medal on the British physicist, Stephen William Hawking in recognition of his important contributions to our knowledge of the universe by means of his theory of "black holes": masses of invisible matter which are present in the universe ([5]).

* * *

In the period 1963-1975 the Academy was indirectly affected by a project of reorganization involving all the Pontifical Academies, with the intention of rendering them structurally and organically better suited to the needs of the Church and of the world.

The opinion of distinguished scholars given to the Holy See was that the number of Academies should be reduced and that the activities of those remaining should in some way be coordinated, by means of an office or of a coordinator.

This moment of uncertainty concerning the right course of action to take (and with direct consequences also for the future of the Pontifical Academy of Sciences) ([6]), in some respects limited progress and held up some important decisions, such as the appointment of O'Connell as President. (In fact the appointment came after an interval of almost two years).

In August 1975 Fr. Enrico di Rovasenda was given the task of making a critical evaluation of the material collected by the Holy See and also of putting forward concrete proposals concerning the matter.

Fr. di Rovasenda outlined the principles for the renewal of the Academies in a highly constructive document, at the same time pointing out that the Pontifical Academy of Sciences had already embarked upon a

([5]) *Stephen Hawking, Médaille d'or Pie XI-1975.* Editio extra seriem (1975).

([6]) The other academies were: the Roman Academy of St. Thomas Aquinas and Catholic Religion; the Pontifical Academy of Theology; the Pontifical Academy of the Immaculate Conception; the International Pontifical Marian Academy; the Liturgical Academy; The Pontifical Roman Academy of Archeology and the Pontificia Insigne Accademia dei Virtuosi al Pantheon.

programme of reorganization in a formal and juridical sense by means of a new Statute, whilst at the same time the initiatives introduced by the President, Chagas, in the scientific field not only put it at the forefront of this sector, but also among the most advanced academies in the world (7).

Fr. di Rovasenda's contribution clarified the Pontifical Academy of Sciences' position with regard to the Holy See once and for all, and at the same time made it possible for the President, Chagas, to pursue all those important initiatives such as the interdisciplinary approach of the problems associated with the modern world and the themes of Science and Peace, thus increasing the international fame and prestige of the Academy.

In December 1975 the following academicians were elected: Hector Croxatto, the Chilean physiologist; Georges Palade, an American of Roumanian extraction and Nobel Laureate for his contribution to our knowledge of biological ultrastructures; the British astrophysicist Sir Martin Ryle, the Israelian biochemist Michael Sela, Director of the Weizmann Institute of Rehovot; the American physicist of Austrian origin, Victor Weisskopf, former director of CERN (8). The new academicians gave the Academy itself the possibility of facing new areas in the fields of Biology, Physics and Energy Production with authority.

In 1976 a study week was held on the subject of natural products and their use in crop protection. The possibility of preventing diseases and insect infestations which considerably reduce agricultural production by the use of ecologically less dangerous means was explored. This theme was of central importance to scientific research on increasing world food production on the one hand, whilst on the other taking into account the growing sensitivity of public opinion to matters concerning protection of the environment.

The 1976 plenary session marked the beginning of a new Academy policy; rather than dealing with talks and the examination of specific research results furnished by academicians, the discussion focused on a common theme introduced by papers given by one or more members on the subject. The theme chosen for 1976 was "Science and the Contemporary World" (9).

(7) Archives of the Academy.

(8) *Septem Doctorum virorum vitae et operum notitia.* Pontificia Accademia delle Scienze. Editio extra seriem, 1-80 (1975).

(9) *Science and the Modern world.* Scripta Varia, 1-88 (1978). The plenary session on 20-23 October 1978 was attended by 17 Academicians under the presidency of Carlos Chagas. P. Dirac gave a lecture on the influence of Heisemberg on modern physics commemorating

On this occasion the Pius XI Gold Medal was conferred on Lucio Luzzatto, an Italian scientist, for his important genetic research on certain species of mosquitoes vectors of malaria which he carried out in Nigeria in collaboration with local scientists ([10]).

In his speech to the academicians Paul VI recalled the alliance linking religion and science: "the Church", he said, "needs you, your enthusiasm for research, your love for truth". The Pope encouraged the Academy to develop science and knowledge in the service of humanity.

In October 1977, at the Pope's specific request, taking into consideration the whole world's interest in the study and research into tumours, a Study Week was held on non-specific immunity in the prevention and treatment of tumours.

In March 1978 the Academy's wish for renewal was expressed through the appointment of fourteen new members: David Baltimore, the American biophysicist and Nobel Laureate; André Blanc-Lapierre, the French physicist; Aage Bohr, Danish Nobel Laureate, and already holder of the Pius XI Gold Medal; Giuseppe Colombo, the Italian mathematician; Johanna Döbereiner, a Brazilian of Czechoslovak origin, vegetable biologist; H.G. Khorana, the Indian chemist and Nobel Laureate for his research into nucleic acid synthesis; the New Zealand physiologist Albert Liley; the Italian physiologist, Giuseppe Moruzzi; the Brazilian geneticist Crodowaldo Pavan; the Italian physicist Giampietro Puppi, who developed his research on weak nuclear interaction; the American biophysicist, Alexander Rich, for his contribution to our knowledge of DNA structures; the American psychobiologist Roger Sperry; the Canadian chemist of Czechoslovak origin, Karel Wiesner, who proposed new stereospecific methods in organic syntheses. Fr. Coyne, Director of the Vatican Observatory, was appointed as an academician *perdurante munere* ([11]).

Paul VI died in August 1978 at Castelgandolfo. This great Pontiff, who undoubtedly left his mark on the history of the Church and of mankind, indicated the importance of adopting new social objectives to

the great scientist. Rita Levi-Montalcini and B. Strömgren gave lectures respectively on Neurobiology and the Expansion of Galaxies. On this occasion the first general discussion on a single argument was held, i.e., on Science and the Modern World. The lectures of M. Roche: Science's role in the contemporary world; of Leprince-Ringuet: The formation of the scientist; and of V. Weisskopf: The responsability of the Scientist.

([10]) *Lucio Luzzatto, Médaille d'or Pie XI-1976.* Editio extra seriem (1975).

([11]) *Quattuordecim Doctorum virorum vitae et operum notitia.* Pontificia Academia Scientiarum. Editio extra seriem. Biographis *8*, 1-104 (1978).

realize universal brotherhood among all peoples. In accordance with this worldview, he constantly helped the Academy in its efforts to use science for the good of mankind.

He was succeeded on the throne of Peter by Cardinal Albino Luciani, who took the name of John Paul I, and who died barely one month after his election. Notwithstanding these sad events and the consequent vacancies of the Holy See, the Academy continued with its activities and did not suspend the plenary session fixed for 1978. This session discussed once again the theme "Science and the Contemporary World" ([12]). An important working group was also held on the subject of "the Origin of Life".

When John Paul II was elected, the academicians were still gathered in the Casina of Pius IV. From there they went to St. Peter's Square to join the crowd acclaiming the new Pope.

Paul VI and the Pontifical Academy

Throughout his pontificate Paul VI had never failed to take an active interest in the Academy's activities and was always ready to give suggestions and advice. Moreover in the nine speeches he addressed to the Academy on various occasions we find the synthesis of his ideas. This material was collected and commented on by Fr. Enrico di Rovasenda ([13]).

Here we will recall those topics which in a special way served as guides and stimuli for the activities of the Academy.

In 1966, at the reception of the academicians and other scientists taking part in the Study Week on molecular forces, Paul VI reconfirmed the links which exist between man and science, and recalled that the Church recognizes and values the importance of scientific research, just as it admires and encourages the intellectual and organizational effort which are necessary to undertake such research.

In Paul VI's opinion, a scientist, because of his moral qualities and

([12]) *Science and the modern world Part II.* Scripta Varia, *49*, 1-148. In the plenary session 11-13 October, 1978, 34 Academicians gathered under the chairmanship of Carlos Chagas. The lectures were held by P. Dirac, on *The gravitational constant*, by Giuseppe Colombo on *Harmonies in the solar system* and by A. Rich on the *Function of t-RNA*. The second part of the Symposium on Science and the contemporary world took place on this occasion. *Reports on Scientific research and scientific policy* were presented by G.B. Marini-Bettòlo, M. Lora-Tamayo, and G. Herzberg. Lépine introduced the discussion on the main topic *Science et le monde contemporain* and V. Weisskopf on *The Limits of Science.*

([13]) *Paul VI: Teachings on Science and Technology.* Istituto Paolo VI, Brescia, 1986.

his devotion to his work is "an ascetic, and sometimes a hero" to whom the whole of humanity is indebted. But science alone is not sufficient in that it is not an end in itself: "*science can only exist thanks to man, and it is by man's intervention that it must break out of the mere world of research in order to reach out to man and therefore to society and to history itself*".

But after this acknowledgement he went on to put a question to scientists concerning the ethical norms which regulate the way science is to be applied.

He touched upon the ethical problems related to the use of science in fields such as genetics, biology, atomic energy, emphasizing the fact that a scientist cannot and must not avoid asking himself what the effects of his discoveries on the psycho-physiological nature of the human personality might be.

Paul VI expressed to scientists the beautiful concept of "*knowledge as charity*", reminding those who hold the key to advanced culture that there are a countless number of people who are rarely aware of more than scattered fragments of the vast field of human knowledge.

In 1972, at the audience granted to the academicians and scientists who had attended the Study Week on fertilizers, Paul VI gave another important speech ([14]).

Amongst other things, he mentioned the moment of contact between scientists and nature, underlining the risk of falling into a state of bewilderment in those cases where scientific results are not considered from a transcendent point of view. "Human intelligence is a spark which belongs to the absolute light which has no shadows". He went on to affirm: "whatever progress we make, whatever synthesis we achieve reveal a little more to us of the plan which governs the universal order of existence and the efforts of man humanity as a whole to make progress. *We are searching for a new humanism which is capable of allowing modern man to find himself again, by voluntarily accepting the higher values of love, friendship, prayer and contemplation*" (Populorum Progressio, n. 20).

Nor did Paul VI limit himself to quoting the above sentence of *Populorum Progressio*. Taking his inspiration from the efforts of scientists to increase soil fertility, he stressed the importance of the problems of world hunger and the absolute necessity for social justice.

([14]) Scripta Varia, *38*, (1973).

In his speech given in October 1976 whilst welcoming those taking part in the Study Week on *natural products and plant protection* he repeated his conviction that it is necessary to put science at the service of man: "Science tends to overcome those barriers which men themselves have set up; ...science encourages the development of a mentality which seeks open, sincere and respectful dialogue with whoever is involved in working for man's common destiny", emphasizing what an important means of reciprocal understanding and peace the research and activity of the Academy were ([15]).

SCIENCE IN THE EIGHTIES

The 80s marked a considerable widening in scientific horizons, in all fields of basic science. At the same time progress in research found an immediate echo in the field of advanced technology.

New scientific fields began to appear during this period, often as the result of a combination of particular methodologies and approaches typical of several disciplines, and whose characteristics they reflect, such as: Computer Science, Science of Materials, Bioengineering, Systems Science, Biotechnology and Ecological Sciences.

In the applied field we find the following examples: the construction of advanced computers — so-called artificial intelligence — the industrial production of hormones, such as human insulin, by means of special bacterial culture after inserting the appropriate genetic code in their genome; the development and improvement of telecommunications based on the physics of solid states and the construction of satellites of increasing sophistication; the creation of new materials endowed with exceptional qualities, ranging from resistance to high temperatures to the ability to modify electron or photon flows.

Physics, by means of theoretical and experimental studies of the forces at play in the nucleus, arrived at the discovery of W and Z particles, and made considerable headway both in exploring the inner secrets of the nucleus and in elaborating theories concerning the unification of weak interactions.

([15]) Scripta Varia, *41*, XXXV (1977) and *66*, (1986).

In the field of lasers new research opened up possibilities for extensive applications, ranging from energy transport and concentration, to chemical analysis, medical treatment, industrial use at all levels and finally also in computers.

Advances of this type have produced results which are so extraordinary that we probably do not yet appreciate fully their importance.

Recent progress in *Physics* has permitted us to widen our knowledge of the universe and its origin, in part through the possibility to record sub-atomic phenomena in space.

The science of materials, and in particular those fields connected with the development of advanced electronics, are the fruit of our theoretical knowledge of basic processes in fluid and solid states.

In the field of *Chemistry* — which ranges from the limits of molecular biology to those of spectroscopic methodologies used in examining organic molecules in the Cosmos — new fields have been opened such as the development of organic compounds with electro-conductive properties, or the study of biological macromolecules. Advances in photochemistry have made possible the synthesis of complex substances on the one hand, and on the other the use of solar energy. Large molecules have been discovered which are capable of carrying small active molecules through membranes or of helping them to react more easily, thus considerably improving the possibility in chemistry of creating co-ordinating compounds.

Life sciences in their modern form are based on morphological studies at a level of ultrastructures as well as on a new systematic based in part on chemical criteria. By making use of the advances in biology, physics and chemistry it has been possible to achieve exceedingly important results in establishing new methodological approaches in genetics, immunology, embryology, neurobiology and molecular biology which now allow us to face on a new basis such problems as cancer, the function of biological membranes, knowledge acquisition and behaviour in terms of brain activity.

This flourishing period in the sciences has brought about many practical advantages, and some of these pose ethical problems of some importance, such as fecundation *in vitro*, the artificial prolongation of life, organ transplants, etc.

Man is currently very close to being able to alter not only his appearance, but also his character. The possibility of curing genetic illnesses is becoming a reality, as is that of creating monsters by the same means.

The earth sciences have made great progress in recent years regard-

ing our knowledge of geological strata and the presence underground of renewable resources. More is now known about the dynamics of the great land masses, the oceans, the energy relationships between the earth and space, thanks in particular to chemical and physical research into the atmosphere and the ionosphere.

The ecological sciences, made up of biology, earth sciences, chemistry and physics and the science of system have by now reached the point of being able to interpret what happens in the biosphere and the other highly delicate balances which condition man's natural environment. Thanks to general and specific studies in this field we have recently begun to appreciate the nature of the dangers which will threaten human existence in the future if we continue to neglect our ecological micro- and macrosystems.

Mathematics, the exact science, science par excellence, which is the highest expression of human thought, went on to develop over this period new possibilities in the field of the calculation of probabilities, topology, and of combinatory analysis. The results of these studies will undoubtedly be of great use in interpreting many of the phenomena of life.

* * *

It may be true that such advances as those mentioned above have made man proud, tempting him to ignore certain basic precautions when using advanced technologies.

Most of what we can do now goes far beyond the limits of what even a few years ago was inconceivable.

Disasters like those of Bhopal, Challenger or Chernobyl, still recent and vivid in our memories, should remind us of the importance of the human factor in scientific development. We must not forget that man is at the same time the subject and the object of progress, and that progress itself should not destroy him.

Concluding these reflections on the development of science in the 80s, I would like to refer to the words addressed by Giuseppe Colombo to the Academy. This outstanding academician — who unfortunately died unexpectedly — expressed the concern of the modern scientist engaged in the search for truth: "Meanwhile, in its recurrent cycles, nature shows us the deep gaps in our knowledge. And, though we may build solid, and often impressive, bridges across these gaps, they usually bring us to even greater crevasses of ignorance. It is hard to proceed along this difficult trail, passing from euphoria to depression

and vice versa. However, we constantly move forward over these obstacles because of the unique prerogative of the human spirit. Call it anxiety or talent, obstinacy or skill, passion or cleverness, it may be the only prerogative which prompted the prophet to write: '*I prayed and prudence was given to me. I pleaded and the spirit of wisdom came to me. I preferred her to sceptre and throne, because all gold, in view of her, is a little sand... Yet, all good things together came to me along with it and countless riches at her hands*'" (1).

THE ACTIVITIES OF THE ACADEMY DURING THE PERIOD 1978-1986

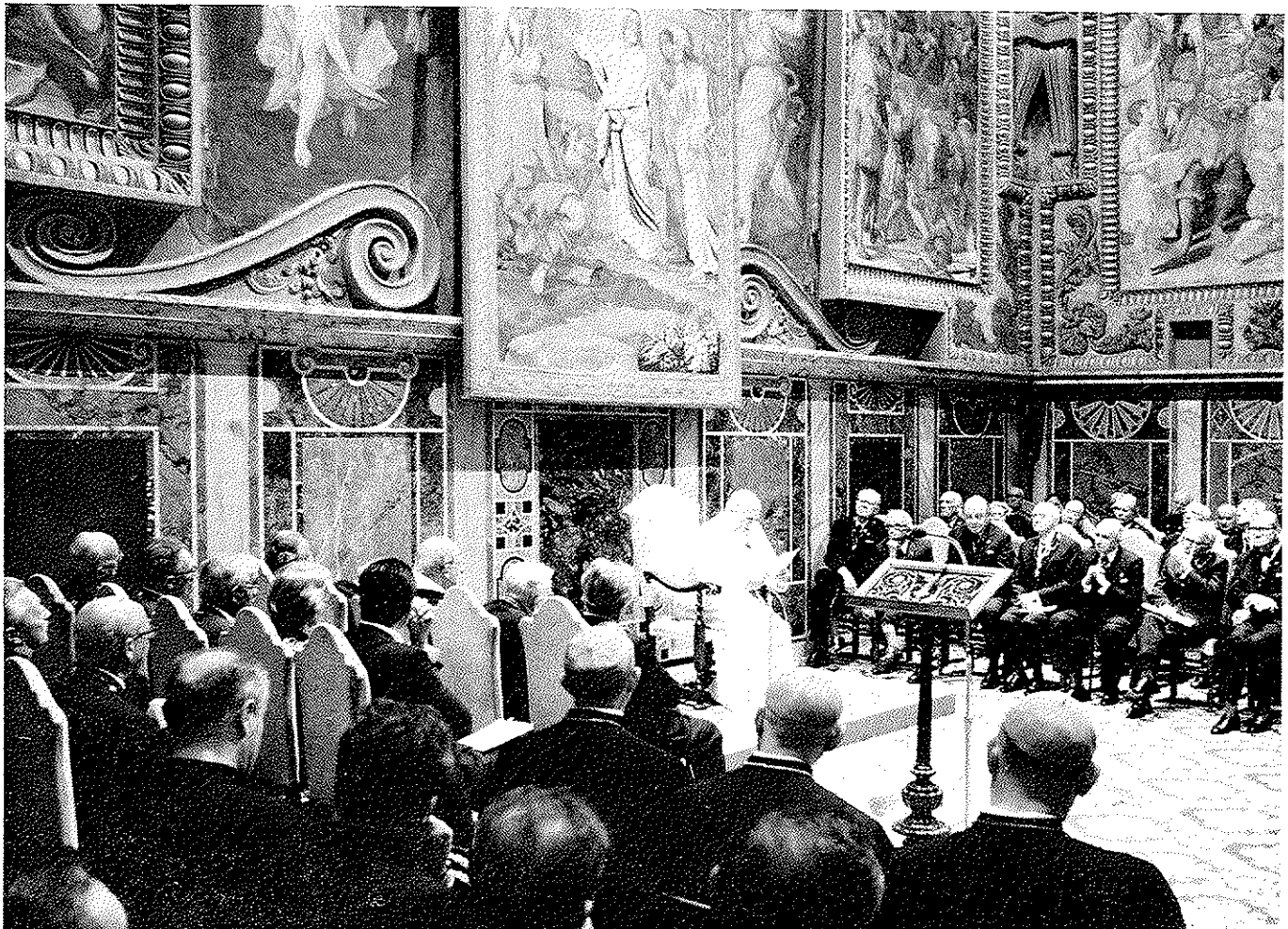
From his very first meetings with the President Carlos Chagas and with the Director of the Chancellery, Fr. Enrico di Rovasenda, John Paul II demonstrated great benevolence and interest towards the Pontifical Academy of Science, both as regards its activities and concerning its function as a bridge between the Church and the international scientific world.

The major themes of his Pontificate, as can be seen from his early speeches onwards, are those of working in the service of man and of peace, in harmony with the teaching of his predecessors.

In these times of amazing technological development science takes on an ever increasing importance, even for the Church, in that scientific research results have a primary rôle which influences the development of contemporary society and life as a whole, with all the ethical implications involved.

In order to realize a harmonious relationship between faith and morals on the one hand, and science on the other, it is vital that any remaining preconceptions on the part of the scientific world regarding the Church as obscurantist — after Galileo's trial and the consequent condemnation of a scientific theory — must be removed. Pius XI, Pius XII and Paul VI had often insisted that faith and science are not opposed, and this same idea was reaffirmed by the Second Vatican Council. Nevertheless, the image of Galileo, a devout Christian, continued to condition the relationship between the scientific community and the Church. To remove this

(1) G. Colombo, Commentarii, III, 27, (1980) and Scripta Varia, 52, 23 (1984).



John Paul II during his speech on Einstein and Galileo on November 10th, 1979.

misunderstanding he addressed an important speech the first time he met the Academy.

At the conclusion of the plenary session of November 1979 (1) during which the academicians had discussed the rôle of science in contemporary life (2), John Paul II met the academicians. There were scientists from all over the world who had come for the centenary celebrations of Einstein's birth. The commemoration was held in the presence of the Holy Father by the President, Carlos Chagas and by the academicians P. Dirac and V. Weisskopf. On this occasion John Paul II gave a speech in which he asserted that "fundamental research must be free from political and economic constraints so as to operate in a creative way without running the risk of being instrumentalized. Scientific truth, in fact, need justify itself to no one other than itself and the supreme truth, which is God Himself, Creator of all things and of man". He continued: "I take this opportunity of endorsing all that the Council said concerning the autonomy of science in terms of the search for the truth written in created things by the finger of God" (3).

Later, whilst referring to Galileo, the Pope recalled that "Galileo Galilei suffered very much — it cannot be denied — from men and structures belonging to the Church. The Second Vatican Council has admitted and deplored certain inopportune events". It was at this point that the Pope expressed the wish that "theologians, scientists and historians, working together in a sincere spirit of collaboration might re-examine the Galileo case, and where it is due, no matter what the conclusions, may succeed in removing those difficulties created even now by that episode which continues to condition the relationship between faith and science, between the Church and the world. Moreover", he said, "I guarantee my complete support to those who undertake this task which can only bring honour to the truth of faith and science and open the way for future collaboration".

At the end of the speech He paid tribute to the Academy's activities:

(1) The Plenary Session — 10-12th november, 1979, — was attended by 34 Academicians, under the chairmanship of Carlos Chagas. Beyond the celebration of Einstein's centenary the third part of the Symposium on Science and the modern world took place in these days. The following items were discussed: *Perspectives of the years 80* introduced by G. Colombo, B. Stromgren, R. Mossbauer, G.B. Marini-Bettòlo and J. Lejeune; L. Leprince-Ringuet spoke about the *Antiscientific movement* and C. Chagas, J. Dobereiner and H. Croxatto on *Science and development of the Third world.*

(2) *Science and the Modern world.* Part III. Scripta Varia, *52*, 1-209 (1984).

(3) *Einstein e Galileo.* Tip. Ed. Vaticana, 1980.

"The existence of this Pontifical Academy of Sciences, of which predecessor Galileo was a member, and which today boasts a large number of eminent scientists, chosen without ethnic or religious bias, is a visible sign for all people of the deep harmony which can exist between religious truth and scientific truth".

During the 80s the Academy continued with its official policy of promoting the sciences with particular regard for human progress.

During the Plenary Session of 1979 John Paul II conferred the Pius XI Gold Medal on the Brazilian scientist Antonio Paes de Carvalho for his outstanding work on cardiac physiology ([4]).

In 1980 the Academy held a study week approaching one of the most difficult themes which affect the future of mankind, energy. That the theme was complex is obvious from the title itself: "*Mankind and Energy: Needs, Resources and Hopes*". John Paul II received the participants and talked of this theme as one of the most serious problems that mankind has to face and solve.

The material and results of the study week were very interesting, also because of the data reported about possible resources of developing countries and their rôle in economic development.

In May 1981 the Academy got its new composition and image with the appointment of fourteen new academicians: A. Abragam, the French physicist; C. Anfinsen, the American biochemist and Nobel Laureate; W. Arber, the Swiss molecular biologist and Nobel Laureate for physiology and medicine; E. De Giorgi, Italian mathematician; M. Eigen, German physico-chemist; J. Lichnerowicz, the French mathematician; the Indian physicist M.G.K. Menon; the Kenyan entomologist Thomas Odhiambo; the French theoretical chemist, Bernard Pullman; the English chemist Max R. Perutz, Nobel Laureate; the British geophysicist, Stanley Runcorn; the Pakistani theoretical physicist, Abdus Salam, Nobel Laureate, and the Hungarian neurobiologist Janos Szentagothai ([5]).

In the same year Silvio Ranzi, professor emeritus of Zoology at the University of Milan, who had already been a member of the Pontifical Academy of Sciences - Nuovi Lincei, was appointed honorary academician.

In the same days the plenary session was held. The object of the

([4]) *A. Paes de Carvalho, Médaille d'or Pie XI-1979.* Editio extra seriem (1979).

([5]) *Vie et synthèse de l'oeuvre scientifique de 18 nouveaux Académiciens nommés par Jean Paul II de 1981 à 1983.* Biographies, *9* (1984).

discussion was *Biotechnologies and their impact on Society* (6). Pius XI Gold Medal was awarded to Prof. Jean Marie Lehn of the University of Strassbourg and of the Collège de France for his work on photochemistry and on coordination chemistry.

In 1981 the Academy held two working groups on, respectively: "*Immunity from parasitic disease*" (7) and "*The medical aspects of the consequences of a nuclear explosion*" (8), which emphasized the fact that modern medical structures would not be able to take care of the thousands of survivors of a nuclear attack.

At the same time a study week was held on the subject of: "*Cosmology and fundamental physics*". The Pope, addressing the participants of the study week and of the various working groups, spoke about man's interest in cosmogony and cosmology from ancient times on and emphasized that all the scientific hypotheses concerning the origin of the universe, even that of Lemaître concerning the primitive atom, leave open the question about the beginning of the universe, and went on to say: "What is necessary above all is the knowledge we obtain from revelation, together with that branch of human knowledge which is above physics and astrophysics and which we call metaphysics". There are some questions which science cannot answer because science itself has limits which it cannot transcend.

In 1982 the Polish mathematician Karol Borsuk was appointed academician, while Dr. Pietro Salviucci was appointed honorary academician in recognition for his services to the Academy.

* * *

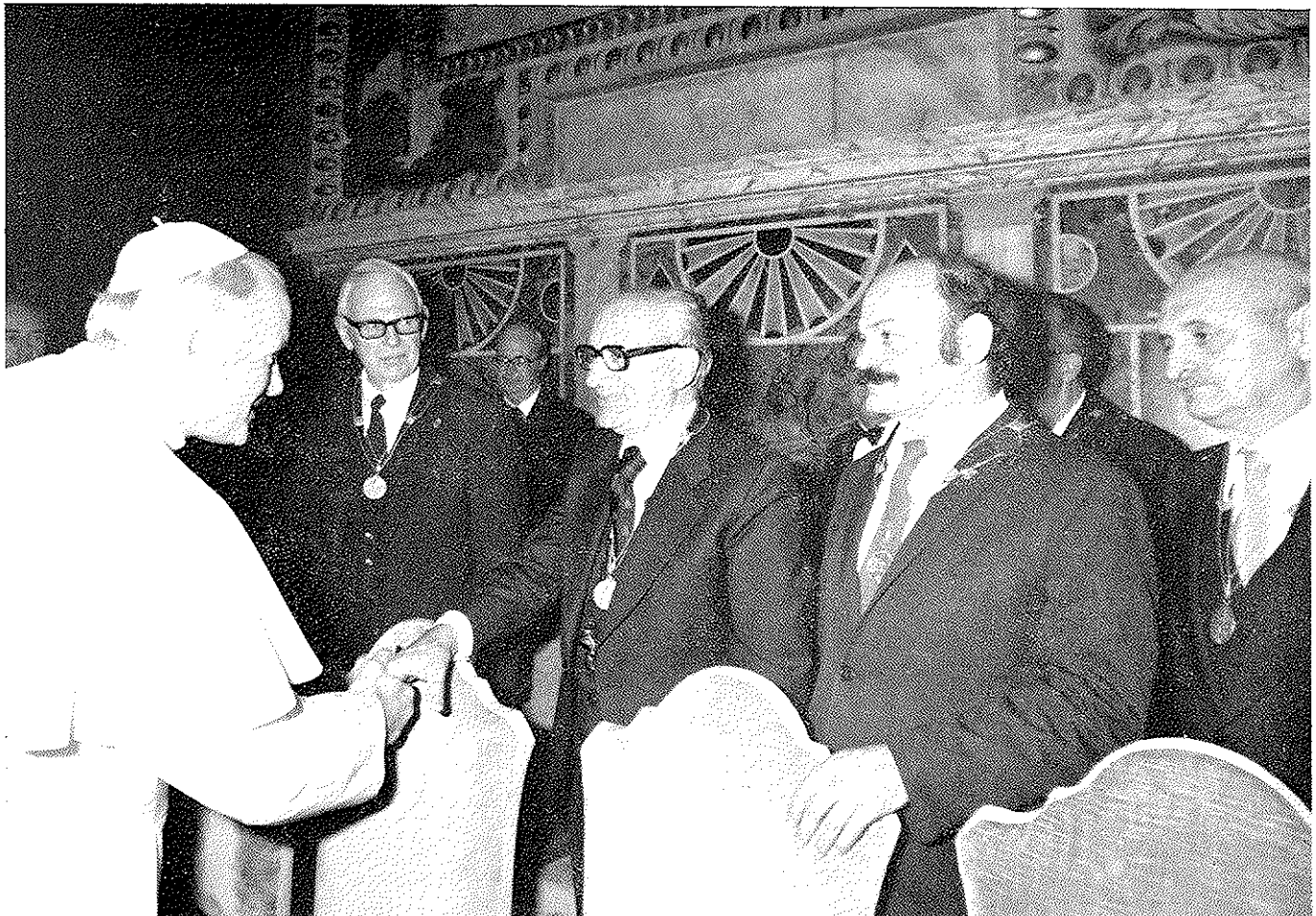
1982 was the year when the Academy found itself particularly involved in the discussion of Peace and how to reach it. On 24th/25th of September the Presidents or representatives of 52 Academies from all over the world met in the Academy's seat, the Casina Pio IV (9). These representatives met to discuss and approve a scientific document

(6) The plenary session was held on October 1981. 45 Academicians participated under the chairmanship of Carlos Chagas. On the topic of the discussion: *The effects of the molecular biology on Society*, many applications were discussed, in particular in the field of medicine (tumors), agriculture (production of plants with special characters) drug production with the use of genetically modified microorganisms.

(7) Scripta Varia, *47* b, 1-178 (1981).

(8) Documenta, *3* (1981).

(9) Documenta, *4* (1982).



John Paul II and Academicians Strömgren, Croxatto, Rich and Giuseppe Colombo after the Audience on November 10th 1979.

expressing the opinion of scientists on the dangers of a nuclear conflict, which, according to the information available, could lead to the destruction of humanity. The group therefore made an appeal to all governments to take a stand on the problem.

This meeting was of great significance and was closely followed both by the international scientific community and by widely-read scientific journals also in the States and in the Soviet Union.

This meeting marked the beginning of a new rôle for the Academy: it became the spokesman of the international scientific community in publicly advocating the dismantling of nuclear arsenals.

The regular activity of the Academy went on as normal. In October 1982 a study week on *biological experimentation* was held. This meeting examined in particular those new biological techniques which are used on man ([10]).

In 1983 various working groups met: in April the problem of *pattern recognition mechanisms* was discussed ([11]), in May the *optimization of the use of ionizing radiations* ([12]), and finally, in November the *specificity of biological interactions* was examined ([13]).

The Study Week held in November 1983 took a multidisciplinary approach to the problem of the effects of man's activities on the atmosphere. The chemical processes involved produce climatic changes, acid rain and modify the natural equilibrium of the Earth's surface which will seriously threaten the future of mankind ([14]).

The plenary session of the same year discussed the important and delicate theme "Science for Peace": many Academicians took part and gave their own contribution to the various reports and debates.

The themes of the discussions were the following:

1. Peace does not simply mean absence of war, but the creation of conditions to permit people to improve their situation: science can do much to achieve this objective by applying various new discoveries and specific research on the problems of the developing countries.

2. Science itself can form the basis for friendship among scientists

([10]) Scripta Varia, *51* (1982).
([11]) Scripta Varia, *54* (1983).
([12]) Documenta, *14* (1983).
([13]) Scripta Varia, *55* (1983).
([14]) Scripta Varia, *56* (1985).

all over the world by establishing mutual trust which is essential for understanding amongst the peoples ([15]).

Dr. Gerhard t'Hooft received on this occasion the Pius XI Gold Medal 1983 for his work in theoretical physics on elementary particles.

* * *

On 29th January 1984 the honorary academician Dr. Pietro Salviucci, formerly Chancellor of the Academy from its foundation until his retirement in 1974 for age reasons, died.

In January 1984 the following were elected Pontifical Academicians: the Polish mathematician Lojasiewicz, and the American physicist and Nobel Laureate for his contribution to the discovery of laser, C. Townes. In September Daniel Bekoe, a chemist from Ghana, W. Kalenga Malu, a nuclear physicist from Zaire and H. Umezawa, a Japanese biochemist were appointed ([16]).

In 1984 the Academy intensified its activities: a working group on "nuclear winter" ([17]) met in the month of January. Another group chaired by Chagas met in the same month, on the scientific and ethical problems of extracorporeal fecundation. In May a third group met to discuss "immunology, epidemiology and social aspects of leprosy" ([18]). This was followed by a study week on the subject "Energy for survival and development", in collaboration with ENEA. This meeting concentrated on the energy problems of the developing nations ([19]).

In October a Study week was held to evaluate the advantages to mankind of space exploration programs ([20]).

In May the following *perdurante munere* academicians were appointed: Fr. Leonard Boyle, Prefect of the Apostolic Vatican Library and Fr. Josef Metzler, Prefect of the Vatican Secret Archives.

([15]) The plenary session 12-14 november 1983 was attended by 39 Academicians and by special invited guests such as F. Mayor and L. Ernster. President Carlos Chagas introduced the discussion centered on the role of Science for Peace. This was also intended as the contribution of Science to the solution of the great challenges which hinder development: hunger and malnutrition, endemic diseases, industrialization of the tropical countries, etc.

([16]) *Vie et synthèse de l'oeuvre scientifique de trois nouveaux Académiciens nommés par Jean Paul II.* Biographies, *10* (1984).

([17]) Documenta, *11* (1984).

([18]) Documenta, *10* (1984).

([19]) Scripta Varia, *57* (1985).

([20]) Documenta, *13* (1984).

In 1984 the Academy, in collaboration with the Vatican Secret Archives published the critical edition, complete with introduction, of the documentation concerning Galileo's trial. This important historical and scientific document was specifically requested by John Paul II in his address to the Academy in 1979 when he asked that the events leading to Galileo's condemnation be re-examined ([21]).

In 1985 Ing. Father Renato Dardozzi was appointed as Co-Director of the Chancellery of the Academy.

In January 1985 a working group was held on the problem of arms in space. Academicians and scientists from all over the world took part. During this meeting much highly technical material was studied, including the plans for the American space defense programme, which are at present the centre of a sort of space competition, particularly between the superpowers. By unanimous decision of the participants it was decided to submit the document to the direct attention of the Pope.

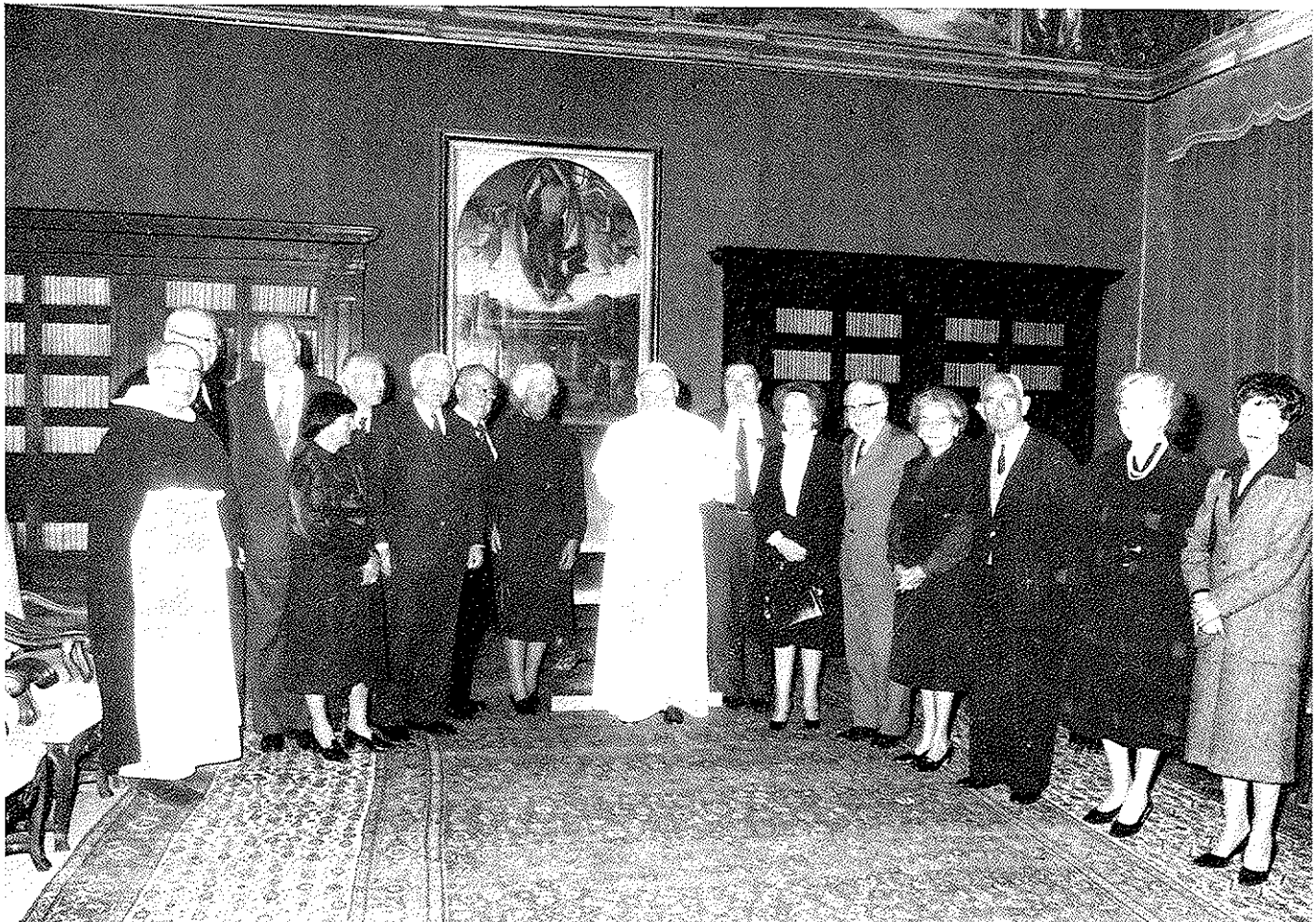
In June 1985 a working group was held to study the latest developments in "*Neurobiology in Mammals*", and in October on "*the artificial prolongation of life and determination of the moment of death*", a very topical subject for recent medical progress in reanimation techniques and the need for organ transplants. Another working group was also held in October on "Malnutrition and Parasitic Diseases", in an attempt to look for a solution to one of the most serious problems afflicting tropical countries.

In December 1985 the following academicians were appointed: Sune Bergstrøm, from Stockholm and Nobel Laureate for research into prostaglandin; Carlo Rubbia, Nobel Laureate for his research on basic W and Z particles; Kenichi Fukui, Nobel Laureate for theoretical and experimental contributions to our knowledge of chemical reactions; Vladimir Prelog, Nobel Laureate for his research in the field of organic chemistry; Kai Siegbahn, Nobel Laureate in physics for his studies of nuclear radiation, and Prof. Stephen W. Hawking of Cambridge, who had received the Pius XI Gold Medal in 1975 for his theories concerning the matter of the universe and in particular for his time-space theory and on the structure of "black holes" ([22]).

In January 1986 John Paul II approved the proposal of the Academy to raise the number of the Academician from 70 to 80.

In June 1986 a study week was held on the theme of remote sensing,

([21]) Scripta Varia, *53*, 1-280 (1984).
([22]) Biographies, *11*, (1986). Annuaire della Pontificia Accademia delle Scienze, 1986



John Paul II with the participants at the meeting on nuclear weapons control, with their families, in April 1980.

used to discuss the importance of satellites for finding renewable and non-renewable resources of particular interest to developing countries, and also for agricultural purposes.

Nine new academicians were appointed in the same month: Nicola Cabibbo, professor of theoretical physics at Roma Tor Vergata University; Albert Eschenmoser, professor of chemistry at the Federal Polytechnic of Zürich; Paul Germain, professor of mechanics at the Paris Polytechnic; Beatrice Mintz, a biologist from the Institute for Cancer Research in Philadelphia; Marcos Moshinski, professor of physics at the Free University of Mexico; Czeslaw Olech, director of the Institute of Mathematics of the Polish Academy of Science; John Polanyi, professor of chemistry at the University of Toronto; Maxine Singer, Director of the biochemical laboratory at the National Institute of Health of Bethseda (USA) and Walter Thirring, professor of physics at the University of Vienna ([23]).

In the June session the Academy Council proposed to award the Pius XI Gold Medal to Dr. Elizabeth A. Bernays, Professor of entomology at the University of California in Berkeley, for her important contributions to entomology and ecology.

On 6th June 1986 the Academy commemorated its origins in the "Lincei", in the presence of several Cardinals and scientists, on the occasion of the fourth centenary of the birth of Federico Cesi, the founder of the Lincei Academy. Fr. Enrico di Rovasenda gave a talk on the historical and cultural background of the founder of the Lincei, and the academician G.B. Marini-Bettòlo analyzed the scientific work of Federico Cesi, stressing how, as a result of the discovery of America, scientific thought in the 17th century began to concentrate on the direct observation of nature and physical phenomena, and therefore, on the experimental method itself ([24]).

Following this an exhibition was opened in the Apostolic Library, dedicated to Federico Cesi and the early Lincei, containing the works by Cesi and early Academy members and some letters written by Cesi and Galileo.

To complete the general cultural picture of the figure of Cesi also several volumes from his private library, together with botanical works about the New World of the period were exhibited ([25]).

([23]) Biographies, *12* (1986).

([24]) Scripta Varia, *63* (1986).

([25]) *Federico Cesi e i Primi Lincei. Catalogo della Mostra.* Pontificia Academia Scientiarum and Bibliotheca Apostolica Vaticana, 1986.

On the 28th October 1986, the fiftieth anniversary of the renewal of the Academy, which at that time assumed the title of Pontifical Academy of Sciences, there will be the plenary session of the Academy (27th - 30th October). Presidents of Scientific Academies which have links with the Pontifical Academy and important international scientific figures have been invited. The theme of this session will be "Scientific progress and the future of Mankind".

Notwithstanding the vast amount of work involved in the organization of the plenary session, other scientific meetings were held in the months of September and October 1986.

In September a Study Week was held on the physical factors which determine our climate, the teleconnections, a theme of great interest in meteorology and which consequently provoke drought or torrential rainfall over vast stretches of the earth, and in particular in tropical regions.

In October a working group was held on the molecular mechanisms of cancerogenesis and the anti-tumour activities by means of which certain chemical substances are capable of blocking the development of tumour cells at the DNA level.

The Teachings of John Paul II

John Paul II's interest in the Pontifical Academy of Science has shown itself in so many ways and on so many different occasions, both public and private, that the task of summarizing his teachings on the subject in an exhaustive way is virtually impossible.

Here we recall some of his speeches, all of which are of extremely high quality and interest, in which he encouraged the Academy in its activities.

At his first meeting with the Academy on the 10th November, 1979, on the occasion of the Commemoration of Albert Einstein, the Pope underlined the fundamental aim of science, the search for truth: "The aim of the basic sciences is the *search for truth*. Pure science is a good thing, and it deserves to be loved in its own right because it represents knowledge and therefore at the same time the perfection of man's intelligence. We should therefore honour science, even without taking into consideration the practical applications of science to human culture. Fundamental science is a universal good, that all the peoples of the earth have the right to pursue with the maximum freedom from intellectual or ideological conditioning. Also basic research should be free from

economic or political power, in fact economics and politics should support research in its work without interfering with its creativity or attempting to instrumentalize it in any way".

The Pope went on to recall the harmony which exists between science and faith. "The existence of this Pontifical Academy of Sciences, of which in its first establishment Galileo was a member, and which is now formed by scientists without any ethnical or religious discrimination, is a visible and high demonstration among Peoples of the harmony which can exist between the truth of science and the truth of faith".

One of the fields of interest of the Academy that the Pope insisted on in particular was the theme of "Science for Peace". While addressing the academicians who had gathered on the 12th November, 1983, for the plenary session on Science and Peace the Pope said: "Science, which brings together researchers, technicians, workmen, which stimulates political and economic power, which transforms society at all levels and in all its forms, this same science today has a task which is both vital and urgent, that of collaborating to preserve and re-establish Peace".

After recalling the speeches of his predecessors the Pope went on to say: "Unarmed prophets have been the object of derision in every age, especially on the part of shrewd politicians, the supporters of power. But today must not our civilization recognize that humanity has need of them? Should not they alone be heard by the whole of the world's scientific community, so that the laboratories and factories of death may give place to laboratories of life? The scientist can exercise his freedom to choose the field of his own research. When, in a particular historical situation, it is all but inevitable that a certain form of scientific research will be used for purposes of aggression, he must make a choice that will enable him to work for the good of people, for the building up of peace. By refusing certain fields of research, inevitably destined, in the concrete historical circumstances, for deadly purposes, the scientists of the whole world ought to be united in a common readiness to disarm science and to form a providential force for peace".

Another point which John Paul II mentions repeatedly is the need for scientific research and scientific applications to respect moral questions. This calls for scientists to exercise wisdom when making concrete use of their scientific discoveries.

The world-wide scientific community, as represented by the various Scientific Academies could be the instrument of science used for the construction of peace and development. This was what the Pope said on

John Paul II participates at the Plenary Session of the Academy on September 24th, 1982.

the occasion of the second centenary of the Italian Academy of Science known as the Forty: "It is the strictly scientific task of the Academies to advance the frontiers of science. But it is also their *social mission to respond to the questions and pleas of society.* It is their moral duty to carry out their activities at the service of humanity and of peace among peoples.

Particularly during the last hundred years, science has been one of the major factors of the development of society and of man's future. But often, the ever more sophisticated and deadly technology that has stemmed from science has been used against man, to the point of creating fearsome stockpiles of both conventional and nuclear arms, and of biological and chemical weapons, capable of destroying a large part of humanity".

"We hold that the Academies of Sciences, made up as they are of scientists of world fame and undoubted probity, as faithful disciples and seekers after truth, and in view of their independence and freedom of judgment, can give a *valid response to the doubts that assail the modern world.* With their knowledge and conscientiousness, they can likewise direct technology toward the true good of humanity".

"This duty of providing information and guidance for the public authorities and for public opinion proves that the Academies, while preserving their necessarily very selective structures, must not close themselves within the ivory tower of their private debates. They must be open to discussions, with the whole of humanity, on *the problems that assail people today* as they face the next millennium".

In this universal vision, John Paul II reminds the Academies and scientists in general of their obligations concerning the use of their scientific discoveries, saying: "Today more than ever, science must *contribute with all its power to true human progress* and it must banish the impending threat of the criminal use of its discoveries; therefore it is necessary that the scientific community, aware that science constitutes an essential element of human development, must watch over the correct use of the fruits of its research in the service of humanity" ([26]).

([26]) *Memorie di Scienze Fisiche e Naturali*, Rend. Accademia Nazionale delle Scienze detta dei XL, V, 7, (11) 33-36 (1985).

EXTRA-MURAL ACTIVITIES

The Holy See closely followed the Academy's activities, and the Popes have commented on and supported its actions.

The Academy played an important rôle in suggesting answers to questions presented to the Holy See by international organizations or individual scientists, not only at a technical scientific level, but also at an ethical-moral level. For example, for matters concerning desertification, water-supplies, the correct use of computers, the ethic of scientific research, the protection of workers exposed to ionizing radiations. Such a scientific support and assessment is often requested by Holy See observers working at the United Nations or in its agencies (UNESCO, FAO, OMS, etc.).

The Academy has also participated in many important international meetings in the person of its members or of the Director of the Chancellery.

Thus the Academy was represented in 1979 at the United Nations Conference on Science and Technology for Development in Vienna (UNCSTD) by the academician Marini-Bettòlo and by the Director of the Chancellery Fr. Enrico di Rovasenda. An important document was delivered on this occasion (1). Fr. Rovasenda also represented the Academy in the following meeting at Hamburg of the Forum Scientificorum (from Feb. 18th - March 2nd 1980) where international cooperation in various scientific fields was discussed.

At the invitation of the UNESCO the Academy sent a delegation composed of the President Carlos Chagas and the academicians Rita Levi-Montalcini, G.B. Marini-Bettòlo and Hans Tuppy to take part in the celebrations in Paris (2nd-4th June 1980) for the visit of John Paul II to the international organization. On this occasion the Pope in a speech underlined the responsibilities of science in the modern world (2).

Subsequently the Academy delegation took part in the work of the UNESCO consultative group on Peace, Human Rights and Development. Various world-famous figures were present, including several Nobel Peace Laureates. A document was drawn up which pointed out the injustice of

(1) Scripta Varia, *44*, 1-53 (1979).

(2) Discorsi di Giovanni Paolo II. *Discours de Sa Sainteté Jean Paul II à l'occasion de sa visite au Siège de l'UNESCO* (2 juin 1980).

misery in the world, reconfirmed the right to development and the need to respect human rights, even at the cost of limiting the powers of the State over the individual.

In June 1981 the Academy sent G.B. Marini-Bettòlo as its representative in the Holy See's delegation to the Science and Politics meeting in Helsinki, sponsored by the Council of Europe.

In 1982 (13th-17th Sept.) the academician Louis Leprince-Ringuet took part in the international conference in Vienna, under the auspices of AIEA on nuclear energy. This conference analyzed problems associated with nuclear energy production by nuclear plants taking into consideration various points of view, but in particular that of safety ([3]).

The academician Giampietro Puppi took part in 1983 in the meeting at the Orthodox Patriarchate in Moscow on the theme of the problems associated with peace in the capacity of representative of the Holy See. Another academician, G.B. Marini-Bettòlo took part in a round table on a similar theme (Development and Peace) in May 1986.

Furthermore, His Holiness John Paul II sent the academicians G.B. Marini-Bettòlo (1982 and 1985) and Jérôme Lejeune (1984) as his personal representatives to the funerals of the Soviet Leaders Breznev, Cernienko and Andropov.

Activities such as these, carried out at an international level, together with the participation in the nuclear weapons ban discussions in 1979 and after have greatly helped the Academy to form a new image.

During the last years, along with traditional scientific themes, the Academy proposed for consideration important instances where science could be applied as a solution to the important challenges posed by the modern world — and in particular, the problems posed by the developing countries to the industrialized nations. The Academy actively advocated nuclear arms reduction and world peace, at the same time promoting the study of the possible uses of space, new improvements in medicine, and the need to face many problems associated with bioethics. The surprising progress of modern biology which led to new possibilities concerning surgery at stages ranging from the gene to the embryo to the artificial prolongation of life meant not only that an objective evaluation of the situation was necessary, but also a deeper awareness of the delicate moral problems created by such scientific developments.

([3]) *Report on the International Conference on nuclear power experience.* Documenta, 7, (1982).

The importance of the documents produced by the Academy was recognized in the scientific world by several international organisms, as was the case with the conclusions of the study week on the subject of the use of space for peaceful aims. In fact the United Nations used these studies as a basic working document for its commissions which deal with this subject at an international level.

The work of the Study Weeks which deal with major themes of science and its applications from an interdisciplinary point of view was integrated by establishing Working Groups on limited and specific topics of great importance. In this view delicate and highly important questions were studied with great scientific accuracy; for example the biological evolution of primates and the origins of life on Earth.

Many publications of the Academy for their importance and interest have appeared in the last years in co-edition with important international publishing companies.

John Paul II in 1986 designated the Pontifical Academy of Sciences and in particular its President Professor Carlos Chagas to assess the Holy See in the procedures the dating of the Holy Shroud in Turin with the method of C^{14} determination, which is at present in course.

During these years the Academy has developed continuous relationships with all the main scientific Academies and Institutions of the World participating through delegates directly in meetings, celebrations or important scientific conferences and exchanging publications.

On the other hand delegates and delegations from other Academies were received at the Academy, as an example on the occasion of the Declaration on Nuclear War on September 1982, and at present October 1986 for the celebration of the Fifty years of the Academy.

An example of the prestige acquired by the Academy is represented by the fact that Academicians and scientists from many countries of Latin America, in a meeting at the seat of the Pontifical Academy of Sciences in September 1982, founded the Latin American Academy of Sciences, with an international character, inspired by the objectives and model of the Pontifical Academy of Sciences.

PART II

THE SCIENTIFIC ACTIVITY OF THE ACADEMY

INTRODUCTION

During the fifty years of its activity, the Pontifical Academy of Sciences has played an important role in the promotion of science in various fields.

An Academy of Sciences does not carry on scientific research — with the exception of the Academies of Sciences of the Socialist Republics, which have also functions that in other countries are those of the National Research Councils — but it promotes science and analyzes and evaluates its results, it plans new studies, it is a forum for discussion on inter-disciplinary questions, sometimes regarding ethical aspects and behavior. One might say that the Pontifical Academy of Sciences has exercised these functions by discussions in its Plenary Sessions, Study Weeks, Working Groups, and the publication of the relative Acts and Proceedings.

The first part of this report of the Academy's activities describes the Study Weeks which have taken place from 1949 to the present. This second part gives more detailed accounts of those Study Weeks, with a description of the aims, the subjects treated and the conclusions reached, thus giving a more complete idea of the Academy's role in the evolution of contemporary science and its contributions thereto.

Since 1972, there have been added to the Study Weeks, on the initiative of President Chagas, Working Groups to discuss scientific subjects of particular current interest.

One might ask how these Study Weeks and Working Groups differ from the thousands of scientific meetings held on all levels in all parts of the world. First is the fact that they take place in Vatican City — the symbol of universality — and that the results of these studies are transmitted to the hierarchy of the Church in order to promote, on a scientific basis, its worldwide mission on behalf of humanity.

Secondly, these meetings are held in tranquillity and freedom of discussion, without any attendants other than the participants, therefore without any fear of conditioning from the public or from the means of communication.

Third is the fact that the conclusions of these meetings are made

known to all of modern society through the Audiences and the speeches of the Pope, as well as the Academy's publications.

The Academy's activity has been not generic but inspired always by the belief that science must serve humankind. It follows that as one of its primary duties, the Academy must also face one of the most serious problems of the modern world, the fact that at least one-half of the population of the world is struggling to raise itself out of the state of underdevelopment, which means poverty, hunger and disease.

Therefore, besides its commitment to basic science, which is the necessary basis for any technological application, the Academy has treated topics of applied science. It has also dedicated itself to the field of ethics and epistemology. In these fifty years since its restoration, it has been active in five fields plus the history of Science. To which may be added another: the phase of its activity in the work for peace, which it has carried on in cooperating with the World Scientific Community.

1. Basic science;
2. Science and technology applied to global problems;
3. Science applied to the problems of the Third World;
4. Scientific policy;
5. Bio-ethics;
6. History of science.

It is necessary to point out that the opinions expressed with absolute freedom during the presentation of the papers and in the subsequent discussions by the participants of the Study Week and of the Working Groups — although published by the Academy — represent only the points of view of the participants and not those of the Academy.

Moreover when the Conclusions of the meetings are not agreed upon unanimously, they represent only the position of the participants but they do not imply the opinion of the Academy.

I

BASIC SCIENCE

INTRODUCTION

In its fifty years of activity the Academy has dealt with important topics of basic science, which in their time represented for the scientific community points of reference for the development of further research and study. The subjects studied during these years can be grouped as follows:

1. Cosmology and astrophysics;
2. Neurosciences;
3. The structure of matter;
4. The origin of life, and evolution;
5. The biochemical bases of biological processes;
6. Econometry.

The first group includes the Study Weeks on Stellar Populations (1957), on Cosmic Radiations in Interplanetary Space (1962), on Nuclei of Galaxies (1970), and finally Astrophysical Cosmology (1981).

The second group regarding research in the fields of basic science concerns the study of the central and peripheric nervous system. This began in 1964 with the meeting on "The Brain and Conscious Experience", followed by one on "Nerve Cells, Transmitters and Behaviour" in 1978 and the Working Group on "Pattern Recognition Mechanisms" in 1983.

There can also be included in this group the Working Group of 1980 on "Mental Deficiency", which dealt with the problem of retarded development of the brain of the child.

A third group studied the structure and function of certain molecules, such as macromolecules of biological interest (1961) and molecular forces (1966).

Two subjects which are still today the great questions of our origin — without an adequate solution from the scientists — are the Origin of life on earth and the Origin of Man. These were the subjects of two Working Groups held in 1978 and 1982, respectively.

This part devoted to basic science will also deal with modern methodologies, such as econometric methods for the planning of development as well as modern biological methods which have already made possible the extraordinary progress of modern biology in recent years.

COSMOLOGY AND ASTROPHYSICS

The interest in a knowledge of the universe, which has been the traditional field of study of the Astronomical Observatory of the Vatican, so closely connected with the Academy since the last century, when Father Angelo Secchi was President of the Academy of the New Lincei, was reflected in four Study Weeks from 1957 to 1982 which emphasized the most important discoveries and developments in recent years for an understanding of the universe.

The first of these meetings, chaired by Academician Father Daniel O'Connell and organized with the collaboration of Father P. Treanor, dealt with the problem of stellar populations. The most outstanding astronomers of the period, among them Baade and Hoyle ([1]), participated in this meeting, which was held in May 1957.

The problem under discussion was to find a way in our galaxy to differentiate between stars of spectral types O and B which are concentrated in a thin stratum around the plane of the galaxy (population I) and the globular clusters generally arranged in a system of spherical symmetry (population II).

This differentiation between the two populations was due to the results of the observations of Baade in 1943. Since then much research

([1]) O'Connell D. J. K., President of the Study Week; Treanor P., Scientific Secretary of the Study Week; Armellini G., Baade W., Blaauw A., Brück H. A., Chalonge D., Fowler W.A., Heckmann O., Herbig G.H., Hoyle F., Lemaître G., Lindblad B., Morgan W.W., Nassau J.J., Oort J.H., Salpeter E.E., Sandage A.R., Spitzer L. Jr., Schwarzschild M., Strömgren B., Thackeray A.

had been done on these phenomena, and the purpose of the Study Week was to compare and discuss the various results in order to learn more about the differences between the stellar populations as well as their origin and nature. The topics discussed were: the galaxies and their stellar populations; the stellar clusters of our galaxy as representatives of the stellar populations; the young stars of the population I in the spiral arms of our galaxy. Also: special types of stars; the evolution of stars and the abundance of the elements; the stellar populations of our galaxy and the evolution of our galaxy. Particular discussion concerned the importance of the evolution of the galaxies, the expansion of stellar associations; the determination of the masses of populations I and II and the relation between heavy elements and the age of the stars.

It can be said that even today after the enormous progress achieved in about thirty years of astronomy and astrophysics, the Proceedings of this Study Week constitute a point of reference of great interest ([2]).

Today a new problem arises regarding the star populations, and that is the existence of a non-luminous mass of an unknown nature, which constitutes the greater part of the galaxies.

The second Study Week in the field of Astrophysics was held five years later, in October 1962, to discuss the "Problem of Cosmic Radiations in Interplanetary Space" ([3]), with the participation of numerous scientists, under the chairmanship of G. Lemaître ([4]).

The availability of accelerators had assured, in the physical research on cosmic particles, complete independence from the astrophysical ones. However, the astrophysical aspect of cosmic radiation constituted even at that time an important field of research. The availability of such means as spacecraft equipped for measuring the bands of radiation surrounding the earth, which consist of particles of medium energy attracted by the magnetic field, in fact provided important new experimental data.

The principal questions which still must be answered, and which

([2]) *Le problème des populations stellaires.* « Scripta Varia », *16*, LXV-550 (1958); *Stellar Populations.* Edited by: D.J.K. O'Connell, S.J., North Holland Publishing Co., Amsterdam. Interscience Publishers, Inc., New York.

([3]) *Le problème du rayonnement cosmique dans l'espace interplanétaire* (original title).

([4]) Lemaître G., President of the Academy; Sandoval-Vallarta M., Scientific Organizer; Hess V. F., Amaldi E., Brück H.A., Bierman L., Bossy L., Denise J.F., De Voegelaere R., Elliot H., Escobar-Vallejo I., Forbush S.E., Gherzi E., Gold T., Hayakawa S., Leprince-Ringuet L., Neher H.V., Ney E.P., Oort J.H., Parker E.N., Peters B., Ray E.C., Rossi B.B., Simpson J.A., Singer F.

were the subject of the 1962 Study Week, were the determination of the solar components — inside and outside the galaxy — of cosmic radiation, and the criteria to be adopted to distinguish them. Moreover, the relations between the Van Allen belt and cosmic rays were to be clarified, as were the influence of solar plasma on the external terrestrial magnetic field and the mechanism of the modulation of cosmic radiation.

Among the most important conclusions was the discovery that the particles of energy greater than many GeV are of extra-solar origin. It was also recognized that heavier protons and particles, with energy up to 2 GeV are produced by the sun during great eruptions. It was further confirmed, on the basis of experimental correlations, that interplanetary space is filled with a plasma in motion, of solar origin (solar wind). Besides, it was firmly established that complex magnetic fields of solar origin, carried by the solar wind in interplanetary space, have a notable effect on cosmic rays of solar and galactic origin in the low energy field.

On the other hand, the meeting did not clarify the origin of the electrons and the protons in the Van Allen radiation belts. These are probably connected with the interaction, in the transitional region, between the geomagnetic field and the solar wind.

These results of great interest constituted the premises for subsequent research on cosmic rays which have been carried on in recent years ([5]).

The third Study Week on the problems of understanding the cosmos was held in April 1970, organized by the President of the Academy, Father O'Connell, with the collaboration of Fathers Coyne, McCarthy and Treanor ([6]). The subject, *Nuclei of Galaxies* ([7]), was of great interest in the 1970s and the center of attention of astrophysicists. In fact, an understanding of the phenomena which occur in the nuclei could be the key to an interpretation of the evolution of the galaxies. At that time there were many contrasting ideas on the exact nature of the nuclei of

([5]) « Scripta Varia », *25*, XLIX-573 (1963).

([6]) O'Connell D.J.K., President of the Academy; Ambartsumian V.A., Burbidge E.M., Burbidge G.R., Fowler W.A., Friedman H., Hoyle F., Kellermann W.H., Low F.J., Lynden-Bell D., McCrea W.H., Morgan W.W., Morrison P., Oort J.H., Osterbrock D.E., Rees M., Salpeter E.E., Sandage A.R., Sargent W., Schmidt M., Spinrand H., Spitzer L. Jr., Van Der Laan H., Wheeler J.A., Woltjer L.

([7]) *Les noyaux des Galaxies* (original title).

the galaxies, and especially on those of high energy; therefore it was decided to invite to this meeting astrophysicists who would represent the different points of view on the question. On that occasion many important results of observations were presented, such as the optical shifting in the red, in the infrared, in the radio frequencies, the distribution and the function of luminosity. The theoretical discussion concentrated on the mechanisms of ejections and on the large rotators.

The meeting led to some conclusions on the nuclei of the galaxies, which were very important in those years. In fact, for the first time it seemed clear that strong infrared fluxes notably increased the emission of energy from the nuclei. Moreover, the doubt arose that the nuclei of the galaxies might contain an overabundance of some elements heavier than helium.

The theoricians discussed the formation of objects of great mass, with strong gravitational fields. They also demonstrated that it was possible to trace a framework within which nuclei evolve through phases of increasing density and of decreasing angular momentum.

The results of this Study Week had an influence on subsequent astrophysical research, especially the suggestion to do further studies on compact rotating systems with or without magnetic fields, and on the relations between the morphological and spectroscopic properties of the nuclei — research which has today produced important results ([8]).

The fourth Study Week in the astrophysical field was held in 1981 on "Astrophysical Cosmology and Fundamental Physics", organized by Academicians Brück and Coyne and Professors Rees and Longair, and brought together numerous specialists from all over the world to discuss a subject of great scientific interest and timeliness ([9]). It dealt with an examination of recent scientific developments which had taken place in those years as a result of the interaction between cosmology and fundamental physics. In fact, physicists interested in elementary particles during the years 1975-80 were very much involved in treating certain

([8]) *Nuclei of Galaxies* (Les noyaux des galaxies). Edit. by D. O'Connell. « Scripta Varia », *35*, XLIX-800 (1971).

([9]) Chagas C., President of the Academy, Organizers of the Study Week: Brück H.A., Coyne G., Rees M., Longair M.; Audouze J., Davis M., Faber S., Fang L.Z., Gratton L., Gunn J.E., Hawking S.W., Leprince-Ringuet L., Lynden-Bell D., Oort J.H., Ostriker J.P., Peebles P.J.E., Schmidt M., Sciama D.W., Setti G., Silk J., Swarup G., Tammann G.A., Van der Laan H., Weinberg S., Weisskopf V., Woltjer L.

fundamental aspects of cosmology, such as nucleosynthesis, the origin of galaxies, the excess of particles over antiparticles, the extreme isotropy of the universe, etc. At the same time some theories of particle physics were being modified on the basis of astrophysical and cosmological considerations.

The meeting avoided introducing new laws and too detailed deductions without a concrete and positive basis. The various presentations led to the formulation of new theories on the basis of experimental observations, such as on primordial nucleosynthesis based on the relative abundance of deuterium, helium and lithium, in favor of a relatively simple model of the Big Bang. On the other hand, we still do not know the sequences of the initial conditions of the universe up to the present evolution of the galaxies and their clusterings. An argument discussed at the meeting, and not yet solved, was the difficulty of determining the extra-galactic distances.

The results of this Study Week were of considerable importance in inspiring and guiding the subsequent research in this field, especially in two sectors which are still under discussion: the nature of the invisible mass which is probably ten times greater than the luminous mass, and the difficulty of carrying on observations in the field of the shifting in the red between 5 and 1000.

The Proceedings of this Study Week were published in 1982 ([10]).

In speaking of modern cosmology, one cannot fail to mention, in the scientific activity of the Academy, a fundamental contribution by P.A.M. Dirac in his address at the Plenary Session of April 1972 on "Evolutional Cosmology", in which, following the theories of Lemaître, he discussed the laws of expansion and the beginning of the universe from a single highly radioactive atom and arrived at the observation that the actual time measured with a clock would be of the order of 10^{39}. At this point Dirac proposes to introduce a factor which makes this theory a part of that of Einstein ([11]).

In that same session we had also a fundamental contribution by J. H. Oort on the formation of the spiral structure in galaxies, based on Westerbork's radiotelescopic observation in Holland of the syntheses of the spiral galaxy NGC 4258 ([12]).

([10]) « Scripta Varia », *48*, xxxv-600 (1982); Edited by: Brück H.A., Coyne G., Longair M.

([11]) Dirac P.A.M., *Evolutionary Cosmology*. « Commentarii », (II) *46* (1973).

([12]) Oort J.H., *Spiral Structure of Galaxies*. « Commentarii », (II) *55* (1973).

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COMMENTARII

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P.A.M. DIRAC

DOES THE GRAVITATIONAL CONSTANT VARY?

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

The Conference of Dirac on Gravitation published in the Commentarii.

Among the contributions to cosmology and astrophysics, recognition must also be given to the work of Stephen Hawking on the nature of radiation in the black holes, which was the subject of his discourse when he received the Pius XI Medal in 1975 ("Gravitational Collapse and After") ([13]).

In the Plenary Session of 1975 Academician Bengt Strömgren also emphasized the present knowledge regarding the evolution of galaxies ([14]). This important presentation included a thorough discussion of the problem of the interaction between stars and interstellar material and that of the interaction of gravitation and mass, which have a fundamental importance in the present concept of the universe.

Dirac, in the Plenary Session of 1978, again took up the new theories on gravitation and their implications in cosmology ([15]).

NEUROSCIENCES

In its approach to scientific problems, the Academy has dealt with very delicate subjects, such as those regarding the functions of the brain, which concern both neurology and psychology, and that is the formation of conscious experience and thought, between matter and spirit. One line of research oriented in this direction has been followed by the Pontifical Academicians and neurobiologists John Eccles, Rita Levi-Montalcini, and more recently Janos Szentágothai.

In 1964 a Study Week was held, organized and chaired by Sir John Eccles, on "Brain and Conscious Experience" ([1]), in which outstanding scientists in the field of neurosciences participated ([2]). Contrary to the

([13]) Hawking S.W., *Gravitational Collapse and After.* « Commentarii », (III) *4* (1976).

([14]) Strömgren B., *Evolution des galaxies dans l'Univers en expansion.* « Commentarii » (III) *20* (1979).

([15]) Dirac P.A.M., *New Ideas about Gravitation and Cosmology.* « Commentarii », (III) *24* (1978).

([1]) *Cerveau et expérience consciente* (original title).

([2]) Eccles J.C., President of the Study Week; Adrian, Lord of Cambridge E.D., Andersen P., Bremer F., Chagas C., Colonnier L., Creutzfeldt O., Giacomello G., De Oliveira Gomes A., Granit R.A., Heymans C.J.F., Hinselwood C.N., Horstadius S., Jasper H.H., Libet B., MacKay D., Moruzzi G., Montcastle V.B. jr., Penfield W., Phillips C.G., Schaefer H., Sperry R., Teuber H.L., Thorpe W.H.; Scientific Secretariat: Lazzari R., Cerquiglini Sergio, Cerquiglini Susanna, Venturini L.

wish of Professor Eccles, it was not possible to invite philosophers, who could have gone deeper into some important aspects of the subject.

In addition to a series of very interesting presentations on the latest research (the last meeting on a similar subject, i.e., "Brain and Conscious Experience" had been held in the United States in 1953) the most interesting part of the conference was the discussions giving not only experimental data but also working hypotheses which were submitted to criticism by the participants.

All the material of that Study Week was published by the Pontifical Academy of Sciences and Springer-Verlag ([3]) and met with great success; it can be said that the volume, still today twenty years later, remains a reference work of great importance. The spirit that guided the participants in the Study Week was « the search for truth », and the words spoken by His Holiness Paul VI to the participants confirm this: "Who does not see the close relation between the mechanisms of the brain as they appear from experience, and the highest truly spiritual activity of the soul?" ... "The soul of the scientist of today is more readily open to religious values and sees, beyond the prodigious discoveries of science in the field of matter, the mysteries of the spiritual world and the splendors of divine transcendence ... these questions are beyond the domain of science, and in all ages man has confronted the question of his origin and destiny".

Fifteen years after the Study Week on "Brain and Conscious Experience", neurological science had made such progress that it was necessary to call attention to the new discoveries, especially in order to delve deeper into certain very interesting aspects, particularly those regarding nerve cells, the mechanisms of nerve transmittal, and behavior.

A Study Week, organized by Academician Rita Levi-Montalcini on "*Nerve Cells, Transmitters and Behaviour*", was held in October 1978 with the participation of scientists from many countries. The presentations and relative discussions centered on three main arguments ([4]).

([3]) « Scripta Varia », *30*, XXXVIII-858 (1965), *Brain and conscious experience*, Ed. J. Eccles, Springer Verlag, Berlin.

([4]) Chagas C., President of the Academy; Levi-Montalcini R., Organizer of the Study Week; Berlucchi G., Burnstock G., Calissano P., Cangiano A., Eccles J., Fambrought D., Filogamo G., Giacobini E., Greene L.A., Hamburger V., Hamprecht B., Hokfelt T., Kosterlitz H.W., Levi G., Levy J., de Mello F.G., Milner B., Nelson P.G., Nirenberg M.W., Paoletti R., Purves D., Raiteri M., Revoltella R., Roberts E., Terenius L., Weiskrantz L.

The first was the use of tissue culture as a means to study nerve cells under different aspects. Thus the importance was pointed out of the growth factor of the nervous system (NGF), a specific protein which stimulates the growth and the differentiation of the sensory and sympathetic nerve cells.

The second part concerned the identification of the mechanism of action of the components which act on nerve transmission, such as gamma-amino-butiric acid (GABA), and on their function. A study was also made of all the complex mechanisms at the base of biosynthesis, activation and inactivation of the substances which act upon nerve transmittal. These results now cast some doubt on the Dale principle, according to which every neuron synthetizes, accumulates and releases a single substance which can transmit the nerve impulse.

The third part of the meeting dealt particularly with enkephalin and other natural peptides which represent endogenous ligands for opiate receptors. Also discussed was the ontogenesis of different nerve cells and their interaction with target cells, as well as some particular functions in the localization of the cerebral cortex. The presentations and relative discussions appeared in a volume, which represents an important document for an understanding of modern neurobiology ([5]).

The Academy's studies of the problems of the brain and the mind include the publication on "Mental Deficiency", the results of a Working Group in 1980, This is a serious problem which today is believed to effect 3% of the world's population, that is, about 120 million people. The Working Group, consisting of distinguished scientists studying the subject ([6]), confronted the numerous problems — biological, sociocultural and economic — which are the basis of this condition and tried to clarify means to reduce its occurrence.

In addition, the Working Group studied closely the chromosomic characteristics of intrauterine life. The processes of human genetics as well as prenatal physiology have already made important contributions to an understanding of the problem, as have also the increased knowledge of the biochemistry of a child's brain and an understanding of the learning mechanisms.

([5]) Scripta Varia, *45*, 679 (1978). Edited by R. Levi-Montalcini; Elsevier-North Holland, Amsterdam (1980). Ed. by R. Levi-Montalcini.

([6]) Chagas C., President of the Academy; Brinkworth R., Lejeune J., Liley A.W., Mathieu M.H., Mayor F., Smith G., Zakharov A.

Socio-economic and cultural factors can also have an important role in mental deficiency, especially if accompanied by conditions of poverty and therefore of malnutrition, as happens not only in many of the developing countries but also in the inhuman conditions of slum housing in large cities and in industrial countries. The problem of assistance for these children and the environment in which they can be raised were also examined, showing the advantages of family surroundings in comparison with treatment in hospitals. The Working Group stressed the possibilities of preventive care and said that science and medicine today offer a message of hope ([7]).

After the 1964 Study Week on "Brain and Conscious Experience" the progress made in the field of biochemical and neurological processes and even in psychology and cibernetics made the Academy take up again in 1983 the problems of the brain in order to make a new assessment of the situation nearly twenty years after the first study in this field, concentrating especially on models of the mechanisms of visual recognition.

The Study Week on "Pattern Recognition Mechanisms", organized in April 1983 by President Carlos Chagas and attended by eminent scientists ([8]), studied the mechanisms of vision and their relation to memory and the localization of these processes in well defined areas of the brain, from an anatomical rather than a functional viewpoint, and it went deeper into the relativity aspects of perception of the external image, introducing also new theories such as those of the textons.

The Academy approached the subject from various points of view; i.e., on an anatomical, neurophysiological and psychobiological basis. Moreover the discussion was integrated with the reports on experiments with various techniques, some of which very advanced and having also epistemological implications.

The subject is so complex that it is not possible to draw any conclusion other than the confirmation of its great interest and the need to continue the research, broadly interdisciplinary, in this frontier field,

([7]) Scripta Varia, *47*, XIII-101 (1981), Edit. C. Chagas, *Debilità Mentale*, Studium, Roma 1982. *Débilité Mentale*, Edit. J. Lejeune, Masson, Paris 1983.

([8]) Chagas C., President of the Academy; Gross C., Gattas R., Organizers of the Study Week; Barlow H.B., Berlucchi G., Calvo F., Campbell F.W., Creutzfeldt O., Desimone R., Eccles J., Julesz B., Maffei L., Mishkin M., Movshon J.A., Roland P., Rolls E.T., Szentagothai J., Ungerleider L.G., Warrington E.K.

on the border between biochemical activity of the brain "system" and the processes which are the basis of consciousness.

During this meeting experimental results were discussed in an attempt to arrive at a univocal interpretation of the phenomena, but this was not always possible and so various hypotheses were presented.

On the other hand, it is difficult to draw conclusions regarding recognition mechanisms by taking into consideration only the visual system without the acoustic and somatosensory systems, which are the basis of other realization problems such as language and touch. Also the problem of memory was held to be essential for the determination of conscious experience ([9]).

The latest undertaking of the Academy in the field of neurological science was the Working Group organized by President Chagas in June 1985 on "Developmental Neurobiology of Mammals". The meeting was attended by twenty scientists from various countries ([10]), who went into various aspects of this subject, from the first events in neurogenesis to the recovery of a function following damage suffered by either the immature or adult brain. They examined the fine structural analyses of the developmental processes and the neutral "plastic" responses which are possible for the advanced techniques now available for the study of the neurobiology of development.

The importance was discussed of having available monoclonal antibodies for the identification of cell types which take part in such mechanisms, particularly those of the brain.

There was also discussed the regressive phenomena during neurogenesis and the function of trophic factors, with emphasis on the fact that non-neuronic cells constitute the major component of neurogenesis. They also studied the plastic reaction to damage to the central nervous system and the mechanisms of recuperation. In addition, the new techniques of transplantation in the central nervous system, which offer interesting models, were examined in detail.

The human brain and the problem of consciousness represent in modern science one of the most delicate points, inasmuch as they regard

([9]) Scripta Varia, *54*, XII-360 (1983), Edit. C. Chagas, R. Gattass, C. Gross.

([10]) Chagas C., President of the Academy; Aguayo A.J., Bennett M.R., Bjorklund A., Cavalcanti L., Giuditta A., Innocenti G.M., Lent R., Levi-Montalcini R., Linden R., Lund R.D., Perry H., Pitts N.G., Rakic P., Ranzi S., Schneider G.E., Silver J., Sotelo C., Stein D.G., Woolsey T.A.

the interpretation of the mechanisms, reduced to their chemical and physical expression, through which the human brain cooperates in the processes of consciousness and acts differently from that of animals.

THE STRUCTURE OF MATTER

The important progress of macromolecular chemistry, and especially the possibility of using refined diffraction techniques by x-ray to establish the structure of the macromolecules have, during the 50s, led to extraordinary success in the knowledge of macromolecules of biological interest, in particular the nucleic acids, which govern the most delicate functions of the living cell.

On this subject, of such fundamental theoretical interest but also full of possibilities of practical application, the Academy in October 1961 held a Study Week (1) organized by Academicians Tiselius and Giacomello, and attended by the most outstanding scientists in this field, among whom we might mention Kendrew, Perutz, Debye, Hevesy, and Lipmann, who later received the Nobel Prize for their work in this field (2).

In 1961, based on the scientific knowledge acquired in that period, it was necessary to study the relations existing between the chemical — and steric — structures of the macromolecules of biological interest and their specific functions in living systems. It was also important to clarify, through a comparison of the various experiments, what lines of research to follow in order to establish the mechanisms of interaction between different macromolecules of biological interest, and also to continue with new means the battle against diseases of viral origin and molecular diseases. The group reconsidered the function of the macromol-

(1) *Le problème des macromolécules d'intérêt biologique avec référence spéciale aux nucléoproteides.*

(2) Tiselius A.W.K., President of the Study Week; Giacomello G., Scientific organizer of the Study Week; Anfinsen C.B., Chantrenne H., Chargaff E., Debye P.J.M., De Hevesy C.G., Jacob F., Frankel-Conrat H.L., Katchalski E., Kendrew J.C., Lindgvist I., Lipmann F., Liquori A.M., Meselson M., Mizushima S., Perutz M.F., Putzeys P., Ranzi S., Rich A., Rossi-Fanelli A., Rubio Huertos M., Schramm G., Siliprandi N., Spiegelman S., Theorell H., Tuppy H., Zamecnick P.

ecules of biological interest in the complex problem of life, in an effort to establish lines for further research and experimentation in this area.

The conclusions recognize the importance of the problem and the numerous questions which still must be answered for a better understanding. We must continue, both in the field of molecular biology and that of biochemistry, to try to clarify especially the relation between nucleic acids and proteins. The functions of hemoglobins of the DNA and RNA and the interactions between enzyme-substratum and antibody-antigens were also discussed.

In the improvement of knowledge regarding macromolecules of biological interest, a very important factor has been the new analytical methods — physical, chemical and biological — which have made possible substantial progress in this field.

Since then the results of research on nucleic acids have emphasized their importance in genetic information and also given a clue in molecular terms to the processes responsible for evolution.

These results, which have clearly indicated the importance of these molecules in the vital processes and are today completely confirmed by recent research, show the validity of the general lines and results of the work carried on at the beginning of the molecular biology era ([3]).

The intermolecular forces, that is, the forces responsible for the deviations of the laws of gases and of the formation of liquids and solids, have considerable importance in physics and in chemistry and for the study of the structure of matter.

It was the famous physicist Debye who proposed this subject for a Study Week on Molecular Forces ([4]), in order to clarify the situation which is evolving after a period of brilliant theoretical experimental results, and to have a thorough discussion of the subject, of such great interest for basic science. Academician Debye, being ill, could not, however, participate in this Study Week, which was directed by Academician Sanichiro Mizushima ([5]).

([3]) Scripta Varia, 22, XLIV-477 (1962), Ed. P. Salviucci.

([4]) *Les forces moléculaires* (original title).

([5]) Mizushima S., President of the Study Week; Bernstein R.B., Bonino G.B., Bowden F.P., Buckingham A.D., Casimir H.B.G., Chagas C., Chu B.T., Debye P.J.W., Fixman M., Garcia de la Banda J.F., Giacomello G., Grimley T.B., Heiskanen W.A., Herzberg G., Hirschfelder J.G., Lowdin P.O., Lyklema J., Overbeek J.T.G., Prettre M., Ricci F.P., Sandoval-Vallarta M., Schwab G.M., Verwey E.J., Widom B.

Various aspects were discussed, beginning with the theory of intermolecular interactions in solids. It was established that the predominant action for non-polar molecules can be attributed to the London-Van der Waals forces, which can be interpreted on the basis of quantum mechanics, while for the molecules with dipolar momentum electrostatic terminals are added. They also discussed the nature of the liquid state, in the light of the theory of radial distribution and of the correlation of functions, which proved to be the most direct and productive way to describe the relations between intermolecular forces and the nature of fluid systems.

The debates during these meetings pointed out the importance of theoretical (orbital theory) and experimental (spectroscopic) methods for the development of such research. They stressed the importance of intermolecular forces in biological phenomena, for example, antigen-antibody interactions, RNA reproduction, synthesis of proteins, and also the hydrogen bond ([6]).

It can be said that the extraordinary progress achieved in this field in the last twenty years — often due to the merit of the same scientists who participated in this meeting — is derived from the results of this Study Week.

ORIGIN OF LIFE AND EVOLUTION

Molecular Aspects of the Origin of Life

Among the great problems discussed by scientists in the last half century, there is that of the origin of life on earth. Today the research on this has made considerable progress, both in laboratory experiments and in astrophysical observations, which reveal the existence of simple "organic" molecules, that is, those containing carbon in the interstellar spaces, which have been defined as prebiotic molecules. By this word is meant molecules which are capable, though theoretically, of giving origin to molecules similar to those which constitute living matter.

([6]) Scripta Varia, *31*, LXVI-758 (1967) and North-Holland, Amsterdam (1967).

A Working Group met in October 1978 to study the *molecular aspects of the origin of life*, a subject of very great interest. Among the participants was S. Miller, who was the author of the laboratory experiments on the so-called "primordial soup" (1).

The first theory on the origin of life goes back to A. Oparin, who in 1925 hypothesized the formation on earth of molecules (HCN, HCHO, HCOOH, CH≡CH, etc.) three or four billion years before the appearance of man. He was followed by Haldane, who admits that these molecules were formed by the ultraviolet radiation of the sun on still simpler molecules: methane, hydrogen, ammonium and water.

Some support for these theories came from the experiments of Urey and Miller, who produced in the laboratory, by electric discharges in an atmosphere similar to Haldane's, prebiotic molecules, including some amino acids, basic constituents of proteins. Ponnamperuma too, in similar experiments, arrives at prebiotic molecules of a certain interest, and probably also eventually nucleic acids. The most interesting aspect of the question is the observation — made possible by the new techniques of astronomical observation — of a certain number of prebiotic molecules from the stellar spaces of our galaxy. Numerous facts have resulted, which confirm the existence of prebiotic molecules in space, as well as experimental laboratory data which confirm the hypotheses regarding the method of formation of these molecules, as well as the presence of "biological" molecules such as the amino acids in meteorites.

At present there are numerous hypotheses which attempt to explain how from these simple molecules biological macromolecules are formed, capable (as is DNA) of reproducing themselves and of storing information, so as to lead to the formation of specific protein for every organism.

Ingenious advanced theories do not always succeed in interpreting many facts, such as the asymmetrical structure of the biological molecules and the great complexity of their distribution in space, which follows a perfect order.

The conclusion of the discussions was the fact that on the basis of the present data we cannot yet propose theories but only guesses, and that only after much further research and the gathering of numerous

(1) Chagas C., President of the Academy; Brown R.D., Goldbeter, Gratton L., Lejeune J., Marini-Bettòlo G.B., Miller S., Pavan C., Rich A., Semerano G., Tuppy H.

other data will it be possible to understand the mechanisms of formation of the biological molecules (2).

Recent Advances in the Evolution of Primates

In May 1982 the Academy, with the collaboration of distinguished scientists from all over the world, approached a particularly delicate and controversial subject related to the origin of man, that of the evolution of primates, in an endeavor to reconcile apparently contradictory results, and in particular anthropo-paleontological, biochemical, citogenetic and paleo-immunological data which go back millions of years.

The Working Group on "Recent Advances in the Evolution of Primates" (3), after having examined also the most recent experimental results of research in this field, admitted that many questions on this subject are still unanswered; for example, the influence of the environment on the appearance of the erect posture. Also, they did not arrive at any unanimity of opinion on the formation of the species and on the mechanisms and the changes due to evolution.

In a subject of this nature, where great space is given not only to the facts but also to their interpretation, it is obvious that there has not been unanimous agreement. But it is very important that the scientific results were freely debated, in complete liberty, with the only aim that of searching for the truth. The possibility of developing new methodologies based on molecular biology, especially by the analysis of hereditary material and of proteins can provide new approaches to precise knowledge regarding the evolution of primates and the human species.

At present, among scholars in this field, two lines prevail regarding the origin of the human family: that of a very long history and that of going back only to the Pliocene era. A comparison of the data and opinions along these two lines, confirmed by the interpretation of experimental data, biochemical and cariological as well as paleontological, based above all on the hybridization of DNA, has served to date back to a maximum of seven million years ago the principal event of our history: the point of divergence after which the big African apes and the austra-

(2) Brown R.D., *Organic Matter in interstellar Space.* « Commentarii », (III) *26*, 21 (1978).

(3) Chagas C., President of the Academy; Bonè E., Coppens Y., Doolittle R., Dutrillaux B., Greenfield L.O., Lejeune J., Lowenstein J.M., Pavan C., Pilbeam D., Sermonti G., Simons E.L., Tobias P.V.

lopithecine are separate from the hominids. During the meeting Coppens proposed for the first time the hypothesis that the tectonic activity which occurred in the eastern part of Africa with the rise of the land, profoundly modified the climate in two sectors: one between the Atlantic and the Rift Valley, and the other between the latter and the Indian Ocean, separating the populations of the large apes from those of the hominids. The former adapt themselves to the warm, humid climate of the forest and the latter to the savanna and the prairies ([4]).

BIOCHEMICAL BASES OF BIOLOGICAL PROCESSES

Biochemistry of tumors

The first Study Week of the Pontifical Academy of Sciences was held in June 1949 at the seat of the Academy in the Casina Pio IV and was organized by Academician Pietro Rondoni, famous pathologist and biochemist of the University of Milan, on the subject "The Biological Problem of Cancer". The meeting was attended by illustrious scholars from various countries and different scientific fields: pathologists, chemists and medical doctors ([1]).

This was during the time when pathology was beginning to evolve away from morphology toward biochemistry; the results of recent years of research have made a series of important steps forward, such as the discovery of a series of steroidic hormones. In the field of chemistry they now speak in terms of the electronic structure of molecules.

In this context new ideas and new possibilities of research arise, and thus in the Study Week a critical approach was adopted. After the participants' presentation of the various aspects of the problem of cancer, especially of cancerogenesis, some lines of research were indicated, which were then followed successfully; for example, cancerogenesis and genetic mutation, the local and general factors of inhibition of the development

([4]) Scripta Varia, *50*, x-204 (1983), Ed. by C. Chagas.

([1]) Rondoni P., Scientific organizer of the Study Week; Berenblum I., Boyland E., Cowdry E.V., von Euler H., Greenstein J.P., Kretz J., Lacassagne A., Maisin J., Peacock P.R., Pentimalli F., Ruzicka L., Sanz-Ibanez J., Schinz H.R.

of cancer, the relation between chemical constitution and cancerogenous activity, the action of physical agents compared to that of other cancerogenic factors, the metabolism of cancerogenic substances, biochemical modifications in relation to the neoplastic transformation of the cell. Finally the problem of the mechanism of formation of metastases was discussed. Pius XII, in welcoming the participants, said: "Now you are thinking of continuing to develop these observations, these experiments, this research, very carefully in a patient work, of which the public at large is not aware. This will probably not bring you renown, but you will deserve, with the confirmation of your conscience, the thanks of future generations."

That meeting was the occasion for experimentation with the new and original formula for the Study Weeks proposed by the Academy. The success achieved helped to perpetuate the model which emerged from the meeting.

As a result of this Study Week, there was published a volume, "The Biological Problem of Cancer", which includes the proceedings, the scientific communications and the discussions ([2]).

The problem of cancer, approached for the first time by the Academy in its first Study Week, organized by Academician Rondoni in 1949, at a time when modern biochemical techniques made it possible to foresee the mechanism of cancerogenesis, was taken up again in October 1977 by the Study Week organized by Academician M. Sela on the subject "The Role of Non-specific Immunity in the Prevention and Treatment of Cancer".

Among the means for treatment of tumors, non-specific immunotherapy has recently become very important, together with surgery. The Study Week tried to clarify the possibilities and the limitations of this new system for the prevention and control of tumors.

The meeting was attended by various Academicians and some of the most distinguished experts in the world ([3]). A detailed description of

([2]) Scripta Varia, 7, XIV-350 (1949), Ed. by P. Salviucci.

([3]) Chagas C., President of the Academy; Sela M., Organizer of the Study week; Terry W., Wolff S., co-organizers; Baldwin R.W., Barcinski M.A., Chedid L., Clerici E., Davies D.A.L., De Duve C., De Marsillac J., Dewdney J.M., Gutterman J.U., Klein Ed., Klein Eva, Klein G., Levi-Montalcini R., Marini-Bettòlo G.B., Mathè G., Merucci P., North R.J., Nossal G., Oettgen H.F., Rapp H.J., Rojas A., Rosenberg S.A., Serafico F., Strander H., Weiss D., Westphal O.

the state of our knowledge in this field and of the new paths to follow was the first result of their presentation. The second point was to understand how a non-specific cellular immunity can cause the death of the cancer cells. To study this problem, it is necessary to have available animals that can be used as models, and specific substances which affect immunity. The nature of the factor of tumor necrosis was studied, as well as the behavior of the cells capable of blocking the cancerous cells. However, it was seen that still today tumor antigens are rare.

During the Study Week lymphocyte-antigens transformed by virus were described. Actually many studies of these antigens have been made, thanks to recent techniques of monoclonal antigens. Also, the role of specific pharmaceuticals for tumoral tissues, formed by a specific antigen of the tumoral tissue covalently bound with a drug or a radioactive compound was investigated.

In this context the mechanisms of the immunitary defenses against tumors were studied in the light of recent knowledge ([4]).

Biological Interactions

A Working Group on "Specificity in Biological Interactions" was organized by Academician Bernard Pullman in November 1983 to shed light on certain biological processes which are basic to an understanding of the mechanism of a great number of chemical reactions on which life is based. This Working Group was composed of numerous scientists from all parts of the world ([5]), who made important contributions with their presentations and discussions, especially on six of the principal topics, which were:

1. Specificity of enzymatic actions;
2. Interactions between nucleic acids and proteins;
3. Interactions between nucleic acids and pharmaceuticals;
4. Interactions of t-RNA;
5. Antibody-antigen interactions;
6. Ionofors.

([4]) *Rôle de l'immunité non spécifique dans la prévention et le traitement du cancer.* « Scripta Varia », *43*, xxxjv-589 (1979).

([5]) Chagas C., President of the Academy; Pullman B., Organizer of the Working Group; Davies D.R., Ebel J.P., Fersht A.R., Levitt M., Matthews W., Ovchinnikov Y., Patel D., Pullman A., Saenger W., Scheraga H., Warshel A., Zimmer Ch.

These interactions can cause the action of an enzyme on a specific substratum, but also that between a molecule and a nucleic acid, which can produce carcinogenic phenomena, as well as a blocking of the functions of the tumor cell DNA, which constitutes the target for the chemotherapy of tumors.

From the discussion it emerged that, contrary to the current belief, specificity of intermolecular interactions is related not only to steric factors — that is, accessibility, adaptability, complementarity — but that it must be attributed rather to the combination of these factors with the electronic structure of the interacting agents. This means that the specificity is the result of factors which depend on the global structure of the reactant species.

It also became clear that in this field of research, collaboration between theory and experience is essential. The present availability of powerful elaborators makes it possible to go deeper into this topic in the light of quanto-mechanic calculations.

This research, both theoretical and experimental, though part of basic science, opens the way to important applications in the field of pharmacology and medicine, and can contribute to the development of new chemotherapeutic means. The meeting therefore combined the interest in research with humanitarian implications, in harmony with the spirit which characterizes the Academy's meetings ([6]).

MOLECULAR MECHANISMS OF CARCINOGENIC AND ANTITUMORAL ACTIVITIES

Today the problem of tumors could be easily solved if we had more knowledge, on a molecular level, of the mechanisms of carcinogenesis and antitumoral activities.

The similarities and the differences in action between the carcinogenesis and the antitumorals — the first related to the formation of covalent bonds with the purine and purimidine bases, while the second is due to the formation of products which enter or somehow affect the

([6]) Scripta Varia, *55*, XXXVI-318 (1984), Ed. by C. Chagas and B. Pullman.

arrangement of the DNA chain — were the subject of the Study Week on "The Molecular Mechanisms of Carcinogenic and Antitumor Activities", held in October 1986, organized and presided over by Professor Bernard Pullman, Pontifical Academician, with the participation of numerous experts (1).

The originality of the approach to the subject was in the comparison between the molecular mechanisms of the oncogenic and the antitumoral activity; for example, benzopyrene is carcinogenic, whereas anthramicine is antitumoral, but both act on the $-NH_2$ group of the guanine of the DNA. This comparison led to a closer examination of the chemical, chemical-physical and biophysical significance of the various ways in which the chemical compounds interact and the effects of these on the structural properties of the DNA. This approach clarified the similarities and differences in the action of various substances. The discussion centered on the specificity of these mechanisms, and especially the specificity of the *site* and the *sequence* of the sterochemical arrangement of the bases in the nucleic acids.

Besides the general themes, there was also a discussion of particular aspects, such as the viral oncogens, the alkylating agents, the function of antitumoral antibiotics, of the pyrrolo-benzo-diazepine, of the ellipticines and of the quinoxalin derivatives, in the inhibition of tumoral growth, as well as the consequences of the damage to the sugars constituting the DNA. Particular attention was given to the mechanisms of action of antitumoral pharmaceuticals with a base of platinum complexes which have recently attracted great interest.

The interpretation of these phenomena on a chemical, chemical-physical and biophysical level is fundamental for an orientation of the strategy to be adopted for the control of tumors. The results of this meeting indicate possible new directions for tumor research and therapy.

ECONOMETRICS

Econometric analysis is an important instrument for setting up plans for development on a scientific basis. The progress in many areas which

(1) Chagas C., President of the Academy; Pullman B., Organizer and President of the Study Week; Arcamone F., Barbacid, Crothers, Dervan, Goldberg, Harvey, Helene, Hurley, Krugh, Le Pecq, Lown, Marini-Bettòlo G.B., Monier, Neidle, Pullman A., Rajewski, Roberts, Roques, Ts'o, Waring, Zimmer.

took place in the 1950's made necessary a thorough study of this question, of which the Pontifical Academy of Sciences became a spokesman when in October 1963 it organized a Study Week on "The Econometric Approach to Development Planning" (1), attended by world-famous economists. The meeting was presided over by Academician Boldrini, and the participants included, among others, Frisch and Leontieff, who later received the Nobel Prize for economics (2).

Important aspects of econometrics in establishing plans for development were discussed, and in particular, the function of capital accumulation in economic development, the relationships between teaching, scientific research and economic development, the need to use econometric models on a regional level, later to be extended to a national level, and the urgency to provide techniques of econometric analysis for the countries of the Third World.

The discussions pointed out the necessity of an empirical as well as theoretical analysis of the social objectives of economic development. They also emphasized how necessary it is to improve the methodologies of the econometric analysis of some phenomena. Moreover, they dealt with the need to extend the possibilities and the limits of the instruments of economic policy of governments. Particular attention was given to a study of the relations between the growth of productivity and the growth of the population in an economic system.

They recognized that in order to have a more complete picture of this complex problem, there must be further research on population growth — theoretical and empirical, sociological, economic and physiological research. In the end it was acknowledged that econometric analysis represents today a powerful instrument of scientific analysis which, if it cannot alone determine economic policy, can however firmly establish the consequences of the hypotheses and the specific observations, and thus promote the good functioning of an economic system independently of the political context of the system (3).

(1) *Rôle de l'analyse économétrique dans la formulation des plans de développement et l'étude des fluctuations économiques* (original title).

(2) Boldrini M., President of the Study Week; Allais M., Dorfman R., Fisher F.M., Frisch R., Haalvemo T., Isard W., Johnson D.G., Koopmans T.C., Leontieff W.W., Mahalanobis P.C., Malinvaud E., Morishima M., Pasinetti L., Schneider E., Stone J.R.N., Theil H., Tinbergen J., Wold H.O.A.

(3) Scripta Varia, *28*, XLVII-1260 (1965), Ed. P. Salviucci.

II

SCIENCE AND TECHNOLOGIES APPLIED TO GLOBAL PROBLEMS

INTRODUCTION

In many cases it is difficult to distinguish where basic science ends and applied science begins. Many modern disciplines have been the result of the combination of basic disciplines, for example: electronics, data processing, medicine and agrarian sciences.

This chapter gives the conclusions of some Study Weeks and Working Groups which dealt with science applied to problems of the modern world, excluding however those meetings that took up the problems of developing countries, which are the subject of a separate chapter.

Thus we have Study Weeks, and other meetings, on the environment and its protection, the possibility of obtaining pure water with new advanced systems, research on means used by plants to protect themselves against insects and fungi in order to learn new strategies for the protection of harvests. Geophysics, from the viewpoint of microseisms on the one hand and climatic irregularities on the other, is among the problems studied in these meetings.

One aspect of applied science of great interest today is the new space technologies at the service of man. So we have a composite and complex picture which, however, has the common objective of going deeper into the various possible applications of science in order to solve some of the great problems of humanity.

MAN AND THE ENVIRONMENT

Since 1970 the Academy has been studying the problems resulting from the modification of the environment as the consequence of the increased activity of man, which threatens to modify profoundly the ecologic equilibria and therefore to affect not only the quality of life and the development of vegetation, but also the phenomena of energy exchange on the earth.

The Plenary Session of 1970 thoroughly discussed "Science and the Protection of the Environment" ([1]), and the conclusion noted the great dangers involved in environmental degradation, if adequate measures are not taken, especially for the long-term variations such as the depletion of the ozone layer in the stratosphere and the increase of carbon dioxide in the atmosphere.

The problem was again approached in 1983 during the Study Week on "Chemical Events and Their Impact on the Environment", which was attended by scholars in the various disciplines, to focus on the different aspects of the question ([2]).

Starting with a critical review of our knowledge regarding the reactions between the normal components of the atmosphere, they examined what happens in the atmosphere in the presence of chemical components (industrial products, CO_2, etc.) of anthropic and geological origin (dust, SO_2 of volcanic origin, etc.) and their effect on the normal components of the atmosphere. These changes produce a series of other processes; thus the presence of increasing amounts of some components such as CO_2 and CH_4, the so-called greenhouse gases, causes continuous increase in the medium temperature of the earth, which could greatly modify all the equilibria of the biosphere, leading, e. g., to a partial melting of the polar ice caps.

They also analyzed the damage due to an irregular cycle of the atmosphere caused by uncontrolled industrialization, which brings about acid depositions harmful to the acquatic life of animals and vegetation.

([1]) Marini-Bettòlo G.B., *Science and the protection of the Environment.* «Commentarii», (II) *25* (1971).

([2]) Chagas C., President of the Academy; Marini-Bettòlo G.B., Organizer and President of the Study Week; Anderson J.G., Arnold F., Brosset C., Canuto V.M., Chameides W.L., Crutzen P., Fiocco G., Hare K.F., Howard C.J., Knabe W., Lag J., Liberti A., Malone T., Phillips D., Pullman A., Ranzi S., Revelle R., Rowland F.S., Salati E., Wandiga S.O., Wiesenfeld J.; Bierbaum V., Scientific Secretary.

Among the modifications caused by man in the equilibria of the atmosphere, there was also discussed what could happen after a nuclear war that would use only a part of the nuclear arsenal which is available to the superpowers today. Working with mathematical models, it became evident that these explosions would bring about a profound change in the environment, known as "nuclear winter", in which the survival of a great part of the human species is doubtful.

One part of the discussions was devoted to the changes brought about by chemical processes in the atmosphere of the tropical zones.

It was concluded that ([3]), in spite of the careful research in this field, we still cannot foresee with any precision the great changes that can take place in our environment and their effects on the soil, the vegetation and animal life. These problems, which concern the entire biosphere, require more profound and broader international collaboration in order to eliminate, even only partially, the negative effects. These are rarely dramatic, as in the case of acid rains, but constant and dangerous, and they can lead to drastic changes for life on earth in the future. Let us bear in mind that the earth has gone through various geological eras, for reasons which are still unknown to us. It is therefore necessary to establish priorities of action and to take measures to eliminate the continuous daily imperceptible threat which is leading to the destruction of the biosphere ([4]).

One of the topics of theoretical interest, with notable possibilities of practical application, is the study of biological membranes, which can serve as a model for the preparation of artificial membranes to be used especially for the desalination of water. The importance of this problem led the Academy to organize a Study Week on "Biological and Artificial Membranes and Desalination of Water", under the leadership of Professor Roberto Passino, Director of the Water Research Institute of the CNR (National Research Council of Italy) ([5]).

That meeting, which was held in April 1975, was attended by scholars from all over the world ([6]), highly qualified in both the field

([3]) Documenta, *9* (1983).

([4]) Scripta Varia, *56*, XIV-702 (1985) Edit. by G.B. Marini-Bettòlo; Elsevier, Amsterdam (1986), Edit. by G.B. Marini-Bettòlo.

([5]) *Membranes biologiques et artificielles et la desalination de l'eau* (original title).

([6]) Chagas C., President of the Academy; Passino R., Organizer of the Study Week; Alberti G., Astarita G., Baker P.F., Batisse M., Boyer P.D., Paes De Carvalho A., De Duve

A short break during the Study Week in April 1975.

of biological membranes and that of artificial membranes, who had a series of important and constructive discussions. The purpose of the meeting was the establishement of a perfected model for the artificial membranes, based on a knowledge of the mechanisms of transport through biological membranes. The artificial membranes must be suitable for the production of large quantities of desalinated water, especially for the needs of the arid zones of the Third World and of certain particular areas such as the small islands.

The meeting was interdisciplinary, with the participation of biochemists, physiologists, physical chemists, biophysicists and even technologists and engineers. They took up the complex problem of the transfer across the membranes.

The most recent data were presented regarding the various types of natural and artificial membranes, artificial structures such as liposomes, and finally, regarding biosynthetic membranes, which combine the transport capacities of the biological membranes with the resistant structure of the artificial membranes.

The results of this Study Week were the subject of a publication, which brought this problem to the attention of scientists on an international level (7).

The "Gordon Conferences" the following year continued with this subject, concentrating on the phenomena of transport in synthetic and biological membranes.

In the research field this Study Week definitely promoted a considerable development of membrane technologies achieved in subsequent years, with notable applications for the treatment of waters and the processes of separation between liquid and gas phases.

* * *

The survival of man and animals is dependent upon the availability of food, which is provided by plants either directly or indirectly. However, the plants, and especially their cultivation, are subject to attack by insects and diseases caused by fungi and virus, so that it is necessary,

C., De Meis L., Hasselbach W., Kedem O., Keynes R.K., Leprince-Ringuet L. Liquori A.M., MacRobbie E.A.C., Meares P., Monnier A.M., Mueller P., Palade G.E., Paoletti R., Paterson R., Post R.L., Ritchie J.M., Slayman C.L., Sollner K., Solomon A.K., Spiegler K.S., Staverman A.J., Stoeckenius W., Teorell T., Weidmann S.

(7) Scripta Varia, *40*, XXXVIII-901 (1976), Edit. by R. Passino.

Discussion at the Study Week on *Natural products and the protection of plants* (October 1976).

for the protection of harvests, to resort more and more to the use of chemical products, the so-called pesticides. These have profoundly disturbed the ecological equilibria and have even entered alimentary channels, creating grave problems for wild animals and perhaps even for man, and altering the ecological equilibria.

Is it possible to protect the harvests by other means, taking as a model the natural equilibria? In order to answer this question, there was held at the Academy in October 1976 a Study Week on "Natural Products and the Protection of Plants" ([8]) organized by Academician G. B. Marini-Bettòlo, to sum up the situation and discuss the present possibilities regarding the use of natural products for the protection of harvests. This was attended by chemists, entomologists, botanists, agronomists and plant pathologists ([9]), who made a multidisciplinary study of the subject. It was found that even in the present conditions — that is, with the use of conventional insecticides and fungicides — the loss of harvests is estimated at 75 billion dollars, amounting certainly to one-third of the annual harvest.

The interest in this problem lies in the fact that man requires an ever-increasing amount of food products, both for the needs of the under-fed populations and for the continuous population increases. To confront this problem the cooperation of scientists of various disciplines is necessary. The possible approaches are: the adoption of special systems of cultivation, the use of disease-free seeds or other materials such as tubers, cuttings, etc., the selection of resistant plants, and the combination of biological and chemical means, i.e., integrated pest control. Another possibility was the subject of the Study Week: a study of those natural substances which condition the behavior of insects (attractants, repellents, moulting hormones, pheromones, etc.) and also their synthetic analogues.

After having analyzed the results of recent research in this field, it was concluded that it is necessary to intensify the research on the physiology of arthropods and to develop selective insecticides. This involves

([8]) *Produits naturels et la protection des plantes* (original title).

([9]) Chagas C., President of the Academy; Marini-Bettòlo G.B., Organizer and President of the Study week; Abo-Khatwa N., Alves De Lima R., Ballio A., Bell E.A., Bernays E.A., Bower W.S., Brader L., Buyckx E., Canonica L., Cardani C., Chapman R.F., Cruickshank I.A.M., Dorn S., Elliott M., Gilbert B., Gonzales R.H., Graniti A., Heimpel A.M., Jacobson M., Karlson P., Knusli E., Nakanishi K., Quijano Rico M., Schildkencht H., Shorey H.H., Siddall J., Somerville H.J., Stall G.B., Wain R.L., Wigglesworth V.B., Williams C.M., Zanini E.

a biological control and further research on toxic products of the microorganisms and their mechanism of action, which can serve as a model for the means of defense. It is essential, moreover, to develop varieties of plants resistant to insects and molds ([10]).

It follows from all these data that the protection of crops cannot be based on a single system. Therefore natural products and their analogous synthetics can be used in an integrated control.

These systems can bring great advantages, in spite of the difficulties of their use, especially in the developing countries, and assure larger harvests, both for food crops (such as cereals) and for the production of fiber (cotton, jute). It can be said that along these lines great progress has been achieved recently, from which new strategies have been developed for the protection of crops.

GEOPHYSICS

Microseisms

The problem of microseisms ([1]) was the subject in 1951 of the second Study Week to discuss a question on which there was some difference of opinion among scientists. The meeting was organized and chaired by Academician Francesco Vercelli, with the participation of numerous seismologists, meteorologists and geophysicists ([2]). The differences of opinion among them concerned particularly the question of whether to attribute microseisms to meteorological elements in the oceans, or to the action of the waters on the coast. The meeting discussed these elements and considered all the factors which together can produce the genesis of the microseisms.

Following the explanation of numerous data and experimental ob-

([10]) *Natural products and the protection of plants.* Scripta Varia, *41*, XXII-846 (1977), Edit by G.B. Marini-Bettòlo; Elsevier, Amsterdam, 1977, Edit. by G.B. Marini-Bettòlo.

([1]) *Le Problème des Microséismes* (original title).

([2]) Vercelli F., President of the Study Week; Bath M., Bernard P., Caloi P., Due Rojo A., Ewing M.W., Gherzi E., Giorgi M., Hardtwig E., Lehmann I., Lopez De Azcona J.M., Menzel H.J., MacElwane J.B., Rothe J.P.E., Stoneley R., Roncalli G., Scientific Secretary.

servations and long discussions, the meeting arrived at the opinion that microseisms on the continents result from the energy of the atmosphere, transmitted to the earth's crust through the mass of the oceans.

They also studied and discussed the laws of the transmission of energy in the light of the most recent research in this field. Agreement was reached on the classifications of microseisms. It was also agreed that their genesis can be due to atmospheric perturbations, such as tropical cyclones and extratropical depressions, which affect the sea.

The participants analyzed the characteristics of microseisms, the origin of energy, the transmission of energy, and finally related phenomena such as the mareographic and microbarometric vibrations and the "pumping effect".

The partial differences of opinion among the participants depend also on the fact that before the meeting there was no international agreement for the standardization of measures and data, or even the coordination of experiments on microseisms in the various parts of the world. This coordination was the first objective achieved by the Study Week.

The second was the development of research along four main lines: the installation of new stations in Europe, the publication of observations made by airplanes, analysis of the mareographic vibrations recorded with very fast apparatus, and measurement of the variations of pressure in the deep sea.

Thus the meeting pointed out a problem of interest not only for basic science, but also for an understanding of the phenomena which affect our planet ([3]).

Meteo-oceanographic Anomalies and Teleconnections

The particular anomalies of climate in the various continents which have occurred in the last decade, have made the scientists reconsider with modern methodologies the relations and distance between these phenomena which are today known as teleconnections.

Because of the importance of the subject for its effects on man, and because it involves phenomena which are still today not scientifically explained, the Academy convoked in September 1986 a Study Week on "Persistent Meteo-oceanographic Anomalies and Teleconnections", orga-

([3]) Scripta Varia, *12*, XLVI-418 (1952), Edit. by P. Salviucci.

nized and chaired by Academician G. B. Puppi and attended by scientists and experts from many countries (4).

The importance of the El Niño phenomenon in 1982/83 increased the interest in climatic anomalies worldwide, and various related unusual weather conditions occurred with the drought in Africa and Australia, the unusual meteo-oceanographic conditions in the tropical Atlantic, the intensification of the typhoons in the Pacific and Indian Oceans, and the monsoons with unusual precipitations on the Pacific coasts. From this came the idea of a physical connection between the various types of phenomena, to which was given the name of "teleconnections". Naturally this connection can be considered from various points of view: that of a real causal connection between the major phenomenon — in this case El Niño — and a series of secondary phenomena, or that of a single anomaly on a planetary scale with various types of regional manifestations, or even that of a casual coincidence between phenomena, the causes of which are substantially independent.

The presentations and the discussions succeeded in identifying a series of phenomena which occur in the ocean-atmosphere system and land surfaces. The participants made a critical analysis of the various phenomena taking place in the different continents.

UTILIZATION OF SPACE

In the present period of history the use of space by satellites and the exploration of the universe by means of spacecraft which transmit to earth the information obtained by closer observation are among the most important conquests of science and modern technology for a knowledge of the universe. Therefore in October 1984 the Pontifical Academy of Sciences held a Study Week on the "Impact of Space Exploration on Mankind" to discuss the subject and to study the future prospects. There

(4) Chagas C., President of the Academy; Puppi G.P., Organizer and President of the Study Week; Bengtsson L., Benzi R., Cane M.A., Datta R.K., Divino-Moura A., Folland C.K., Hoskins B.J., Kalnay E., Legras B., Miyakoda K., Palmer T.N., Pearce R., Rasmusson E.H., Reed R.J., Shukla J., Simmons A., Speranza A., Sutera A., Tibaldi S., Tribbia J., Wiin-Nielsen A.C.

are still some very important questions to be answered; e. g., how can the space data obtained by remote sensing be elaborated? Is it possible to slow up and eventually end the use of space for military purposes? Can space technologies help to solve the problem of famine throughout the world or to supply the present lack of infrastructures in the developing countries, or to provide sanitary education and assistance? Most important of all these questions is: To whom does space belong? This is a juridical question of great importance, mentioned by the Holy Father in receiving the participants at the conclusion of the meeting.

These problems, which require the collaboration and participation of all the peoples of the world, were studied by the scientists from thirteen nations and other representatives of international organizations participating in the meeting (1). They examined very thoroughly the following subjects: communication via satellites, remote sensing, and future uses of space.

After a long discussion the participants arrived at certain conclusions: spatial technologies can greatly contribute to reducing the technological inequalities in the world only if all countries are involved in future programs, so that the benefits help all of them. Telecommunication via satellite today can have a great economic, social and cultural influence and must therefore be at the service of all peoples. As far as remote sensing systems are concerned, new means must be developed to integrate the present technologies with the cultural and economic variables in the different parts of the world.

However, the great problems of famine, education and medical assistance cannot be solved through space technologies if the structures already existing in the developing countries are not integrated, bearing in mind the local capabilities and the existing means. It was stressed that the information gathered by systems of remote sensing should not become the monopoly of a few but should be available to all those directly interested, especially if it regards their own resources. Finally, it was pointed out that the results of space exploration have not yet brought to the poorer nations the benefits they need, such as the development

(1) Chagas C., President of the Academy; Canuto V.M., Organizer of the Study Week; Menon G.K., President of the Study Week; Altshuler J., Aretz J., Balogun E.E., Butler R.E., Carassa F., Caruso A., Carver J.H., Cazenave M., Clarke A.C., Colino R., Coyne G., Pal Y., De Giorgi E., Garwin R., Gonzalez R., Hinners N.W., Hodgkins K.D., Howard J.A., Kopal V., Leprince-Ringuet L., Maffeo S., Levi-Montalcini R., Marini-Bettòlo G.B., Murphy W., Paul C.K., Ponnamperuma C., Puppi G., Ranzi S., Smith M., Smith R., Stefanizzi A., Sunaryo R., Zraket C.

of education and an improvement in the harvesting of crops. Research on mineral resources, meteorological forecasts, management of the waters, and communications must be available to the countries that need them.

The new possibilities open to man in space could lead to an era of greater brotherhood and integration among nations.

The importance of the conclusions ([2]) of this conference can be well evaluated from the fact that they have become an official document of the United Nations, which was sent to all its member countries. The Proceedings of the Study Week have become a part of the publications in the *Scripta Varia* - "The Impact of Space Exploration on Mankind" ([3]).

([2]) Documenta, *13* (1984).
([3]) Scripta Varia, *58*, XXVI-364 (1986), Edit. by C. Chagas and V. Canuto.

III

SCIENCE FOR DEVELOPMENT

INTRODUCTION

The Pontifical Academy of Sciences has always been interested in scientific problems concerning development. This interest increased after the Encyclical of Paul VI "Populorum Progressio". It is known that among the principal factors which hinder or retard development there are: inadequate nutrition and malnutrition, tropical diseases and hygienic conditions which, by creating a state of poverty and hardship, make it difficult for populations to overcome the conditions of misery and hunger and build a developed society. Along these lines the Academy held a series of Study Weeks and Working Groups to study the possibilities of overcoming these difficulties, with the advice and help of experts from all over the world.

One of the topics discussed was agricultural production and its improvement as a basis for assuring food for everyone and thus for combating hunger in the world. From the first Study Week on "The Problem of Oligoelements in the Vegetal and Animal Life" in 1955, they went on to the one on "Organic Matter and Soil Fertility" in 1968, and then in 1983 on "Modern Biology Applied to Agriculture".

Another topic was that of health, with particular attention to tropical diseases and their prevention. In this connection, Working Groups were held on Perspectives of Immunization in Parasitic Diseases, the interaction between parasitic diseases and malnutrition, the prevention and cure of leprosy. Still another topic was energy, which was the subject of two Study Weeks, in 1980 and 1984.

In addition to these important meetings on science and technology for the developing countries, there was a report presented at the United Nations Conference in Vienna in 1979 on "Science and Technology for

Developing Countries". This report was prepared by a small group of Academicians and experts, headed by the Academy's President Carlos Chagas. It stressed the importance of science for the development of modern society as well as the importance of technology in working toward the new horizons opened up by science.

The need for science is deeply felt in the developing countries, where it is necessary to respect the local cultural context if science is to bring about through technology a real benefit for those populations. The document stressed the need of cooperation for a useful and productive transfer of technologies, but this must be in a spirit of brotherhood and love which respects the nature and customs of each country, its traditions and its experience. It is also important that the developed countries bear in mind the negative aspects of industrialization and the need to consider the risk-benefit criterion in introducing new technologies and new products.

Certain criteria are emphasized which must be followed in development: respect for nature in industrialization, discipline of urbanization in order to avoid the formation of huge metropolises of poverty; protection of forests, which should not be sacrificed to a type of agriculture that may not be suitable and may produce steppes and then deserts.

Regarding nutrition, all possibilities should be explored to increase rationally the agricultural productivity, not excluding the study of non-conventional foods. Public health should be improved, by increasing hygiene on the one hand and education on the other. Medicine should be, above all, preventive medicine even if outside the cities the methods of traditional medicine cannot be abandoned as they are the only means for bringing assistance to the people before modern medicine can be introduced everywhere.

Finally, attention was called to the importance of a scientific policy which should serve to create in those countries research centers which can be the foundation of development based on the initiative of the citizens themselves ([1]).

([1]) *Science and Technology for Developing Countries.* Scripta Varia, *44*, 53 (1979), by C. Chagas, G.B. Marini-Bettòlo, G.P. Puppi, Padre E. di Rovasenda, P. Bisogno and A. Rambelli.

AGRICULTURAL PRODUCTION

In the 50's the new scientific progress, and especially the analytical techniques which now can use largely spectroscopic methods, called attention to the function of small quantities of elements which are active in natural substances and generally in vegetable and animal tissues. While the function of iron in the hemoglobin was already known, it had not always been easy in those years to identify the specific function of other metal ions such as zinc, manganese, molybdenum, or copper. In subsequent years the development of the chemistry of coordination components and the advanced techniques of separation shed light on these ions, which are essential for the life of plants and for the function of certain animal tissues.

It is a great merit of the Academy to have proposed this theme in a moment when the new chemical and biological techniques were becoming established and made it possible to deal with this problem by new means and new methods.

A Study Week on "The Problem of Oligoelements in the Vegetal and Animal Life" (1) was organized in April 1955 by Academician Albareda Herrera with the participation of eminent scholars from various countries, among them Professor M. G. Bertrand, who is considered a pioneer in this field (2).

The Study Week was oriented principally toward the problems of plant growth — that is, the influence of oligoelements on the development of plants, with the major stress on agricultural productivity and an important field of earth science: pedology and edaphology.

Also covered was a series of relationships calling attention to our knowledge in that field in 1955. Attention was focused on the various aspects of the role of oligoelements in plant and animal life and an analysis of the function of oligoelements in the fixation of atmospheric nitrogen as well as numerous other aspects of the physiology and pathology of plants.

The conclusions established the need in some plants for less fre-

(1) *Le problème des oligoéléments dans la vie végétale et animale* (original title).

(2) Albareda Herrera J.M., President of the Study Week; Arnon D.I., Aykroyd W.R., Bertrand M.G., Bonino G.B., Gerretsen F.C., Laatsch W., Lavollay J., Lundgardh H., McCance A., Mitchell R.L., Mulder E.G., Santos-Ruiz A., Scharrer K., Seekles L., Tonzig S., Vilas L., Virtanen A.I., Wallace T.

quent elements, such as manganese, copper, molybdenum and zinc, which have been proved to be essential for plants, since they have a fundamental importance in plant nutrition. It was also recognized that animal cells require elements such as iron, zinc, copper and molybdenum in small quantities. The importance of oligoelements in animal nutrition was also stressed, as well as the fact that some of them can be toxic for some organisms.

The Study Week closed with a motion to promote new research on soils, plants, animals, and even on man. This meeting provided useful documentation ([3]) for the basic research carried on during the following thirty years and has led us to understand today, on a chemical and biomolecular level, the function of the above-mentioned elements in the metabolic processes of plants and animals.

* * *

The meeting of 1955 on "The Problem of Oligoelements in Plant and Animal Life" was the first of a series of Study Weeks on the problem of agricultural production directly related to that of nutrition.

In 1968 the subject centered on the organic material of the soil, which was recognized as one of the essential factors of agricultural productivity at a time when little was known about this, and the topic was a very new one. The study of the problem was interdisciplinary, and participants included soil scientists, microbiologists, zoologists and chemists. The Study Week on "Organic Matter and Soil Fertility" ([4]) was organized by W. Hernando Fernandez and chaired by Academician Lora-Tamayo ([5]).

It was necessary to clarify the function of the organic matter in the soil, and it was recognized that this must be regarded as the basic and irreplaceable factor in fertility, especially regarding the microbic flora. Also stressed was the importance of recycling agricultural refuse in the soil itself, as is generally done in tropical climates — recycling which must be extended everywhere in order to complete the ecological cycle.

([3]) Scripta Varia, *14*, XLVI-616 (1956), Edit. by P. Salviucci.

([4]) *Matière organique et fertilité du Sol* (original title).

([5]) Lora-Tamayo M., President of the Study Week; Hernando Fernandez V., Scientific Secretary; Alexander M., Baver L.D., Bradfield R., Bramao L., Bremner J.M., Broadbent F.E., Chaminade R., Dhar N.R., Flaig W.A.J., Franz H., Haussmann G., Henin S., Jenny H., Khristeva L.A., Kononova M.M., Kovda V.A., Norman A.G., Primavesi A., Reese E.T., Reuszer H.W., Swaby R.J., Waksman S.A.

The results achieved stimulated subsequent research in this field, particularly on the strategies to be adopted for tropical agriculture (6).

* * *

A series of Study Weeks on the basic problems of agriculture included the April 1972 meeting on "The Use of Fertilizers and its Effects in Increasing Yield with Particular Attention to Quality and Economy" (7). Organized by Professor V. Hernando Fernandez and chaired by Academician Lora-Tamayo, the meeting (8) stressed one aspect of agricultural production — namely, the importance of the qualitative and economic factors, compared with the quantitative one. In this context they took up the problem of fertilizers, which make possible an increase in the quantity of production sought by the developing countries. Regarding a better use of fertilizers, it was agreed that new innovative techniques should be used, as in fact happened subsequently. The problem of the quantity of harvests is very important also in connection with the increase in world population, and therefore a more scientific and rational use of fertilizers is necessary. Here the education of farmers in accordance with the new techniques is of primary importance, and this problem has not yet been solved.

This meeting confirmed the validity of the Study Week of 1968 on "Organic Matter and Soil Fertility", and for the first time recognized the importance of environmental conditions in forecasting the potential yield of the harvest and understanding the effect of the various negative factors.

These conclusions are today perfectly valid: it can be said that the highest yields obtained in a given region are based precisely on the calculation of factors related to meteorological conditions. These parameters (temperature, relative humidity, etc.), together with a knowledge of weather forecasting, can in fact be quantified and anticipated, thus

(6) Scripta Varia, *32*, LXVIII-1018 (1968).

(7) *L'emploi des fertilisants et leur effet sur l'accroissement des récoltes, notamment par rapport à la qualité et à l'économie* (original title).

(8) Lora-Tamayo M., President of the Study Week; Hernando Fernandez V., Scientific Secretary; Araten Y., Baade F., Blanchet R., Bornemisza E., Bramao L., Bussler W., Capò G., Coic Y.M.F., Colwell J.D., Davidescu D., Ewell R., Fitts J.W., Fried M., Hauser G.F., Homes M.V.L., Latkovics I., Oberlander H.E., Pesek J.T. jr., Primavesi A., Rotini O.T., Russel E.W., Saalbach E., Theron J.J., Van Der Paauw F., Walsh T., Welte E.

achieving the highest possible production. Certain factors were pointed out which can depend on the use of fertilizers, as for example, the sensitivity of the crops to various parasites or diseases, and especially the cultivation conditions in the semi-arid areas ([9]).

AGRICULTURE FOR THE DEVELOPMENT OF THE THIRD WORLD

The new biological technologies of fertilization, selection of plants resistant to disease and infestation, etc., have been the basis for the green revolution, which has profoundly modified the agricultural productivity of India and southeast Asia during the last twenty years. Meanwhile numerous new techniques have been developed, such as genetic engineering, which, if properly used, could bring considerable benefit, especially in tropical agriculture, and help to satisfy the needs of developing countries.

In accordance with the spirit and the lines of research in agriculture followed by the Academy, a Working Group was held in November 1983 on "Modern Biology Applied to Agriculture", which brought together high level experts from many countries ([1]) in an interesting approach to the possibilities of improving agricultural productivity through the use of new biological techniques.

The Group believed that in order to produce larger harvests it is necessary to make agriculture more intensive rather than more extensive. Moreover, it is necessary:

1. To improve agrochemical fertilizers and pesticides and to select among the latter, products that are compatible with the environment;

2. To develop genetic engineering techniques for using particular organisms in the production of food and forage, in the battle against insects and plant diseases, and in the utilization of biomasses;

([9]) Scripta Varia, *38*, XCII-1424 (1973).

([1]) Chagas C., President of the Academy; Ahrens C., Beringer J.E., Burris R.H., Day P., Dobereiner J., Jaworski E., Joandet G., Lyman J., Olembo R., Schell J., Van Montagu M.

3. To select suitable species for the fixation of atmospheric nitrogen, using not only Rhizobium but also Cyanobacteria for the control of the fermentation of biomasses;

4. To effect reforestation with rapid-growth plants — today identified — so as to meet the people's needs for wood and to avoid the destruction of forests;

5. To continue, for the improvement of natural fertilization, the study of various species of Rhizobia and other nitrogen-fixing microorganisms and eventually resort to genetic engineering in order to introduce the nitrogenetic gene in other microorganisms;

6. To develop research on mycorrhizae, which can offer great advantages in the plants' use of products present in the soil.

These lines of action drawn up by the Working Group are an important contribution to the knowledge of strategies to approach the problem of agricultural production, especially in the developing countries, where the conditions of soil and climate vary greatly.

TROPICAL DISEASES

Parasitic diseases — especially malaria, schistosomiasis, filariasis, leishmaniasis and tripanosomiasis, which considerably reduce the physical efficiency of the persons affected, altogether amounting to about one hundred million — in the tropics are one of the factors which limit the development of the countries.

The Academy, faced by the difficulty of science in finding effective preventive as well as curative treatments by the use of pharmaceuticals, turned its attention to the possibilities of using vaccination for immunization, in parasitic diseases too. The Working Group which met in 1981 to study and discuss the "Perspectives of Immunization in Parasitic Diseases" stressed this point and discussed the possibilities of using vaccination in individual parasitic diseases.

In the last thirty years research on immunity and immunization has made great progress both in the basic knowledge of the mechanisms of immunity and in the preparation of vaccines for diseases of bacterial and

viral origin which have in some cases succeeded in eradicating some sicknesses, such as yellow fever and smallpox. One field yet to be solved is that of immunity regarding parasitic diseases. On this topic the Working Group (1) studied thoroughly the possibility of developing immunitary techniques, especially vaccinations, for the prevention of parasitic diseases. From this angle they discussed — also in the light of recent progress in the knowledge of immunity (the use of monoclonal antibodies) — some parasitic diseases which are more widely diffused in the developing countries: tripanosomiasis, leishmaniasis, schistosomiasis, and particularly malaria. They discussed especially malaria, since today people are less protected because of the resistance of plasmodium to pharmaceuticals and that of carrier insects to insecticides.

These phenomena of resistance have in many cases caused the failure of worldwide plans to eliminate these diseases, which a few years ago it seemed possible to eliminate completely. The efforts by Nussenzweig to produce vaccines against malaria with monoclonal antibodies which could act upon the various stages of the malaria parasite, seem close to achieving success. In this research — which is being followed and coordinated by the World Health Organization — the modern techniques of bioengineering have a continually increasing role.

The Working Group took up the complex problems of vaccination against *Trypanosoma brucei*, the cause of sleeping sickness, and *Trypanosoma cruzii*, the cause of Chagas' Disease, and they discussed the difficulties due to the particular nature of these parasites. They also analyzed the problems regarding the various forms of leishmaniasis and the difficulty of preparing vaccines, due to the high specificity of the different stocks. It was noted that very little has been done to study any form of vaccination whatsoever for schistosomiasis, a disease that is extremely widespread.

There is considerable interest in this work because, in spite of many difficulties which still exist, there is a glimpse of a new way to protect man, especially in the tropics, against diseases which heretofore constituted a basic obstacle to the well-being and thus the development of peoples in the tropical countries.

The Working Group came to the conclusion that there are scientific

(1) Chagas C., President of the Academy; Brener Z., Camargo E., Cioli D., Colley D.G., Dean D., Garnham P.C., Gazzinelli G., Manuel J., Mott K.E., Nussenzweig R.S., Sher A., Smithers S.R., Vickerman K.

possibilities for producing the vaccines, but it is still necessary to carry on research in the laboratory and in the field and to observe carefully the conditions in the endemic areas. It is necessary to proceed with great caution; therefore new vaccines must be subjected to a trial period in order to establish their safety, tolerability and effectiveness.

The Working Group stressed the state of research for the immunization of malaria, schistosomiasis, leishmaniasis and both African and American tripanosomiasis, and the difficulties which are still encountered regarding the nature, the adaptation, the reaction and the cycles of the parasite in order to obtain truly effective vaccines ([2]).

To overcome these difficulties, the Working Group considered it necessary to have more extensive research and closer international collaboration.

* * *

In October 1985 a Study Week on "Interaction of Parasitic Diseases and Nutrition" to study the relations between nutrition and the parasitic diseases which are found in many countries, but especially in tropical countries. During the meeting it was ascertained that a correlation exists between these two phenomena, also in the light of research in the last few years ([3]).

The analysis of available data indicates that the production of food, in many parts of the world, is not the limiting factor for adequate alimentation in the various regions; a limiting factor instead is the parasitic infection which causes, in the persons infected, difficulty in utilizing food, because of the appearance of pathological mechanisms which is due to two small proteins, interleukin and cachectin, produced by the host cells during the infection. Eight of the most important parasitic diseases were studied: malaria, leishmaniasis, amebiasis, giardiasis, criptosporidiosis, ascariasis, schistosomiasis and American tripanosomiasis, and the relation to malnutrition was analyzed in order to establish the relations between these. Thus the hypothesis that malnutrition protects against these infections, which had already been suggested, was abandoned as not plausible.

A possible solution in primary health care for this problem was also

([2]) Scripta Varia, *47 b*, 178 (1981), Edit. by C. Chagas.

([3]) Chagas C., President of the Academy; Brown K., Brown T.R., Cerami A., Farthing M., Garnham P., Heywood P., Hussain M.A., Keusch G.T., Lunven P., Martinez-Palomo A., Mata L., Measham A., Nations M.K., Pawlowski Z.S., Pearson R.D., Rocha H., Sarker S.A., Tomkins A., Torun B., Wolff S.M., Wyler D.J.

mentioned. This is based on preventive medicine and hygiene, i.e., the purification of water and the construction of sewerage systems together with a program of sanitary education, which require not only adequate financing but also cooperation from governments and communities ([4]).

* * *

Immunology, Epidemiology and Social Aspects of Leprosy. The field of the immunology of tropical diseases includes in some degree the problem of leprosy, a disease of bacteric origin widely prevalent especially in tropical climates among the poorer classes.

Continuing the study of a cure for tropical diseases, which hinder development in the Third World, the Academy in May 1984 held a Working Group ([5]), organized by Professor Chagas and attended by scholars who were very competent because of the research they had carried out and their personal experience with locations of contagion. They examined the problem of leprosy in the light of the possibilities offered by biological techniques. The major difficulty for the study of leprosy is known to be the fact that it has not yet been possible to cultivate *in vitro* the pathogenic agent, *Mycobacterium leprae.* It was also stressed that the study of Hansenian pathology, especially the specific damage to the skin and the nervous system, can give much information regarding the factors of immune response in man which are useful for a knowledge of neurological diseases and tumors.

The Working Group drew attention to the fact that the use of a single drug in the battle against leprosy can lead to the selection of mutants of the pathogenic agent and therefore more pharmaceuticals must always be used in order to obtain positive results and avoid the appearance of resistant batches.

The discovery that certain animals, like the armadillo and the Mangabey monkey, make possible experimental infection can now be of great help for research in this field, which will open the way to its study in man.

The techniques of bioengineering can make possible the production of specific proteins of the *M. leprae*, which cannot yet be cultivated *in vitro*, for the preparation of eventual vaccines. Some vaccines, such as

([4]) Scripta Varia, *61*, 352 (1986), Ed. by C. Chagas and G.T. Keusch.

([5]) Chagas C., President of the Academy; Andrade L., Bier O., Bloom B., Convit J., Godal T., Lechat M., Mendes N., Meyers W., Mutatkar R., Nordeen S., Ulrich M., Walsh G., Young R.

countries, where the lack of adequate energy sources not only hinders development but indirectly causes the destruction of the renewable resources of the environment, causing deterioration of the soil, changes in climate and impoverishment of water resources.

On the subject "Energy for Survival and Development" the Academy with the collaboration of ENEA ([3]), in 1984 held a Study Week, organized by Professor Umberto Colombo, attended by 36 scientists and experts from all over the world, especially from the developing countries. The need for larger quantities of energy for the developing countries very soon became evident, and especially the importance of its better distribution. For this the economic factors must be borne in mind because the price of petroleum conditions many possible solutions. From the presentations and the discussions it resulted that many developing countries have potential coal and oil resources, which, however, require large amounts of capital for their exploitation and further research. All this requires greater North-South and South-North collaboration.

Furthermore, it was noted that electricity is not yet widely enough distributed in the developing countries, despite the fact that it is the basic factor for raising the living standards, including education, health, security and high productivity in agriculture, in industry and service. Therefore the problem was confronted of urban and rural electrification in the developing countries, which must use local renewable resources and appropriate technologies in the best way possible.

In order to solve these problems, it is necessary to study the transfer of technology, which implies also the formation of infrastructures and local specialized personnel.

The conclusions of this Study Week were published ([4]) in the form of a report and sent to the governments of developing countries and of industrialized countries, to international organizatinos, to electric companies, to research and educational centers, and to consumer organizations. The ethical aspect of the need to furnish energy to all people was stressed.

([3]) Chagas C., President of the Academy; Rovasenda (Di) P. Enrico, Director of the Chanchellery of the Academy; Colombo U., Organizer of the Study Week; Al-Houmoud A., Angelini A.M., Barth B., Bernardini O., Blanc-Lapierre A., Boettcher A., Carter J., Choucri N., Couture J., Demirchian K.S., Desprairies P., Dherse J.L., Di Vecchia A., Eden R.J., Farinelli U., Foley M., Frisch J.R., Goldemberg J., Gonzales Ortega F., Khan M.A., Konan L., Lansberg H H., Laue H.J., Lemkecher B., Malu Wa K., Marini-Bettòlo G.B., Matsui K., Mensah M., Menon G.K., Puppi G., Smith K.R., Suarez C.E., Thring M.W., Zeghbib H.

([4]) Documenta, *12*, (1984).

The meeting ended with an appeal on behalf of the poorer countries for collaboration among nations, in order that they can build together a new order for well-being, in which energy assumes its function of primary importance ([5]).

REMOTE SENSING AND ITS EFFECTS ON DEVELOPING COUNTRIES

The Study Week held in 1984 on "The Impact of Space Exploration on Mankind" had stressed the great importance of remote sensing for the managment of renewable and nonrenewable resources for the developing countries.

The large extensions of land, the vast areas of difficult access, scarce communication and other difficulties due to climate and difficult natural characteristics make remote sensing a very important instrument to developing countries for a proper administration of their resources.

A Study Week on "Remote Sensing and its Impact on Developing Countries", organized by Professor V. Canuto, was held at the Academy during the first week of June 1986 under the direction of President Carlos Chagas, attended by numerous experts from many countries ([1]). Particular attention was given, on the one hand, to the need or rather the urgency to set up a system of remote sensing for the developing countries, and on the other hand the economic, political and technical difficulties which hinder its realization.

In the presentations and the discussions there emerged some qualifying points of the advantages of this system for the developing countries, and precisely the provision of an up-to-date inventory of the available resources, including agricultural ones; and the possibility of

([5]) Scripta Varia, 57, XVIII-615 (1986), Edited by C. Chagas and U. Colombo.

([1]) Chagas Carlos, President of the Academy; Canuto Vittorio, organizer of the Study Week; Puppi G.P., Barret E.C., Brockmann Carlos, Cappellini V., Colwell R.N., Della Rocca B., Fea M., Gonzalez R., Hassan H.N., Howard J.A., Khan F.A., Kolosov Y., Malla K.B., Moore D.G., Murphy W.F., Myers V.I., Nanayakkara C., Nualchawee K., Oliva-Gutierrez G., Pisani P.H., Ponnamperuma C., Sanchez-Pena M., Sellman A.N., Shutko A.M., Stancioff A.S., Stefanizzi A., Szekielda K.H., Tilford S.G., Umali R.M., Vibulsresth S., Wigton W.H.

supervising the environment especially in the tropics as an instrument for the management of natural resources.

Four basic topics were studied, viz:

1. The present state of the technology of remote sensing;

2. Its potential usefulness in developing countries, especially as regards the environment and the "renewable" natural resources such as the marine resources, forage, water, wood, minerals, lands and agricultural cultivation;

3. Its potential importance to the developing countries for the administration of "non-renewable" resources such as minerals and combustible fossils;

4. Economic, social and legal considerations.

The debate showed the importance of these systems for the administration of resources, for meteorological forewarnings, and also for following the variations and changes in the environment, especially regarding deforestation and desertification.

From the juridical point of view, particular importance was given to the resolution of the United Nations Committee for the Pacific Use of Space on "Principles Regarding the Remote Sensing of the Earth from Space". Also stressed was the extreme caution necessary in using this means to diffuse the information which can be prejudicial to some national interests.

Among the recommendations resulting from this meeting, an outstanding one was the importance of remote sensing to assure on a global level the availability of food by the timely detection of natural disasters, such as drought, floods, and invasions by locusts. Great importance was attributed to cooperation between the industrially advanced nations and the developing nations, for the administration of these programs and the training of technical scientific personnel.

The participants also called attention to the need for accurate information about these systems on all levels, particularly the political level, in order to promote and facilitate the use of these techniques.

IV

SCIENTIFIC POLICY

SCIENCE AND THE CONTEMPORARY WORLD

The great social and economic changes of the modern world and the behavior of man today depend largely, as everyone realizes, on the extraordinary technological impact of the development of science. The Pontifical Academy called the attention of the scientific world to this subject in three Plenary Sessions, in 1976, 1978 and 1979.

In the 1976 session the presentations by Academicians were followed by an important debate ([1]), in which three priority lines stand out:

1. The direct and indirect impact of science has brought extraordinary changes in a very short period, which have profoundly influenced modern society, such as: the means of transportation and communication, new pharmaceuticals, nuclear energy in both its peace and war versions, automation and data processing.

2. The recognition of the need for science and scientific research to solve the problems of the world of tomorrow and of the developing countries, and therefore the importance of the preparation of scientists and technologists, especially in the developing countries.

3. The responsibility of scientists with regard to the improper use of science.

President Carlos Chagas summarized the session in a few pages, from which the following passage conveys the substance and spirit of the discussion: "The role and place of science in modern society seem

([1]) *Science and the Modern World.* Part I. Scripta Varia, *42*, 88 (1978).

clear. Its responsibility, which should never be restricted, is that of opening up new roads of knowledge, widening those already existing, and thus creating the only way which can allow mankind to face the material challenges of tomorrow. By its own strength science has become a component of our social and political structures, if not an asset".

Professor Chagas emphasized the fact that "the need or desire to keep a permanent and ever-expanding turnover of weaponries, and the supposed need to maintain an ever-developing economic expansion, without a profound regard for the real needs of the human condition, create forces restraining the freedom of science and its growth for the real benefit of man". From this comes the reaction of those who distrust science and technology, believing that science has done very little for the good of man, and therefore impose restrictions on the financing of basic research.

"Our profound belief in the importance of science", continues Chagas, "does not mean that we must not evaluate its role, its perspective in a political world, its position in relation to other forms of knowledge, its influence on daily life. On the contrary, it obliges us to find some way in which we can, by the advancement of knowledge, contribute to a harmonious world where the advancement of knowledge by itself is not considered a mere intellectual exercise and where the progress achieved by this advancement may contribute at least partly to meet the need of social justice" ([2]).

The most important aspect of the discussion was the recognition that if science is the work of man, man has value only in so far as it has that divine spark which makes him sublime in the various fields of faith, of art, of science. Scientific research has limits. Some negative aspects, which are the indirect result of scientific progress and of its technological applications, often become more evident, as for example environmental pollution, the uncontrolled use of renewable and non-renewable resources, the destruction of beautiful areas for unlimited urban and industrial establishments, not to mention military applications and ecological accidents.

Hence the need to set if not limits at least rules for scientific research, for example in experimentation with recombinant DNA, which could cause great dangers if not carefully disciplined. Research in the field of armaments and of distribution systems on the one hand, and

([2]) Scripta Varia, *42*, 7 (1978)

the little attention to foreseeing harmful effects of technological developments on the other hand, such as environmental pollution, lead scientists to discuss ethical problems which are faced by all scholars and researchers. Scientific research is a powerful instrument to resolve the problems of humanity, but it cannot be outside of an ethical and moral context which is the basis of our existence. It is in fact indispensable that the new discoveries be used to assure social justice and the welfare of humanity and of every single individual.

The second meeting on the same subject was held in October 1978 ([3]) and dealt with general problems of great interest, with presentations on specific subjects, followed by long and exhaustive discussions. The four principal topics were scientific research and scientific policy, science and the contemporary world, the limits of science, and finally the new frontiers of science, which are illustrated by an example of avant-garde research, the tridimensional structure of t-RNA ([4]).

The planning of scientific research and its advantages and disadvantages today emphasize the role of science in a modern economic system, a role which is all the more evident if we consider the scientific policy in various countries and the importance of its being the result of a dialogue between scientists and political leaders. We must remember especially that progress is achieved only via intermediary steps, often not foreseeable, which may subsequently give practical benefits, sometimes incidentally and unpredictably.

The function of science in the contemporary world, the second topic of the meeting, is essential, but scientific progress depends always more and more on large investments for innovative ideas. For this it is necessary also to prepare highly qualified researchers. The discoveries regarding the structure and the biological function of t-RNA — as described by Academician A. Rich and particularly in the genetic code — represent an example of what science has been able to do in recent years for an understanding of the most hidden mechanisms of life.

It may be concluded that the "central theme which was treated needs every day more reflection in order that the moral and spiritual values which upgrade human dignity do not become submerged by technical advances resulting from the stupendous progress made in recent years in the fields of basic science" (Chagas).

([3]) *Science and the Modern World.* Part II. Scripta Varia, *49*, 148 (1983).
([4]) Scripta Varia, *49*, 129-145 (1983).

The third meeting in 1979 on "Science and the Modern World" (5) treated topics of great importance, and in particular the origin and significance of the anti-scientific movement and science and the Third World. The first part of the discussion was centered on the present state and prospects of science, specifically of mathematics, astronomy, physics, chemistry and human genetics. These constitute an important critical contribution on a high level to a knowledge of the new tendencies of science and offer a broad basis for discussion of their implications on the future of men and their moral and ethical aspects.

These perspectives of science and its development were followed by a thorough examination of the anti-scientific movement, which is today widely diffused in the more advanced societies as a reaction to certain negative aspects of the applications of science such as the pollution of the environment, nuclear armaments, uncontrolled industrialization. These have brought accusations against science, not only technology, and caused the rise of movements for the defense of human and environmental values. In the discussions it became apparent that this emotional attitude does not take into account the real benefits which science has brought, with the battle against hunger, the increase of thirty years in the average lifetime during one century, improved living conditions, not to mention the fact that science itself can in many cases correct the negative effects of some of its hasty and less controlled applications.

Since the anti-scientific movement appeals to the enthusiasm of the young generations, the need was emphasized to increase more and more a knowledge of the principles of science and to raise the scientific cultural level.

The last topic of the meeting was science for the development of the Third World and the complex problems of the transfer, of science more than of technology, in order to meet the ever-increasing needs of development. Starting from the results of the broad discussion held at the United Nations Conference in Vienna in August of 1979 on the applications of science and technology to development, and especially on economic and structural conditionings which are opposed to definite progress, the Academy examined the function of the universities as stimulating bodies for development in the formation and the functioning of research to promote economic and social development.

The discussion of this problem indicated that the solution will be

(5) *Science and the Modern World.* Part III. Scripta Varia, *52*, 212 (1984).

found when these countries become able to manage independently their research and therefore their development. For this it is necessary to educate always more scientists and put them in condition to work in adequate research centers for their own countries.

This session too constitutes an important contribution of the Academy in establishing orientations for scientists towards the great problems which humanity must face in order to achieve its development.

V

BIOETHICS

Introduction

The developments of modern science, especially in the last few years, have touched upon some delicate aspects of modern life, which, if not guided by wisdom, can cause serious harm to society and the individual.

Science today finds itself facing ethical and moral problems such as never before. Among these we can identify two aspects: the first is the legitimacy of the harm which a new technology can cause to individuals or even to populations; for example, emissions from chemical products into the atmosphere or an increase in the level of radiation in waters or contamination in the factories. The second regards all the processes that can be activated in man based on the development of biotechnologies: these latter can go from organ transplants to the genetic manipulation of the embryo, or to the creation of mutants acting on the DNA, etc., and even the techniques of reanimation raise some questions, since the physician finds himself confronting a vegetative life which is maintained only if and so long as the machine functions.

It is indispensable that in all these problems there be an ethical and moral guide for the scientist.

On this subject the Pontifical Academy of Sciences has taken up various topics, with the collaboration of scientists and moralists, starting in 1974 with the study of genetic mutations in man, followed by that of biological experimentation in 1982. In 1983 they discussed, in connection with the optimization of the use of ionizing radiations, the problem of the adoption of a general criterion that would make it possible to establish acceptable limits for doses of radiation received especially by workers.

This criterion, it is obvious, can be applied to all industrial work

which involves some risk. Therefore, with the impossibility of having a zero risk, the need arises to establish as a criterion a cost-profit ratio, which implies also a moral aspect.

In 1984 the Academy held a Working Group on extracorporeal fecundation, and in 1985 they studied criteria to determine the exact moment of death.

Oriented Mutations in Man

The Working Group on "Oriented Mutations in Man" was held in 1974 at a particularly opportune but at the same time a delicate moment in the development of biomedical sciences (1). That year discussion had hardly begun on "genetic engineering", a combination of techniques which offered the possibility of modifying the DNA molecule, the macromolecule carrier of genetic information, and of breaking it up in order to isolate its individual genes, to transfer them from one cell to another even of very different species, thus modifying the genetic information of a given cell or of the subject itself. On the other hand, we had almost succeeded in the clarification of the techniques of fecundation *in vitro* even for man: we had achieved the possibility of developing human zigotes *in vitro*, up to the blastula stage and were hoping to better establish the optimal conditions for the transfer of the embryo into the maternal uterus in order to permit its development up to birth. The temptation to apply genetic engineering also to the zigote and to the human embryo could not fail to suggest itself, even quite forcefully, to many scientists.

Attention was drawn especially to the emerging problems of the easily foreseeable applications of the new technologies to the human species. It was quite obvious that these techniques were not yet developed enough to predict that their use could in a few years create serious risks for man and for human society, when genetic modifications would be produced in the human embryo by genetic engineering. However, it appeared very clear that the danger that that might happen exists and that its avoidance implies a very serious analysis of the direct and indirect moral responsibility of the experimenters.

It is difficult to say what reaction the results of this Working Group

(1) Chagas C., President of the Academy; De Duve C., Lejeune J., Marini-Bettòlo G.B., Nirenberg M.W., Ochoa S., Rovasenda (Di) E., Serra A., Visser J.

had in the international scientific community, but it is certain that there began to develop a notable awareness of the ethical aspects of the application of the new biotechniques, especially when it was obvious that their refinement and the possibility of their utilization were increasing so rapidly that the human embryo could no longer be safe from any type of biological manipulation, particularly genetic, and there was real danger of abuses both in the strictly scientific field and in the political-social one. Certainly, because of this awareness (to which the work of the Holy See has certainly and documentably contributed since they were familiar with the final document drawn up by the Group) parliamentary hearings took place and committees were established by many governments and international organisms to study the problems raised by the use of the new technologies.

Modern Biological Experimentation

The development which has taken place in recent years, especially in molecular biology, has substantially changed the picture of biological experimentation and opened the way to that ensemble of techniques which has come to be known by the general term biotechnologies. For example, genetic engineering can be used for the production of medicine, such as interferon, adopting techniques of recombinant DNA; it can be used for the modification of plant characteristics, etc. Monoclonal antibodies, tissue cultures, embryonic genetics are all basic achievements. Therefore it became necessary for the Academy to go deeper into such a complex subject, and this was done in October 1982 in a Study Week on "Modern Biological Experimentation" (2).

The subjects discussed went from the coding function of the RNA and DNA macromolecules in the synthesis of the basic proteins of living matter, to the problems of development and cellular differentiation; from the use of particular transfer systems for the creation of plant variations to the possibility of manipulating the chromosomes of microorganisms, of introducing a new gene in a genome as well as the utilization of these techniques in the occurrence of malignant tissues. Their

(2) Chagas C., President of the Academy; Alonso C., Carbon J., Davis R., Edwards R., Hammerling G., Illmensee K., Köhler G., Koprowski H., Lejeune J., Liley A.W., Mintz B., Nathans D., Ranzi S., Revel M., Saxen L., Scharfstein J., Schell J., Serra A., Singer M., Winocour E.

implications in genetics are numerous and sometimes preoccupying from the ethical point of view if not kept within their just limits.

This Study Week indicated that the interpretation of the vital processes requires a qualified and interdisciplinary cooperation. The topic was discussed in strictly scientific terms, as always, without preconceptions, for the sole purpose of arriving at the truth. Yet the concern over the wrong use of these techniques was not overlooked, especially in the case of genetic manipulations of man ([3]).

Ionizing Radiations in Man

The meeting of the Working Group in November 1975 on "The Effects of Ionizing Radiation in Man" organized by President Chagas ([4]) coincided with the moment in which a great amount of public opinion questioned directly or indirectly the adequacy of basic data in the field of human radiobiology and the general principles of radioprotection. In view of a possible future expansion of nuclear technologies for peaceful purposes, the principal objective of the meeting was that of a broad recognition of the existing data, in order to gather useful elements on which to base a judgment.

They discussed especially the reasons why the effects and the risks of radiation were the object of so much attention, while other human activities, which certainly involve much greater risks, are accepted without any apparent objection. Among the various reasons suggested, insufficient knowledge and unequal distribution of the risks and benefits were considered to be those that could cause the greatest difficulties to accepting them. A more rational approach to these particular situations and a comparative evaluation of the risks and benefits of possible alternative choices seemed to be the best way to avoid errors of judgment and evaluation of the relative problems.

In regard to the health hazards of exposure to radiation, the Group identified three types of effects: the immediate somatic ones, the delayed somatic effects, and the hereditary ones. It was concluded that in normal conditions the delayed and hereditary somatic effects were those of

([3]) Scripta Varia, *51*, XXVII-260 (1984), Edit. by C. Chagas.

([4]) Chagas C., President of the Academy; Beninson D., Jamet H., Lepine J., Silini G., Sowby D., Upton A.C.

greater interest. It was possible to establish a system of limitation of dosage based on quantitative evaluations.

In order to minimize the risks of exposure, the general principles of radioprotection recommended by the international organizations require that every source of radiation be justified, in the sense that from it is derived a net benefit for society; that the resulting collective dosage from each source be kept at the lowest possible level; and that the amount received by each individual exposed be limited accordingly. It was recognized that in conditions of normal functioning of the plants the practical measures that can be derived from these principles can assure a protective level for the workers at least equal to that of other industrial activities regarded as safe, and a level of protection of the population superior to that of many other activities of everyday life.

There were also discussed certain special aspects of the risk of radiation, such as those derived from accidents in the functioning of nuclear plants, or those related to the elimination of toxic radionucleides which have a long life.

It was the unanimous opinion that whenever it becomes necessary in the common interest to resort to further development of nuclear energy for pacific ends, the continuous and careful application of the generally accepted principles and practices of radioprotection can assure reasonably low levels of risk for the persons exposed, even permitting the carrying on of essential activities involving irradiation.

These conclusions make it possible to regard the basic information available as sufficient to assure an adequate degree of safety in the production of energy from a nuclear source.

Biological Aspects of Optimization of the Use of Ionizing Radiations

Technological development brings important benefits to humanity by improving living conditions; however, at the same time it increases the possibilities of risk for man.

The risk — despite continuous efforts to minimize it — must be accepted in activities which are indispensable for man's existence. It must be faced even in trying to produce a well-being which is not indispensable to human life itself, so long, however, as it is less than the benefit which it produces and an effort is made to keep it at a minimum. The problem arises when the risk-benefit ratio involves a risk that is equal or superior to the benefit.

The discovery of nuclear energy has led to discussion concerning the possible harm that can be caused by "ionizing radiations" which are inevitably present in the production of nuclear energy, but also in many other cases such as the use of x-rays, for example. As we know, ionizing radiations are harmful to man, and in the present state of our knowledge, the risk of harm does not have a "threshold"; that is, there is no dosage of ionizing radiation which, no matter how small, does not involve a possibility of harm to anyone exposed to it. This observation, which was made in the 50's, has led to the "acceptance" of a certain amount of ionizing radiations, with the relative risk involved, bearing in mind the considerable benefits of the use of nuclear energy.

The discussion of this subject was, and is, very intensive and complex on the international level, especially because there is not yet complete clarity on the scientific level regarding the ratio between the risk of harm and the amount of ionizing radiation received by the human body. This situation led the Academy in 1983 to hold a Working Group on the "Biological Implications of Optimization in Radiation Procedures" ([5]). The Group discussed the principles on which the criteria of radio-protection are based, which are:

1. Stabilizing for each individual dosage amounts which must not be exceeded;

2. "Optimization" of radio protection, that is, of technical procedures to reduce the risk. The principal function of the "optimization" consists in trying to reduce the doses established as limits;

3. "Justification", which means acceptance of the use of ionizing radiations because of the benefit produced, but in making this evaluation the benefits and risks must not be measured in quantitative, e.g., monetary terms;

4. Special consideration of doses in the "future" from radioactive products with a half life of hundreds or thousands of years, as is the case of radioactive residues from nuclear plants.

In conclusion, it is hoped that there will be further research on the subject, and the methodology used in radio protection is an example for the study of other analogous problems.

([5]) Chagas C., President of the Academy; Beebe G., Beninson D., Eisenbud M., Failla L., Jacobi W., Latarjet R., Lejeune J., Lindell B., Polvani C., Silini G., Sobels F.H., Sowby D.

It should be pointed out that the "cost-benefit" view, which means the "monetization" of human life and which is already being accepted in the non-nuclear context, is being practically replaced by the idea of "risk-benefit". Human life, however, cannot be evaluated in economic terms. This viewpoint has a fundamental ethical importance for all the problems of modern society which involve the use of dangerous substances or processes and the valuation of human life (6).

Extra-Corporeal Fecundation

Modern biological techniques have succeeded in recent years in producing fecundation *in vitro* for the human species. These results have had much publicity in the press and on television and have caused not a few problems of a moral and juridical as well as scientific nature. In order to study this question, a Working Group on "Extra-Corporeal Fecundation", attended by biologists, geneticists, ginecologists, and even moralists and philosophers, met in October 1984 at the Academy (7).

In vitro or extra-corporeal fecundation makes possible the birth of a child even in pathological conditions of the mother, especially in case of tubal obstruction, since it suffices to have contact *in vitro* between the ovule and the sperm. The embryo thus formed from this fecundation can then be replanted in the mother's uterus for a normal gestation.

The Working Group, after discussing the present state of research on the subject, affirmed that the embryo cannot be considered a simple mass of cells but a human being of great dignity, even if there has not yet been agreement on the exact moment the embryo can be considered as a person. It can never be used as experimental matter, and all the rules of medical deontology must be observed in this connection. For these reasons the Working Group rejected every technique which does not give the maximum possibility for the survival of every embryo and any experimentation on any embryo.

Some of the participants mentioned the moral and ethical problems related to the dissociation between the sexual act and procreation, but they did not arrive at any solution.

(6) Documenta, *14* (1985).

(7) Chagas C., President of the Academy; Baumiller R., Bompiani A., Caffarra C., Carenza L., Frydman R., Jones H.W. Jr., Jones Seegar G., Lejeune L., Serlupi G., Visser J., White R.J.

PONTIFICIAE ACADEMIAE SCIENTIARVM SCRIPTA VARIA

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WORKING GROUP

ON:

THE ARTIFICIAL PROLONGATION OF LIFE AND THE DETERMINATION OF THE EXACT MOMENT OF DEATH

October 19-21, 1985

EDITED BY

CARLOS CHAGAS

PONTIFICIA
ACADEMIA
SCIENTIARVM

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

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The Prolongation of Life and the Determination of the Exact Moment of Death

In recent years the use of instruments for reanimation has made possible for some patients the artificial prolongation of life. Moreover, the possibility of making transplants has raised the problem of determining the exact moment of death. In October 1985 the Academy organized a Working Group made up of biologists, physicians and moralists, to discuss deeply this subject ([8]).

Both the artificial prolongation of life and transplants raise scientific and moral problems. The Working Group considered it permissible to suspend reanimation treatments when spontaneous cardiac activity and the respiratory function have irreversibly ceased and when the functioning of the whole brain has irreversibly ceased. They established the criteria for the interpretation of instrumental data to determine the irreversible cessation of all cerebral activity and the method for effecting this control (the measurement of the brain's electric activity must be repeated at least twice with an interval of six hours); and they suggested norms for medical deontology in these cases.

They also discussed the problem of organ transplants, which are today possible due to the progress in surgery and immunology, and they concluded that these techniques should be encouraged, with due respect for the wish of the donor or of his relatives.

([8]) Chagas C., President of the Academy; Di Rovasenda P. Enrico, Director of the Chancellery; Dardozzi R., Co-Director of the Chancellery; Harvey J.C., Hossman K.A., Jatene A., Ingvar D.H., Lejeune J., Lemaire J.F., Lombardi Vallauri L., Manni C., Mathè G., Milhaud G., Pia W., Ponten U., Sgreccia E., Visser J., Walder A.D., White R.J., Wolff S.M., Zerbini S.J.

VI

THE HISTORY OF SCIENCE

Together with the discussion of the problems of contemporary science, the Academy has also promoted and conducted a series of studies of the work of scientists which represent a substantial contribution to knowledge of the history of science. This contribution can be divided into two parts: the first regards science in the Renaissance, the studies on Galileo and the work of Federico Cesi, founder of the original Lincei Academy, historical documents, many of which are in the Vatican Secret Archives and in the Apostolic Library, and finally the reform of the calendar and the manuscripts of scientists in the Apostolic Library. The second regards the work of contemporary scientists who have been part of the Academy: Marconi, Lemaître, Heisenberg, Gemelli, and Tiselius, etc. This comes from the testimony of other scientists, sometimes of quite notable scientific and historic importance — e.g., Lemaître, who describes the work of Charles Jean de la Vallée Poussin, his teacher, and that of the eminent physicist Lord Rutherford (1).

Galileian Studies

In the field of historical studies the Academy has from its early years developed a line of Galileian studies. On the third centenary of Galileo's death, in 1942 the Academy decided to publish a History of Galileo Galilei from a strictly scientific point of view. The task was assigned to Monsignor Pio Paschini, Professor of History at the Pontifical Lateran University, who produced, with great objectivity and precision, especially on the basis of original documents published in the national

(1) Commentarii, (I) *8* (1962); Acta, *13*, 93-96 (1949).

edition of Galileo's writings, a complete and exhaustive account of the life and work of the founder of modern science.

The war and the difficulties which followed, especially objections raised in religious and cultural circles, made impossible the publication of Paschini's work for the tercentenary. Ten years later this was taken up again by Father Edmond Lamalle, S.J. (Monsignor Paschini having died in the meantime), who published it together with two important essays, one by Vasco Ronchi on the telescope and one by Father Soccorsi, S.J., on the trial of Galileo. This was published by the Academy in 1954 in three volumes under the title "Galileian Miscellanea" (2).

This exhaustive work, intended to inform not only the scientific world but also the clergy, is an undertaking of the Academy which might be considered bold at the moment in which it was planned, but which instead was an objective reconstruction of the sometimes dramatic events which characterized the work and life of Galileo. The Academy's work on Galileo represents a step also in the development of historic studies which have led the Holy See to reexamine the position of this scientist with regard to his condemnation in 1633.

This initiative of the Academy and of its President Carlos Chagas was openly manifested by John Paul II in his speech in 1979 (3) on the commemoration of Einstein, when he said: "Permit me to present to your careful consideration some points which seem to me important to put a true light on the case of Galileo, on which the points of agreement between religion and science are more numerous, and especially more important, than the lack of understanding which caused the bitter and painful conflict which has lasted for centuries".

He who is rightly called the founder of modern physics declared very clearly that the two truths — faith and science — can never contradict each other, since both sacred Scripture and Nature come from the Divine Word, the former as the dictation of the Holy Spirit, and the latter as the very careful executor of God's orders, as he wrote in the letter to Father Benedetto Castelli of December 21, 1613 (national edition of the works of Galileo, vol. V, pp. 282-285). *Methodic research in every discipline, if it proceeds in a manner that is truly scientific and in accordance with moral norms, will never be in real contrast with faith*

(2) Paschini P., « Miscellanea Galileana », I-II. Scripta Varia, *27 a*, 721 (1964). Paschini P., Ronchi V. e Soccorsi F., *Idem*, III. Scripta Varia, *27 b*, 223 (1964).

(3) *Einstein* and *Galileo - Commemoration of Albert Einstein.* Libreria Editrice Vaticana (1979).

because profane realities and the realities of faith have their origin in the same God (Gaudium et Spes, No. 36).

Along the lines traced by the Pope, the studies on Galileo by the Academy and the special Committee led by Cardinal Garrone were developed in these years.

The Pontifical Academy, in collaboration with the Vatican Archives, has supervised the entire critical publication of the Proceedings of the Galileo trial, with a long introduction by Professor P. Sergio Pagano ([4]). Moreover, in order to provide information regarding the sources for the interpretation of Sacred Scripture by Galileo, the Academy published a profound study by Professor Rinaldo Fabris on the history of the biblical exegesis in the 16th and 17th centuries ([5]).

With the commemoration of Federico Cesi ([6]), the Academy wanted not only to remember its first founder, but also to add to a knowledge of the scientific environment and horizon of the first Lincei as well as the relations between Cesi and Galileo and the religious authorities of the time. In collaboration with the Vatican Library, it organized an exhibit of the Lincei documents in the Vatican Library, thus contributing to the understanding of a period of the history of science which was very interesting and fruitful although not always thoroughly studied and objectively related to the picture of the historic events of the time ([7]).

The History of Science in the 16th and 17th Centuries

Another important historic contribution of the Academy was the meeting on the fourth centenary of the Gregorian Reform of the Calendar, held in 1982, in collaboration with the Specola Vaticana ([8]). Its purpose was the critical review, based on the most recent scientific

([4]) *I documenti del processo di Galileo Galilei*, a cura di S.M. Pagano, Scripta Varia, *53*, XII-280 (1984).

([5]) FABRIS R., *Galileo Galilei e gli orientamenti esegetici del suo tempo*. Scripta Varia, *62*, 1-44 (1986).

([6]) DI ROVASENDA E. e MARINI-BETTÒLO G.B., *Federico Cesi nel quarto centenario della nascita*. Scripta Varia, *63* (1986).

([7]) *Catalogo della Mostra di Federico Cesi e i primi Lincei*, a cura di G. Morello. Accademia Pontificia delle Scienze e Biblioteca Apostolica Vaticana, Città del Vaticano, (1986).

([8]) Chagas P., President of the Academy; Baldini U., Bruck H.A., Bruck M.T., Casanovas J., Coyne G., Dobrzycki J., Fischer K., Gingerich O., Hoskin M.A., McCarthy M.F., Moesgaard K.P., Moyer G., Nobis H., North R.J., Pedersen O., Proverbio E., Russo F., Ziggelaar A.

findings, of the work carried on in that connection and to lay the foundation for further studies and research. The fundamental concepts on which the calendar is based were studied, as well as the historic events which implied the interactions of various institutions: social, economic, religious and political. There was also analyzed the contribution of some of the principal protagonists of the Gregorian Reform of the Calendar: Cristoforo Clavius, Aloysius Lillius and Ignazio Danti.

In the meeting some important aspects of the Ecclesiastic Calendar in the life of the Church were brought out, as well as the negative reactions to this reform during four centuries. Another aspect was the reform decree and the astronomic bases of the calendar.

The volume of the proceedings ([9]) of this Working Group was extremely well received by the critics, who judged it "an essential and fascinating work for all those who are interested in the calculations and the evolution of calendars" and also "the best work in English in this field" for the wealth of information and the excellent clarity of its presentation, "which constitutes thus a fundamental document for the history of science".

In the field of the history of the sciences the Academy has also published the letters of scientists in the Secret Vatican Archives, taken from a Codex of the Vatican Library ([10]). This is an excellent work by Cardinal A. Mercati, Pontifical Academician. The letters are by Ulisse Aldrovandi, Nicola Stenone, I.D. Cassini, G. Morgagni, Ruggero Boscovich, A. de Dolomieux and S. Canterzani, among others. Another monograph by Mercati is devoted to the writings of Lazzaro Spallanzani ([11]). There is also the correspondence of Antonio Vallisnieri and of the German physicist G.M. Bose, which are documents of great scientific and historic importance ([12]).

For the centenary of Father Angelo Secchi's death, the Academy wished to honor his work in a memorial session organized by Academician Brück. The commemoration volume contains a series of important

([9]) *Gregorian Reform of the Calendar.* Proceedings of the Vatican Conference to commemorate its 400th anniversary (1582-1982). Edit. by G.V. Coyne, M.A. Hoskin and O. Pedersen. Academia Pontificia Scientiarum - Specola Vaticana, XXIV-322 (1983).

([10]) MERCATI A., *Lettere di Scienziati dall'Archivio Segreto Vaticano.* « Commentationes », (V) 2, 61-210 (1941).

([11]) MERCATI A., *Lettere dell'Abate Lazzaro Spallanzani.* « Commentationes », (III), 693-719 (1939).

([12]) MERCATI A., *Briciole della corrispondenza di Antonio Vallisnieri.* Ibidem (VII), 783-881 (1941).

data for the history of the sciences in Father Angelo Secchi's works on the classifications of stars and a knowledge of the sun ([13]). Father Secchi was President of the Pontifical Academy of the New Lincei from 1874 to 1878.

Among the other eminent scientists the Academy wanted to remember the work of Father Giuseppe Gianfranceschi on the 50th anniversary of his death, in a work by Father Enrico di Rovasenda, which describes how the physicist Gianfranceschi with new experiments on the fall of weights confirmed Galileo's intuition of the earth's rotation ([14]).

Contemporary Science

In the field of contemporary history, the Academy has made its greatest contribution. Mention should be made especially of the studies and writings in honor and memory of its first two Presidents, Agostino Gemelli and Georges Lemaître, which deal with the life and scientific work of these two eminent scholars by various authors who have commemorated them or described the most important results of their scientific work.

The work on Father Gemelli appeared on the tenth anniversary of his death in 1969 and contains, besides the papers of numerous Academicians, the words of Cardinal G.B. Montini, then Archbishop of Milan, and others who were close to Gemelli ([15]).

The volume published on the fifth anniversary of the death of Monsignor Lemaître ([16]) contains his most important writings, together with a thorough analysis of his scientific work, by Academician Dirac. The scientific and moral figure of Lemaître is also reflected in the

([13]) BRÜCK H.A., *P. Angelo Secchi.* « Commentarii », (III) *22* (1979).

([14]) DI ROVASENDA P. ENRICO, *P. G. Gianfranceschi S.J., Presidente della Pontificia Accademia delle Scienze - Nuovi Lincei.* « Commentarii », (III), *13* (1975).

([15]) SALVIUCCI P., *En Mémoire du Rev. Père Agostino Gemelli à l'occasion du dixième anniversaire de sa mort.*

a) Editio extra seriem, 1-112 (1969).

b) *Mnemosynon.* Editio extra seriem, 1-40 (1969).

c) *L'Académie Pontificale des Sciences en mémoire de son premier Président Agostino Gemelli à l'occasion du dixième anniversaire de sa mort.* Scripta Varia, *34*, 1-268 (1970).

([16]) SALVIUCCI P., *L'Académie Pontificale des Sciences en mémoire de son second Président Georges Lemaître à l'occasion du cinquième anniversaire de sa mort.* Scripta Varia, *36*, 1-298 (1972).

magnificent article by his collaborator O. Godart and later in another memoir based on the unpublished writings of O. Godart and M. Heller ([17]).

The figure and work of Guglielmo Marconi, who was also among the first members of the Academy, have been more closely studied through the work of Academicians Vallauri ([18]), Lombardi ([19]) and Bjerknes ([20]). In 1974, the centenary of Marconi's birth, the Academy held a solemn commemoration with a talk by Academician G.B. Marini-Bettòlo ([21]), in the presence of Pope Paul VI and numerous Cardinals, civic authorities and a large group of scientists and men of culture.

A volume entitled "Heisenberg's Influence on Physics" ([22]) is a work of great scientific and epistemological value, almost biographical, in which Dirac relives in the first person the conceptual revolution, which occurred at the end of the 1920's, regarding the structure of the atom. The introduction by Heisemberg of new mathematical instruments, such as non-commutative algebra, is for Dirac "a solution so far from common sense that one wonders how a human mind, even that of a genius, can have thought of it". And again from Dirac and Heisenberg: "He has had an extraordinary influence on the entire course of atomic physics, but especially he gave me the cue which put me on the right road and changed all my work on atomic theory". These are beautiful and very clear pages, in which we read of the effort of scientists in the 1920s to give a rational explanation of the atom.

Of the work of Einstein, Dirac gave a concise and profound analysis during the commemoration of this great scientist in 1979, showing how in the theories of Einstein are found "*in nuce*" all the latest developments of modern physics, such as, for example, the existence of anti-matter, "a direct consequence of the restricted relativity of Einstein". On that occasion President Chagas and Victor Weisskopf described the life and the personality of Einstein, his influence on the world of today, and his scientific work ([23]).

([17]) *Les relations entre la science et la foi chez Georges Lemaître.* « Commentarii », (III), *21* (1974).

([18]) VALLAURI G., *Guglielmo Marconi.* « Acta », *13*, 75-86 (1949).

([19]) LOMBARDI L., *La vita e l'opera di Guglielmo Marconi.* « Commentationes », *6*, 1031-1078 (1941).

([20]) BJERKNES W.F.L., *Guglielmo Marconi.* « Acta », *13*, 87-92 (1949).

([21]) MARINI-BETTÒLO G.B., *Commémoration de Guglielmo Marconi.* « Commentari », *3*, (III) (1975).

([22]) DIRAC P.A.M., « Commentarii », *14*, (III) (1976).

([23]) P. DIRAC, C. CHAGAS, V. WEISSKOPF, *Einstein and Galilei.* Lib. Editrice Vaticana, 1969.

Solemn Session of the Academy in the presence of Paul VI for the Commemoration of the centenary of the birth of Guglielmo Marconi (November 13th 1974).

VII

SCIENCE FOR PEACE

The threat of nuclear war has been a constant preoccupation of pontifical teaching. Pius XII expressed apprehension regarding the wrong use of nuclear energy and deplored the events of Hiroshima and Nagasaki. John XXIII (1) declared that in times of atomic armaments war is not a means suited to solving disagreements. Paul VI on more than one occasion stressed the danger of recourse to nuclear armaments.

The problem of the abnormal increase of nuclear armaments, especially in the arsenals of the two superpowers, has for many years disturbed the world scientific community, as the specter of an atomic conflict appears always more dreadful. Because of their responsibility in having created these armaments, because of what a nuclear war would mean for the future of humanity, the possibility of errors in a control system no matter how perfect, and especially the immense reserves of fissile material, equivalent in power to three tons of the most powerful conventional explosive, TNT, for every inhabitant of the earth, the scientists regarded the threat of a nuclear conflict as the gravest problem to be faced for the future of humanity. The Academy could not remain indifferent to the preoccupations not only of the scientists but of the whole world.

In the autumn of 1979 President Chagas discussed this with Academicians Weisskopf and Leprince-Ringuet, two nuclear physicists of great prestige, and in a letter to the Holy Father expressed his great preoccupation and that of the scientists for what was developing in the world.

In January 1980, in the celebration of the Day of Peace, John Paul II sent an appeal to the nuclear powers stressing their responsi-

(1) Enciclica *Pacem in terris*, n. 67. « Acta Apostolicae Sedis », *55*, 291 (1963).

bilities to humanity. Following the Holy Father's appeal, the Academy began to study the possibilities of strictly scientific research on the effects of a nuclear war for both man and the environment.

In April 1980 the Academy's President organized a Working Group of Academicians and outside experts to focus on the problem of nuclear armaments. This meeting, which also evaluated the problem of conventional armaments, was attended by Professor Chagas and Academicians Lejeune, Brück, Lambo, Leprince-Ringuet, Marini-Bettòlo, Tuppy, Weisskopf as well as experts like Professor York of San Diego, Professor Emilio Segré of Berkeley, Professor Von Weizsacker from Hamburg. A document was drawn up establishing some key points regarding the present state of nuclear armaments and the dangers they represent. The Group was received by the Holy Father, who was pleased with the work accomplished and spoke with the participants individually in a round table discussion about the main aspects of the report. The addresses by John Paul II at UNESCO in June 1980 and at Hiroshima in February 1981 are based also on data included in this report.

The Academy is pledged to find a way to collaborate with the world scientific community to stress the consequences of a nuclear war. The sacrilegious attack against the Holy Father in May 1981 made it necessary to postpone until October of the same year the meeting of a Working Group of Academicians and others including one Soviet scientist ([2]), which concluded by preparing a "Statement of the Consequences of the Use of Nuclear Weapons" ([3]). This is a scientific and ethical document, far from any political purpose. It thoroughly examines the effects on the population and on individuals of the explosion of an atomic bomb. The spirit of the document is clear from the words: "Although most of the consequences of the explosion of a nuclear bomb would appear obvious, it seems that they are not adequately appreciated. The conditions of life following a nuclear attack would be so severe that the only hope for humanity is the prevention of any form of nuclear war".

"By making known these consequences all over the world, it can be shown that nuclear arms must never be used in case of war and that their number must therefore be reduced progressively in a balanced way".

([2]) Chagas C., President of the Academy; Amaldi E., Bochkov N., Caldas L., Hiatt H., Latarjet R., Leaf A., Lejeune J., Leprince-Ringuet L., Marini-Bettòlo G.B., Pavan C., Rich A., Serra A., Weisskopf V.

([3]) *Statement of the Consequences of the Use of Nuclear Weapons.* « Documenta », *3* (1981).

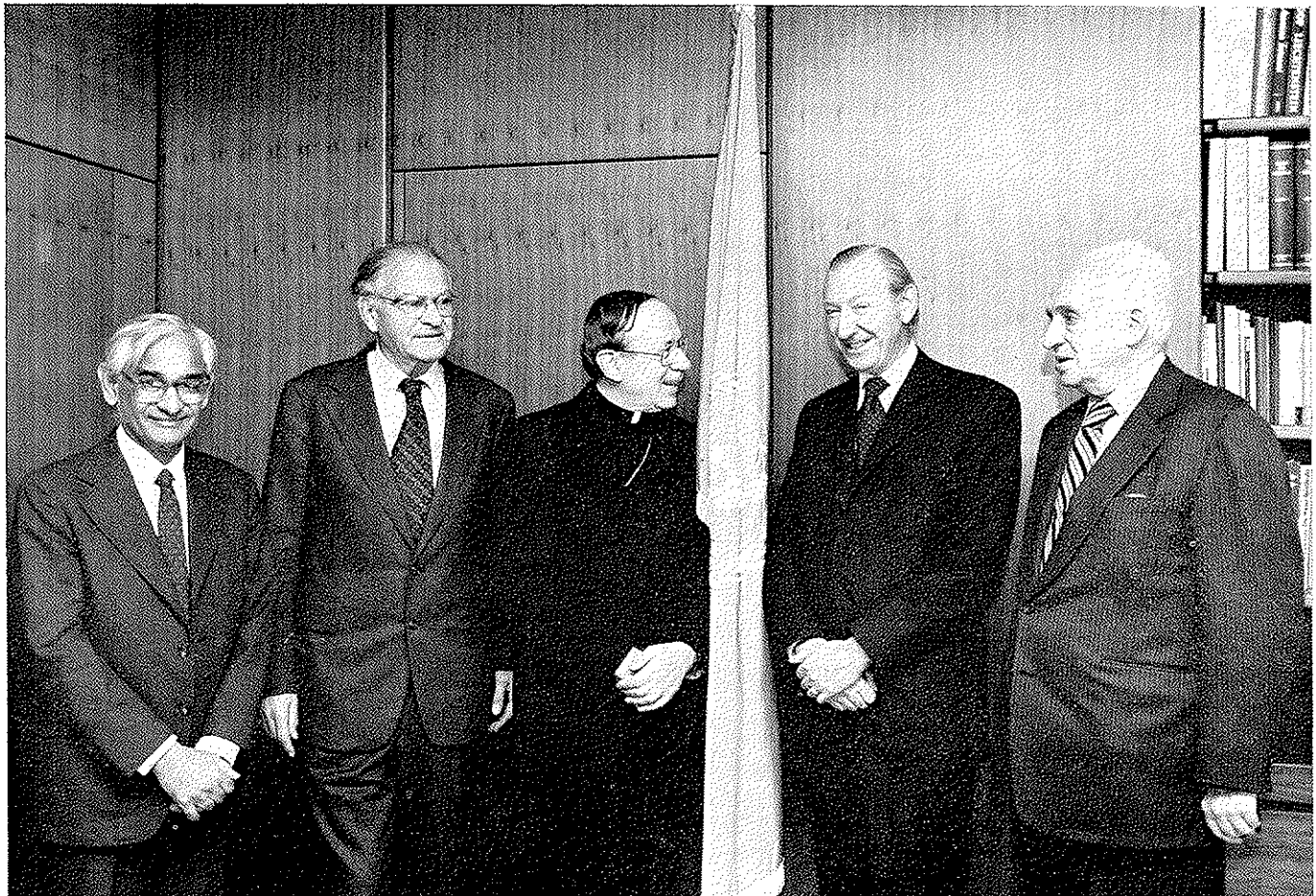
The scenario which the document seeks to set up is based on what happened at Hiroshima and Nagasaki in 1945, and considerations of the present possibilities which medical science offers to deal with the effects of a nuclear explosion on humanity. The document states that the use of explosives several orders greater than the first atomic bombs (they have now increased from 15,000 tons to the equivalent of a million tons of TNT) would have tremendous effects: an estimate of 250,000 deaths for a city of 2 million inhabitants, and 500,000 severely injured or burned, for whom medical science can do nothing — even if all the hospital structures were efficient — based on the daily experience of what happens today for the seriously burned. All this without mentioning the destruction and the long-term effects such as radioactive contamination of the atmosphere, of water and of food.

The document takes a very high moral stand in its conclusion. "Our knowledge and credentials as scientists and physicians do not of course permit us to discuss security issues with expertise. However, if political and military leaders have based their strategic planning on mistaken assumptions concerning the medical aspects of a nuclear war, we feel that we do have a responsibility. We must inform them, we must inform the whole world, of the complete clinical situation that would follow a nuclear attack and of the impotence of the medical community to offer a valid response".

The document drawn up and approved unanimously by the Working Group of October 1981 was communicated to the Holy Father, who decided that it was important to appeal to the conscience and sense of responsibility of the heads of states having atomic arsenals as well as those of other nations. In fact the Holy Father, in receiving the participants recalled the statement of February 25, 1981, on Hiroshima, which had stated that "a pluridisciplinary study will certainly be for the heads of state a reminder of their tremendous responsibilities, giving humankind an ever more ardent thirst for harmony and peace".

Consequently, at the request of the Holy Father, the Academy sent five delegations: to the United Nations in New York, to London, Moscow, Paris and Washington to meet the heads of state and present and explain the Academy's document on the use of nuclear arms (4).

(4) On December 14, 1981, Victor Weisskopf, Marshall Niremberg and David Baltimore, accompanied by the Pro-Nunzio Monsignor Pio Laghi, presented the document in Washington in a brief interview granted to them by President Ronald Reagan. The Academicians were accompanied by Dr. Howard Hiatt, Director of the School of Public



U.N. General Secretary K. Waldheim receives the delegation of the Pontifical Academy of Sciences for the presentation of the Document on the consequences of the use of nuclear weapons. (from the left: Khorana, Weisskopf, Mons. Cheli, Waldheim and Ochoa).

The international steps taken by the Academy were a historic event of great importance and a universal appeal to the world leaders on a scientific level.

The Church, with its high moral authority and on the basis of its high scientific standing, appealed to those having the destructive power of atomic arms to reflect on the effects of the use of such armaments, thus assuming a decisive position to avoid the holocaust which threatens humanity. The Academy officially informed the holders of nuclear power of the situation humanity would face in case of a war.

Now the initiatives for peace are seeking a broader base. The action promoted by the Cardinal Archibishop of Vienna, His Eminence König, to bring closer together the positions of East and West also supports that of the Academy. Together with Cardinal König at Vienna in February 1982, President Chagas met with the Russian Academicians Velikhov and Skriabin, and in this meeting it was decided to convene a limited group of scientists in London in March 1982 to prepare the draft of a declaration on the consequences of nuclear war. The text was reviewed and discussed by the Working Group on "Peace and the Rights of Man" held at the Academy on June 9-11, 1982 ([5]).

The conclusion was that against the consequences of a nuclear war

Health of Harvard University and author of one of the documents that had served as a basis for the one prepared by the Working Group of the Academy.

On December 15, 1981, the then President of the General Assembly of the United Nations, Ambassador Kittani of Iraq, and the U. N. Secretary General received the document from the Pontifical Academicians Victor Weisskopf and Severo Ochoa, they too accompanied by Dr. Howard Hiatt.

On December 15, 1981, Academicians G. B. Marini-Bettòlo, member of the Academy's Council, and Jérôme Lejeune went to Moscow, where they delivered and explained the document to President Leonid Breznev. There were present on the Soviet side Academician Bochkov of the Soviet Academy of Medicine, who had taken part in its preparation in the Working Group, and Academician E. Chazov of the USSR Academy of Sciences.

On December 16, 1981, Academicians Leprince-Ringuet, of the Academy's Council, Lépine, Blanc-Lapierre, and the Chancellor Father di Rovasenda, accompanied by the Apostolic Nunzio His Excellency Monsignor Felici, presented the document to President Mitterand.

On December 18, 1981, President Carlos Chagas, together with Academicians Herman Brück of the Academy's Council and Max Perutz, were received by Mrs Margaret Thatcher, Prime Minister of the United Kingdom. In presenting her with the document, President Chagas stressed the Academy's desire to alert the nations regarding the catastrophe of a nuclear war.

([5]) Chagas C., President of the Academy; Amaldi E., Benvenuti F., Bykov O., Kastler A., Keeny S.M. jr., Lejeune J., Leprince-Ringuet L., Malone T.F., Marini-Bettòlo G.B., Puppi G., Rossano Mons. P., Townes C., Velikhov Y., Weisskopf V.

PONTIFICIAE ACADEMIAE SCIENTIARVM DOCVMENTA

4

DECLARATION ON PREVENTION OF NUCLEAR WAR

(Text in English, French and Italian)

September 23-24, 1982

PONTIFICIA
ACADEMIA
SCIENTIARVM

EX AEDIBVS ACADEMICIS IN CIVITATE VATICANA

MCMLXXXII

The text of the *Declaration on prevention of Nuclear War* published in Documenta.

science cannot offer the world any really adequate defense to protect the cities and populations. While fear and suspicion increase among nations and there is no serious dialogue between East and West, the Working Group of the Academy agrees on the principles of the document to be submitted to the approval of the Presidents of the Academies of Science of the whole world. President Chagas takes the initiative of sending the text agreed upon to the Presidents of the Academies of Science, with an invitation to come to Rome in September to discuss and approve the final document ([6]).

The date was selected in agreement with the National Academy of Sciences known as the XL, which had already invited the scientific academies of the world to attend the celebration of its bicentenary ([7]). The sessions of September 23 and 24 at the Academy in the Holy See were attended by the Presidents of 35 Academies from every part of the world, including international scientific organizations (ICSU, Pugwash), represented by 61 persons ([8]). In its final session the meeting made an appeal which was firm and anxious. The title was "Declaration on the Prevention of Nuclear War", and it was substantially different from the earlier one in its approach. It began with the data previously discussed: "Science cannot offer a truly effective defense against the consequences of a nuclear war. It is impossible to set up a sufficiently effective defense to protect the cities since the penetration by a single nuclear weapon can cause massive destruction". This declaration is still valid today even if a space shield is being planned. The document is moral in nature and political in some aspects, even if this description has no indication of partisanship; it is an impartial document, born in the Pontifical Academy of Sciences with the cooperation of representatives of science from countries of the East and the West, who participated in the signing and its presentation to the Pontiff, and it is addressed to all the world.

([6]) *Declaration on Prevention of Nuclear War*. « Documenta », *4* (1982).

([7]) *Memorie*, « Accademia Nazionale delle Scienze detta dei XL », *101* (1983).

([8]) E. Amaldi (Italy), I. Badran (Egypt), A. Balevski (Bulgaria), D. Baltimore (USA), A. Bekoe (ICSU), F. Benvenuti (Italy), C. Bernhard (Sweden), O. Bikov (USSR), B. Bilinski (Poland), C. Chagas (Brazil), E. De Giorgi (Italy), B. Dinkov (Bulgaria), G. Hambraeus (Sweden), T. Hesburgh (USA), H. Hiatt (USA), D. Hodgkin (PUGWASH), S. Hsieh (Taipei), A. Huxley (UK), S. Iijima (Japan), S. Isaev (USSR), P. Jacquinot (France), W. Kalweit (GDR), M. Kazi (Pakistan), S. Keeny (USA), K. Komarek (Austria), F. König (Austria), J. Labarbe (Belgium), J. Lejeune (France), L. Leprince-Ringuet (France), L. Levi-Montalcini (Italy), M. Tora-Tamayo (Spain), T. Malone (USA), G.B. Marini-Bettòlo

The position taken by the Academy together with the other scientific academies of the world, is perfectly legitimate and timely, because the use of nuclear energy for war purposes, which began in the 1940s, is due especially to the work of scientists, and the scientists today feel very heavily this responsibility. Thus the ethical aspect of the document is based on the solemn affirmation: "It is the duty of scientists to help prevent the perversion of their achievements and to stress that the future of mankind depends upon the acceptance by all nations of moral principles transcending all other considerations. Recognizing the natural rights of humans to survive and to live in dignity, science must be used to assist humankind towards a life of fulfilment and peace".

The declaration continues with a warm appeal to the governments and the peoples of the world: "The catastrophe of a nuclear war can and must be avoided. Leaders and governments have a grave responsibility in this, but it is all of humanity that must take action for its survival. It is the greatest moral challenge that humanity has ever faced and there is no time to lose".

This first part of the declaration, which has a high moral content, is followed by a series of technical and political recommendations in parts II and III. These recommendations, which respond to the reasonable entreaties of the scientists of the various countries, are aimed at reducing the tension among nations and especially the suspicion and fear which encourage the mad rush toward nuclear armaments.

Part IV expresses a very noble invitation with a strong ethical content, addressed to the heads of state, to scientists, to the religious, and to all peoples: " 1) To national leaders, to take the initiative in seeking steps to reduce the risk of nuclear war, looking beyond narrow concerns for national advantage; and to eschew military conflict as a means of resolving disputes. 2) To scientists, to use their creativity for the betterment of human life, and to apply their ingenuity in exploring means of avoiding nuclear war and developing practical methods of arms control. 3) To religious leaders and other custodians of moral principles,

(Italy), S. Mascarenhas (Brazil), M. Menon (India), G. Montalenti (Italy), R. Peierls (UK), M. Peixoto (Brazil), J. Peters (Belgium), G. Porter (UK), F. Press (USA), G. Puppi (Italy), B. Rifai (Indonesia), W. Rosenblith (USA), P. Rossano (Italy), P. Rudomin (Mexico), B. Rysavy (Czechoslovakia), I. Saavedra (Chile), V. Sardi (Venezuela), T. Shin (Korea), E. Simpson (South Africa), J. Sirothovič (Yugoslavia), L. Sosnovski (Poland), A. Stoppani (Argentina), J. Szentágothai (Hungary), S. Tanneberger (GDR), C. Townes (USA), E. Velikhov (USSR), W. Watts (Ireland), V. Weisskopf (USA), K. Weizsäcker (FRG).

to proclaim forcefully and persistently the grave human issues at stake so that these are fully understood and appreciated by society. 4) To people everywhere, to reaffirm their faith in the destiny of humankind, to insist that the avoidance of war is a common responsibility, to combat the belief that nuclear conflict is unavoidable, and to labor unceasingly towards ensuring the future of generations to come".

The Academy, in promoting the debate on the use of nuclear arms, at first limited to a few experts and then extended on an ever wider scale until it involved the Presidents of all the science academies of the world, has rendered a valuable service to humanity. Its position, far from one of partiality or ambiguously neutral or propagandistic — with its high moral and scientific authority representing the opinions of world scientists — takes on a historic significance. The very fact that the Holy Father in 1981 asked the Academicians and collaborators participating in these studies to go to the heads of nations possessing nuclear arms and to point out the problem and present the Academy's document, is extremely significant, as is the fact that the results of these studies have been taken up by John Paul II and transformed into strong and earnest messages to all peoples. The opening of discussions on a moral basis between scientists of various nations indicates the path to be followed to overcome diffidence and fears. Today the number one problem for the future of man on earth, beyond the insufficiency of energy sources and contamination of the environment, is the impending danger of a holocaust in case of the evasion of control of destructive energy so madly accumulated in the world during the last twenty years.

It can be said that the commitment of science for peace finds its strongest expression in the address which John Paul II made on November 13, 1983, to the scientists who met in the Plenary Session on the subject "Science for Peace" (9). On this occasion the Pope emphasized to the scientists the importance of a science which builds peace: "Truth, freedom, justice and love: such, Gentlemen, must be the cornerstones of the generous choice of a science that builds up peace. These four values, the cornerstones of science and of the life of civilized society, must be at the basis of that universal call of scientists, of the world of culture, of the citizens of the world, which the Pontifical Academy of Sciences, with my full and convinced approval, desires to address to the world for the reconciliation of peoples, for the success of the only war

(9) « Documenta », *15* (1983). Scripta Varia, *65* (1986).

President Chagas, address to Pope John Paul II at the Solemn Audience during the Plenary Session of the Academy of *Science and Peace* (November 13th 1983).

that must be fought: the war against hunger, disease and the death of millions of human beings whose quality and dignity of life could be helped and promoted with seven per cent of the amount spent each year for the incessant and threatening rearmament of the richest nations".

The Pope enlists the Academy in this action, urging them: "It is an irreplaceable task of the scientific community to ensure, as is your intention, Mr. President of the Pontifical Academy of Sciences, that the discoveries of science are not placed at the service of war, tyranny and terror. The intention to direct science to the promotion of justice and peace demands a great love for humanity".

* * *

Nuclear winter

In the studies carried on in various countries, especially with mathematical models, there arose, in 1980, the knowledge of the danger of the consequences of a nuclear war not only for man and objects but also for the environment. These studies led to the admission that, where an explosion of about one-third of the present nuclear arsenal of the world might occur, there would be immissions into the atmosphere of dust, smoke and soot, the latter two due to the fires caused by nuclear explosions. The mass of the suspended material would create a cloud around the earth which would hinder the passage of a large part of the sun's radiation. As a result there would be a considerable decrease in temperature, the so-called Nuclear Winter, and the hindering of photosynthesis in plants, and for several months there would be no vegetation in the regions of the earth darkened by the cloud, thus making survival in any form difficult. On this subject the Academy in January 1984, under the direction of President Chagas, held a Working Group composed of scientists from all parts of the world ([10]). The conclusions were the subject of a document which makes one stop to think about the future of humanity: "Effects of a Nuclear Explosion on the Atmosphere (Nuclear Winter, a Warning)" ([11]).

([10]) Chagas C., President of the Academy; Alexandrov V., Amaldi E., Beninson D., Crutzen P.J., Ernster L., Fiocco G., Gould S.J., Godemberg J., Isaev S.N., Latarjet R., Leprince-Ringuet L., Sagan C., Schaerf C., Shoemaker E.M., Townes C., Velikhov E.P., Weisskopf V.

([11]) « Documenta », *11* (1984).

Arms and Space

The peaceful use of space, as was shown during the Study Week devoted to this subject in October 1984 ([12]), brings many benefits to humanity, whereas the transfer of armaments into space would raise many questions and dangers.

In view of the United States defense plan known as the Strategic Defense Initiative (SDI) and its scientific, and technological implications especially for peace in the world, the Academy in January 1985 invited experts from various countries, including USSR and the United States, to come to Rome for an objective study of the situation. The Working Group ([13]), under the guidance of President Chagas, examined the problems from the scientific technical point of view and also on the basis of the present international treaties.

It soon became evident how vulnerable peaceful satellites, as well as those seeking military information, are to means of destruction. Therefore a study was made of earth-based systems capable of intercepting and destroying in flight, missiles and so-called ABM systems (Anti-Ballistic Missiles) and their partial effectiveness was acknowledged. The development of technologies today leads one to think that it is possible to produce a system of interception and destruction of missiles based on a system of global defense which nevertheless uses space. That would be possible with advanced systems using powerful lasers, space mirrors located on stations — with adequate systems of defense — in orbit or to be launched for the occasion, and by utilizing space as an intermediate phase for the destruction of missiles in flight. This would create a considerable defense potential, but its efficiency statistically will always be less than 100% and therefore it is feared that this system would lead not to a reduction in the number of nuclear missiles but to an increase in order to penetrate more easily the new defenses with a greater number of offensive instruments.

It is believed that the realization of a unilateral system of defense, even if not 100% effective, could change the present strategic equilibrium

([12]) Pag. 119.

([13]) Chagas C., President of the Academy; Abragam A., Amaldi E., Bertotti B., Canuto V.M., Chevalier R., Coyne G., Crutzen P., Ernster L., Fubini E.G., Garwin R.L., Gverdtseteli I.G., Hesburgh T.M., Keeny S.M. jr., Kulik S.A., Latarjet R., Leprince-Ringuet L., Levi-Montalcini R., Marini-Bettòlo G.B., Mayor F., Murphy W., Panofsky W.K.H., Sagdeicov R., Vasiliev A.A., Zraket C.A., Weisskopf V.

of the powers, thus creating a state of crisis. However, this system could not begin to function without ten or fifteen years of previous study and research; but peace cannot wait.

The Working Group believed that in the interest of peace, aside from scientific and technical considerations, it is necessary to avoid the transfer of armaments into space and hoped it will be possible to make new international agreements.

* * *

The problems of controlled disarmament and peace are still today very far from being solved. The Academy is and always has been open as an international forum to all scientific initiatives which can lead to the welfare of man and especially to that irrepressible blessing that is Peace. However, the fact that in meetings between superpowers (at Geneva in November 1985) there was mentioned the impossibility of nuclear war because it would lead to the self-destruction of humanity, is already success on the part of the Academy's work in this field, as well as that of other institutions which at present are engaged in this cause, on the basis not only of moral considerations but especially of irrefutable scientific data.

PART III

THE FIFTIETH ANNIVERSARY CELEBRATIONS

On October 27-30, 1986, fifty years after the renewal of the Pontifical Academy of Sciences, a Plenary Session was held, which because of the occasion was a solemn meeting. Besides the Academicians, outstanding personalities in the scientific world and winners of the Pius XI Gold Medal were invited, as well as the Presidents of Academies of Sciences from all over the world.

At the inaugural session, with Dr. Carlos Chagas presiding, fifty-seven Academicians (1) were present. There was a commemoration of the Academicians deceased since the last Plenary Session in November 1983. Martin Ryle was commemorated by H.A. Brück, A. Hurtado by H. Croxatto, G. Colombo by G. Puppi, P. Dirac by C. Rubbia, A. de Almeida by Carlos Chagas, G.B. Bonino by G.B. Marini-Bettòlo, G. Moruzzi by R. Levi-Montalcini, and A. Szent-Györgyi by H. Tuppy. Just before the meeting it was learned that Academicians A. Szent-Györgyi and E. Doisy had passed away the day before.

The ceremony was followed by the presentation of the Apostolic Briefs and the gold chain to the following new Academicians as well as a brief summary of their scientific research: Sune BERGSTRÖM, Nicola CABIBBO, Albert ESCHENMOSER, Kenichi FUKUI, Paul GERMAIN, Stephen HAWKING, Beatrice MINTZ, Marcos MOSHINSKY, Czeslaw OLECH, John C. POLANYI, Vladimir PRELOG, Carlo RUBBIA, Kai SIEGBAHN, Maxine SINGER, and Walter THIRRING.

Then the delegates from the various Academies of Science were greeted by President Chagas and presented messages from their Acad-

(1) Abragam A., Anfinsen C., Arber W., Bergström S., Blanc-Lapierre A., Bruck H., Cabibbo N., Chagas C., Croxatto H., De Duve C., De Giorgi E., Döbereiner J., Eccles J., Eigen M., Eschenmoser A., Fukui K., Germain P., Hawking S., Herzberg G., Lejeune J., Lépine P., Leprince-Ringuet L., Levi-Montalcini R., Lichnerowicz A., Lojasiewicz S., Malu W., Marini-Bettòlo G.B., Menon G., Mintz B., Moshinsky M., Mössbauer R., Olech C., Pavan C., Perutz M., Polanyi J., Porter G., Prelog V., Pullman B., Puppi G., Rasetti F., Rich A., Rubbia C., Runcorn S., Salam A., Sela M., Siddiqui S., Siegbahn K., Singer M., Szentágothai J., Thirring W., Townes C., Tuppy H., Ubbelohde A.; Ranzi S., Boyle L., Coyne G., Metzler J.

PONTIFICIA ACADEMIA SCIENTIARVM

FIFTIETH ANNIVERSARY
AND
PLENARY SESSION

October 27th - 30th, 1986

CINQUANTIÈME ANNIVERSAIRE
ET
SÉANCE PLÉNIÈRE

27-30 Octobre 1986

PONTIFICIA
ACADEMIA
SCIENTIARVM

The programme of the Plenary Session on the Fiftieth Anniversary.

The Academy's Fifty-year Commemorative Medal.

emies. They were called in the order of the date of the founding of the Academy they represented, beginning with Professor Francesco Gabrieli, President of the National Academy of the Lincei (which was founded in 1603) (see Table 1).

Each President or delegate received from President Chagas, together with his thanks, a medal which was coined for the commemoration of the Academy's 50th anniversary and has on one side a view of the Casina Pio IV, the inscription Pontificia Academia Scientiarum with the dates MCMXXXVI-MCMLXXXVI and the names of Popes Pius XI and John Paul II. On the other side of the medal is the motto of the first Lincei: *Sapientiae Cupidi* — anxious for knowledge — and an allegorical group in which Science appears, with a series of symbols representing the scientific achievements in various fields during these fifty years: space exploration, Schrödinger's equation, Halley's comet, Marconi's parabolic antenna, the double helix, the orbital and the formula of the steroids. The Medal was designed and engraved by Guido Veroi (Fig. page 175).

Also for the anniversary the Vatican Post Office issued two commemorative postage stamps, where alongside the coat-of-arms of the Academy are two details of the School of Athens or Platonic-Aristotelian Academy from a fresco by Raphael in the Vatican Palace. The stamps were engraved by P.N. Arghittu ([2]) (Fig. page XIX).

Professor Chagas then gave his official address ([3]), in which he described how science in its impact on modern society has raised *hopes*, but also *doubts* which have been expressed in various forms of anti-scientific movements. Therefore, he said, in utilizing the results of science, moral

([2]) Pius XII in 1939, compared the Academy of Sciences to the School of Athens: "It is this admirable and legitimate bond of the sciences with faith, this vestibule which the sciences and the arts erect at the entrance of the temple of faith, an image which already for centuries has amazed the world in the Vatican Hall of the Segnatura where science and faith face and illuminate one another in the sublime light of the thought and paintbrush of the incomparable painter Raphael from Urbino. You will certainly have paused to admire the scene named after the school at Athens. In those people, you will have recognised your oldest predecessors in the investigation of both matter and spirit, in the contemplation and the measurement of the skies, in the study of nature and of man, in the mathematical calculations and the learned discourses. The search for truth both animates and gives colour to those countenances and they seem to speak one to another of the many speculative and practical sciences, of their many late nights in study; their faces betray a certain concentration of thought debating with itself and concluding with the realisation of how little actual truth is surrounded by so much which was believed to be true so as to create a number of different worlds, not all of which could become reality". « Scripta Varia », *66*, 38 (1986).

([3]) Documenta, *19* (1986).

The Academicians participating in the Plenary Session on the occasion of the Fiftieth Anniversary of the Academy, October 29th, 1986.

TAB. 1 - *Academies Attending the Fiftieth Anniversary Celebrations.*

Year of foundation	Academy	Represented by
1603	Accademia Nazionale dei Lincei (Italy)	F. Gabrieli President
1662	Deutsche Akademie der Naturforscher Leopoldina (German Democratic Republic)	H. Bethge President
1662	The Royal Society (Great Britain)	Sir George Porter President
1666	Académie des Sciences (France)	A. Blanc-Lapierre President
1700	Akademie der Wissenschaften der Deutsches Democratisches Republik (German Democratic Republic)	Dr. W. Scheler President
1713	Real Academia de Ciencias Exactas Físicas y Naturales (Spain)	A. Martin-Municio President
1724	Academy of Sciences of the USSR (USSR)	V.A. Kirillin Member of Presidium
1739	Kungl. Vetenskapakademien (Sweden)	C.G. Bernhard past-President
1759	Bayerische Akademie der Wissenschaften (German Federal Republic)	A. Schulter President
1769	Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique (Belgium)	H. Chatrenne Director
1769	Köninklijke Académie vor Wetenschappen Letteren en schonen kunsten van Belgie (Belgium)	G. Smets President
1779	Academia de Ciencias de Lisboa (Portugal)	M.J. Nunes President
1782	Accademia Nazionale delle Scienze detta dei XL (Italy)	A. Ballio Member of the Council General Secretary
1785	Royal Irish Academy (Ireland)	J.O. Scanlan Secretary
1808	Köninklijke Nederlandse Akademie van Wettenschappen	D. de Wied President
1825	Magyar Tudomanyos Akademia (Hungary)	I.T. Berend President
1854	Australian Academy of Science (Australia)	A.J. Birch past-President

Year of foundation	Academy	Represented by
1857	Norske Videnskaps Akademi	D. Johansen Director General
1863	National Academy of Sciences (USA)	W.A. Rosenblith Foreign Secretary
1869	Bulgarian Academy of Sciences	A. Balewski President
1872	Polskiej Akademii Nauk	J.K. Kostrzerwski
1873	Academia Nacional de Ciencias Exactas Físicas y Naturales (Republic of Argentina)	G.B. Marini-Bettòlo Member, representing President A.O.M. Stoppani
1879	Nippon Gakushiin (Japan)	K. Fukui, Member, representing the President H. Arisawa
1884	Academia Nacional de Ciencias (Mexico)	M. Moshinsky
1886	Jugoslavenska Akademia Zanosti i Umietnosti (Yugoslavia)	J. Sirotkovic President
1909	Heidelberger Akademie der Wissenschaften (German Federal Republic)	H. Mosler President
1916	Academia Brasileira de Ciências	C. Pavan
1917	Academia de Ciencias Físicas Matemáticas y Naturales (Venezuela)	L. Wannoni Lander President
1926	Akadimia Athinon (Greece)	C. Bonis Vice-President
1959	The Israel Academy of Sciences and Humanities	J. Jortner President
1960	Centre Scientifique de Monaco (Monaco)	C.C. Solamito President
1964	Academia Chilena de Ciencias (Chile)	L. Vargas Fernandez President
1969	Institut National de Recherche Scientifique et Technique (Tunisia)	N. Arriguib Director
1976	National Academy of Sciences of Sri Lanka	J. Samarasekara President
1982	Academia de Ciencias de América Latina	R. Villegas Member, General Secretary

Federico Cesi (1585-1630). The founder of the Academy of the Lincei. (Medagliere della Biblioteca Vaticana, XXVIII, 14).

values must always be considered. Certainly the use of the atomic bombs in Hiroshima and Nagasaki in 1945 have changed the course of our civilization.

Yet scientific progress is important in meeting the great challenges of the modern world: space, the use of the ocean's resources, energy, and ecology. But all this must be viewed in the perspective of *being* and not of *having*.

The greatest challenge which science must face is development, which is necessary to assure acceptable living conditions for two-thirds of the world's population. In this case science is indispensable — but to avoid creating forms of neocolonial dependence in the transfer of technology, it is necessary to promote basic science in the developing countries through the creation of autonomous research centers.

Another point mentioned by the President was the wrong use of scientific results and the refusal to work for bad ends. Science and technology in the modern world must be integrated with humanistic culture in order to solve the dilemma of the two cultures, but they cannot be the only determining factors in the development of a civilization.

The Academy must study more closely the influence of science on man's activities and how science reacts to these activities, bearing in mind that science has not eliminated the transcendental. "The Pontifical Academy", said Prof. Chagas, "has the sole aim of promoting the understanding of science and human progress and wishes to strengthen the ethical and moral values which must guide humanity toward its destiny, thus abiding by the idea of Pius XI and his successors". Therefore the Academy is against nuclear war and is dedicated to peace — peace based on social justice on a world level with respect for the dignity of man. As Paul VI said, the new name of Peace is Development.

The Academy is also committed to creating new ties between the nations of the north and of the south, of the east and the west. Therefore it has called together academicians and scientists from the world community to discuss these problems with complete freedom. The extent of this activity is seen in the following figures: during the last fourteen years 900 scientists and more then 330 academicians have participated in meetings at the Academy.

The Academy has taken a strong stand against war, particularly nuclear war. In September 1982 it issued a Declaration against the use of nuclear arms, which, with the participation of representatives from Academies of Science from all over the world, produced strong repercus-

sions everywhere. At the same time as the Pope's meeting in Assisi for Peace in the World, the Academy expressed great zeal for this work on behalf of peace, which, as John Paul II said, cannot wait for tomorrow.

On October 28th, the 50th anniversary of the Academy, with the attendance of its Members, of Presidents and Delegates from many foreign academies and of outstanding world personalities (4) the celebration opened with a presentation by Academician G.B. Marini-Bettòlo, giving a brief summary of the history of the Academy from its first beginnings in the Academy of the Lincei, founded by Federico Cesi in 1603 in Rome — the first academy with strictly scientific aims — up to its restoration by Pius IX in 1847 and its renewal in 1936 by Pius XI (5).

Professor Carlo Pietrangeli, Director General of the Vatican Museums, described the Villa of Pius IV, which was built by Pirro Ligorio in 1561 and has been the seat of the Academy since 1921; he pointed out the architectural and pictorial aspects which make it an artistic jewel of the late Italian Renaissance.

Professor Elizabeth Anna Bernays from the University of California, Berkeley, then gave a lecture describing her research in the field of ecology, stressing some interesting aspects of the co-evolution and the interactions between plants and insects (6).

The most important part of the session was the Solemn Papal Audience to the Academy in the Sala Regia of the Vatican, with the presence of Eminent Cardinals and the ecclesiastic hierarchy, the Diplomatic Corps and numerous scientists and other invitees.

In his address to the Pontiff, President Chagas noted that the 50th anniversary of the Academy corresponds to a period of outstanding dis-

(4) Among the invitees were the winners of the Pius XI Gold Medal Prof. G. Nemethy of Cornell University and J. M. Lehn of the Louis Pasteur University, Strasbourg; also Prof. Ernster and Prof. F. Baker of the ICSU, Paris; Director General of UNESCO Amadou M'Bow; Prof. V. Canuto of NASA, New York; Dr. P. Lazar, Institut National de la Santé et de la Recherche Médicale, Paris; journalist J.-F. Lemaire of *Le Point*, Paris; Prof. F. Mayor, Universidad Autónoma de Madrid; Dr. C. Mérieux, Fondation Mérieux, Lyon, France; Dr. H. Uznanski, National Science Foundation, Washington; Dr. R. White, Cleveland Metropolitan General Hospital, Cleveland, Ohio; Dr. S. Widnall, American Association for the Advancement of Science, New York; and Dr. D. Wince, Office of Science and Technology, Executive Office of the President, Washington.

(5) G.B. Marini-Bettòlo: *Historical Aspects of the Pontifical Academy of Sciences.* « Documenta », *21* (1986).

(6) E.A. Bernays, *Medaille d'Or Pie XI - 1986.* Editio extra seriem, 1-36 (1986).

Solemn Audience of the Academy in the Sala Regia on October 28th, 1986, for the celebration of the Fiftieth Anniversary.

coveries in the field of science and technology, which has profoundly changed modern society. The ethics of science, he said, can lead to a lasting peace among nations, which however will not be possible if the problems of the developing world are not also considered.

Dr. Chagas mentioned the Academy's efforts for peace and the importance that it continue in this direction. It must also dedicate itself to the study of the recombinant DNA techniques in order to obtain products useful as vaccines, such as insulin, etc., as well as genetic manipulations and their advantages and their dangers. He went on to say that modern science and technology can face the problems of the Third World, which grow always more complex.

He referred to one of the problems which preoccupy the Academy: the predatory activity of man against the environment, and he gave a warning cry of alarm to defend nature which surrounds us; he asked the Pope to appeal for an end to this destruction of the environment which threatens the future of man.

At the end of his talk the President introduced the new Academicians and then asked the Holy Father to present the Pius XI Gold Medal to Professor Elizabeth Anna Bernays ([7]).

John Paul II spoke of the great prestige and the very high scientific level achieved by the Academy and its role in the promotion of the world scientific community.

He praised the Academy's dedication both to pure science, emphasizing its legitimate autonomy, and to applied science, which should be free and inspired by love and wisdom. The applications of science cannot be separate from the moral law, he said.

He discussed the matter of "revealed truth and empirically discovered truth", recalling that Galileo himself excluded any real contradiction between science and faith. He reminded scientists that "no field is separate from scientific investigation, so long as it respects the human being", and he added that "it is rather the methodologies which require certain abstractions and limitations".

Calling to witness the Academy, but addressing the entire world scientific community, he recalled that it is important to place scientific activity in the general context of culture and asserted that *free scientific*

([7]) Documenta, *20* (1986).

research for truth for its own sake is one of the noblest prerogatives of man. Science loses the right road if it deviates from the pursuit of its ultimate goal, which is the service of culture, and therefore of man. It goes into crisis when it is reduced to a purely utilitarian model; it becomes corrupted when it becomes a technical instrument for domination or manipulation for economic or political ends. Thus there exists what we might call a crisis of the legitimacy of science. So it is urgent to defend true science, open to the question of the sense of man and the search for the whole truth, *an independent science dependent on truth alone.* From the Church's point of view, science and culture cannot be separated.

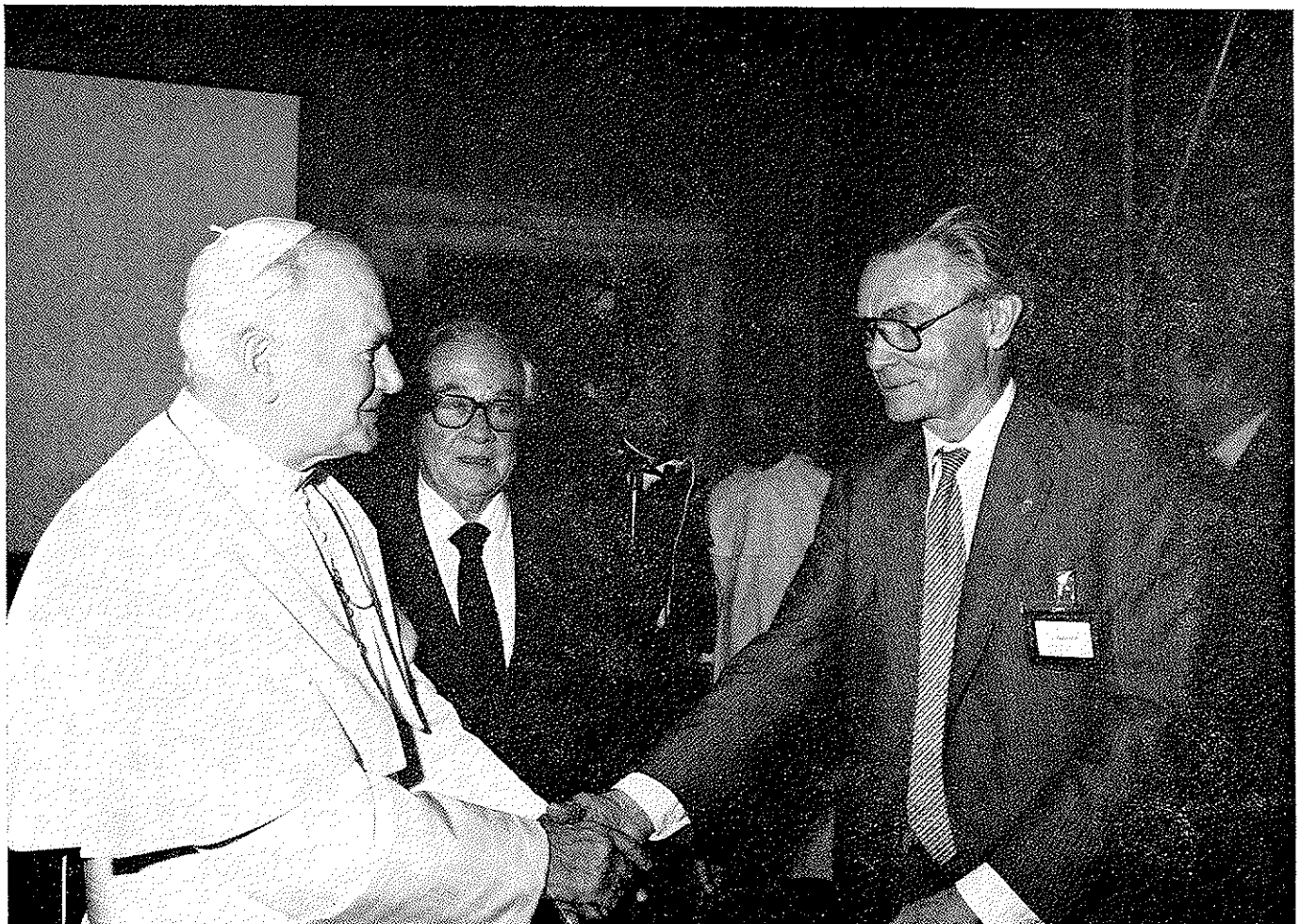
Another point is the necessity that science, from extreme specialization return to a unitarian view. It must be aware of the values of the spirit and must be led to collaborate in interdisciplinary research together with thinkers and theologians, because philosophical and theological studies need the contribution of scientists in order to increase our knowledge of the inanimate world, of the living universe and of humankind.

A cause of great concern is the "wrong use of the power that comes from science". Recalling the discovery of nuclear energy, he said that "researchers have been at the origin of a moral crisis equal to no other in history, which can be overcome only by combining conscience with science, making the supremacy of ethics respected". Stressing the need for peace among peoples, the Pope mentioned also the need for a "harmonious relationship between man and nature" as a basic element of civilization, emphasizing the importance of science in the field of ecology for the protection of the environment, for the improvement of the quality of life.

He then spoke of the dangers of the wrong use of science in the field of human genetics, and affirmed that science "must serve mankind, respecting and assuring the basic objective rights of the individual".

The Academy and its work were highlighted when John Paul II pointed out how much has been done in recent years that has been and will be of benefit also for sociologists, philosophers, theologians, moralists and the entire world scientific community and said: "The Holy See on various occasions has received valuable service from the scientific capability of this Academy on questions which closely concerned natural and evangelical morality, and it continues to count on you".

He urged the Academy to collaborate on an interdisciplinary basis with the other cultural institutions of the Holy See and the Universities,



in a vocation of cultural ecumenism "to promote and defend culture, which is the basis of man's dignity".

In conclusion, the Academy's work was summarized in the words, "During this half century, the Pontifical Academy of Sciences has carried on a work of historic importance".

With a special greeting to the representatives of the Academies of Science of the whole world, the Pope expressed his thanks and at the same time urged them to make "scientific knowledge advance in complete liberty, with an approach to fundamental truth regarding man and the cosmos, so that science may remain always in all its applications at the service of man, of his life, his culture and his moral and spiritual growth" (7).

* * *

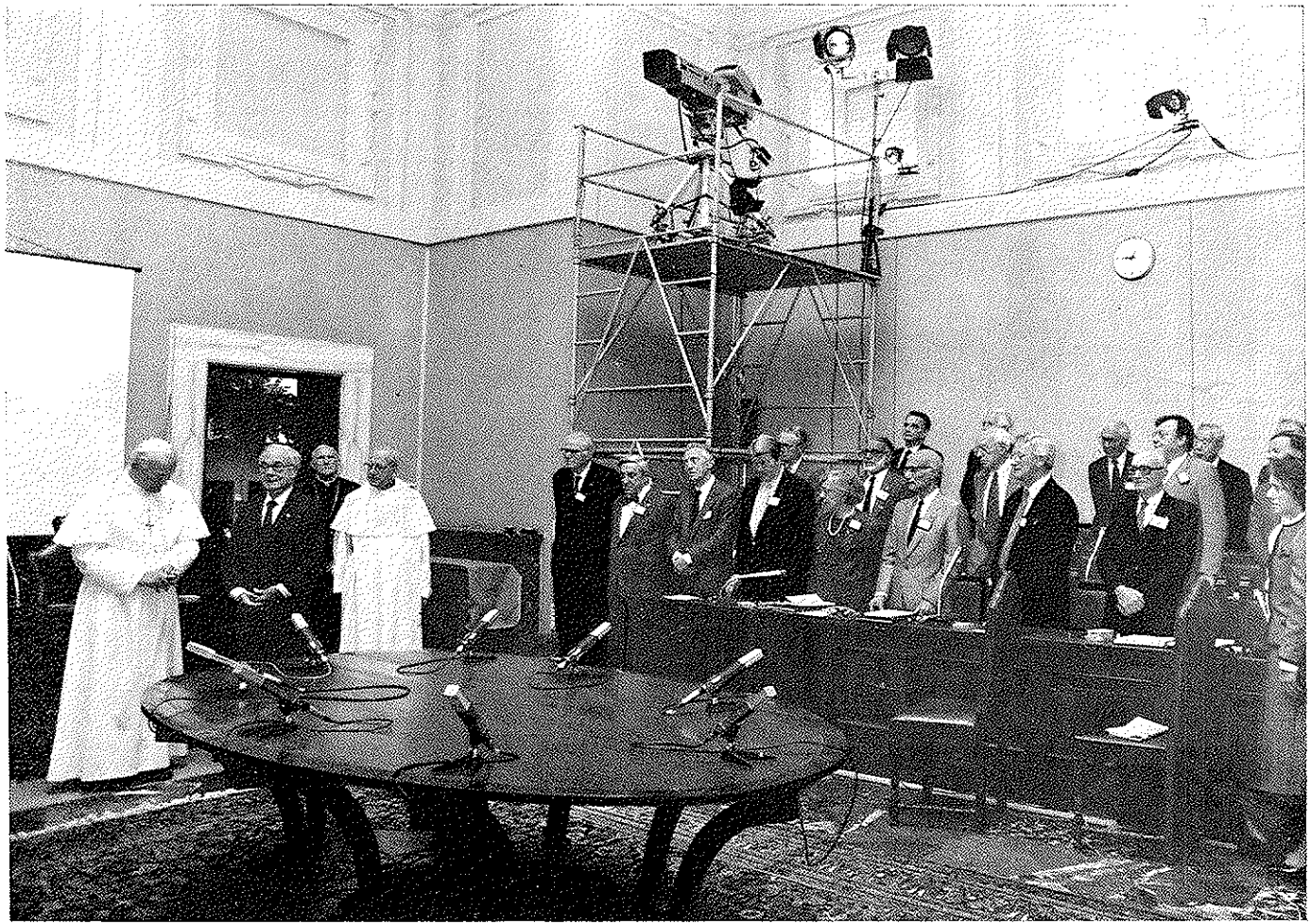
The Plenary Session which began on the afternoon of October 28 was centered on a discussion of the progress of science thus far and on the future prospects in certain fields of science.

In the first part the speakers explored thoroughly the topics of pure and applied science. Academicians Abragam, Mössbauer, Rubbia and Siegbahn spoke of the developments in the field of physics, and Academician Lichnerowitz spoke on mathematics.

On October 29th they discussed the field of Molecular Biology, presented by Academicians Eigen and Rich. A summary of the advances in the field of biology was given by Academicians Bergström, De Duve and Mintz, while Sela spoke of immunology and Eccles on neurobiology. Eschenmoser gave a complete picture of the present state and the new trends of chemistry.

On October 30th continuing the discussion of general topics, Runcorn spoke of earth sciences, while Puppi commented on space and science Hawking described the present frontiers of cosmology. Ecology, or rather the ecological sciences, were treated by Marini-Bettòlo, and the problems of agriculture, in particular fertilization by natural means was discussed by Döbereiner. Science for the developing countries was the final subject, presented by Academicians Bergström, Menon and Pavan. President Chagas in conclusion presented again the complex problems of these countries, the most important of which are tropical diseases.

(7) Documenta, *20* (1986).



The general discussion on topics to be taken up by the Academy in the near future emphasized those of the environment, science for the Third World, and the continuation of the activity already initiated against nuclear warfare, evolution, both biological and of the universe, survival in a nuclear world, ethics of science, populations and resources. Academicians Abragam, Anfinsen, Blanc-Lapierre, De Giorgi, Eccles, Lejeune, Moshinsky, Perutz, Polanyi, Pullman, Rich, Runcorn, Siddiqui, Singer, Szentagothai, and Townes participated in the discussion chaired by President Chagas.

During this session John Paul II paid a short visit to the Academy, and once more had occasion to talk with the Academicians.

A Round Table, broadcast by the Italian television RAI and directed by Bruno Vespa, concluded this important session. At the Round Table different aspects of the theme: the future of Science and its tasks, were presented by Academicians Werner Arber, Sune Bergström, Sir John Eccles, Manfred Eigen, Rita Levi-Montalcini, M. Menon, and Carlo Rubbia, and by President Carlos Chagas. Academicians Abragam, Croxatto, Lejeune, Rich, Runcorn, Singer and Thirring also participated in the discussion.

As a conclusion of the discussion, the importance was stressed of informing the public regarding academic activity, independently of learned presentation or discussions in meetings and congresses, in order to bring science to everyone.

CONCLUSION

During its fifty years of activity, the Pontifical Academy of Sciences has always been an important point of reference and a forum for the world scientific community to study the problems of basic science, and to promote initiatives to put science at the service of humanity.

While its seat has remained in the beautiful Casina Pio IV in the Vatican gardens, its activity today extends to the whole world, without limits.

An Academy of great prestige — because of its ancient tradition and its present representativity — it has come out from its ivory tower, combining with the "natural desire to know" (Cesi's heritage to all Academies) the study and probing of the great problems of the contemporary world, which it approaches with its scientific experience and with profound wisdom.

Science can indeed conquer hunger and disease, by furnishing means to combat them, and promote the development of peoples, also with regard to the environment.

In its zeal for truth and good, the Academy has also, in its highly qualified role, raised ethical and moral problems concerning scientific research — not only in areas such as those regarding life processes but also in the problems of transferring, sometimes too rapidly, the discoveries of science to a society often unprepared to receive them, on either the individual or global level.

In recent years the Academy, with a great step forward, has added the weight of its undisputable prestige and that of its members to the opposition to the wrong use of scientific discoveries, especially in the development of new armaments such as nuclear weapons, in its endeavor to assure peace to the world and to avoid the woeful equilibria based on mutual deterrence.

Hope and anxiety today illuminate and shade our future.

The Academy is now entering its second half-century — which coincides with the beginning of the third millennium of our Christian era — and it will promote with an always vigilant spirit the progress of science, directing it to the knowledge of truth and the benefit of mankind.

APPENDIX

EX MOTV PROPRIO

THE PONTIFICAL ACADEMY OF SCIENCES

October 28th, 1936

PIVS PP. XI

Amongst the many consolations which Almighty God has seen fit to bestow on Us during the course of Our Pontificate We are pleased to acknowledge that we have seen that not a few of those who experiment with the secrets of nature change their spiritual inclinations and attitude so radically, as to appear entirely renewed in spirit.

Science, which consists in a true recognition of fact, is never opposed to the truths of the Christian faith; in fact — as everyone who examines and meditates on the history of science, is bound to admit — the Pontiffs, together with the Church, have never at any time failed to encourage the research work of learned men, also in the sphere of experimental science; this research work has, in turn, made a valid contribution to the defence of the treasure of heavenly truth entrusted to the Church.

Consequently, as was solemnly declared by the Vatican Council, "not only can faith and reason never disagree with each other, but they rather offer each other reciprocal help, because real reason demonstrates the foundation of faith and, illuminated by the light thereof, develops the science of things divine; while faith, in turn, liberates and defends reason from errors and enriches it with considerable knowledge".

Unhappily, in recent times, some, who formerly lived in the paternal home of their inherited religion, have, like the "prodigal son", miserably abandoned it, though not really for the purpose of learning the truth. It has also been asserted, especially during the last century, with false deductions and daring rashness, that the methods and reasonings of human science and of Divine Revelation are contrary one to the other. But now —

and it is with no little consolation that We note it — such prejudiced opinions have been so thoroughly discredited that scarcely anyone can be found, among those who worthily carry on research in the physical sciences, who still asserts and defends such an error.

Nor do we wish here to pass over in silence the fact that, during the years of Our Pontificate, a number of scientists — among whom some were considered the highest in their special field and who had received the highest honours — when visiting Rome, even from various very distant lands, to attend meetings for the advancement of science, came to offer Us their deferential homage, or, rather, to offer it to that venerable Authority which, in the person, although undeserving, of the Successor of St. Peter, has been entrusted in perpetuity to this Apostolic See.

It has also happened that, among those eminent persons, some there were who, though they had not the precious gift of the Catholic Faith, did not, nevertheless, think it unbecoming to bow in reverence before this, Our Chair of Truth.

Some of these, moreover, speaking to Us in their own name as well as in the name of their colleagues, did not hesitate to state, and rightly, that all natural science prepares and consolidates the road leading to the Christian Faith; and their words filled Our fatherly heart with great happiness...

Therefore by the plenitude of Our Authority, *motu proprio*, and after careful deliberation... We constitute and declare established "The Pontifical Academy of Sciences"...

To testify that We attribute to this Institution a dignity equal to its very high task, We ourselves appoint — and for this first time not by Our Authority alone, but of Our direct and spontaneous will — the seventy renowned scientists who will constitute the Pontifical Academy, and who will be called Pontifical Academicians.

These We have chosen with the greatest care from among those learned men who have, in their own countries, attained the highest peaks of renown.

In making Our choice, We have not only been influenced by the excellence of the research and achievements by which each of them has contributed to the advance of science, but also have taken into consideration their personal renown among scholars, as attested by the approbation and general esteem they enjoy.

Consequently, this Apostolic See hopes and expects to receive from them that help and honour of which this Senate of learned men, as it were a "Scientific Senate", is a certain augury.

Nor should it seem excessive that this Assembly of noble disciplines should be designated by us as, so to say, the Senate of the Apostolic See in the field of science. In fact, all honour rendered by scientists to the Divine is not only the homage due from human reason to the Supreme Truth, but also a noble expression of reverence to God the Creator.

Verily then do we desire and expect that the Pontifical Academicians, by means of this Institute of studies, which is both Ours and theirs, will give an ever greater and higher contribution to the advance of science. We ask no more than this, since the service we expect of these servants of the truth is based on this high purpose and noble efforts...

Given in Rome, at St. Peter's, on the twenty-eighth day of October in the year 1936, the fifteenth of Our Pontificate.

PIUS PP. XI

STATUTES OF THE PONTIFICAL ACADEMY OF SCIENCES 1936

PART I

CONSTITUTION AND PURPOSE

ART. 1 - The Pontifical Academy of Sciences has as its purpose the promotion of the study and the progress of the physical, mathematical and natural sciences and their history.

ART. 2 - To achieve these aims, the Academy:

a) examines and discusses the most important problems pertaining to science through Communications or the presentation of Notes and Memoirs;

b) promotes scientific investigations and research and assists institutions and private individuals in their execution;

c) attends to publications of a scientific nature;

d) organizes lectures, congresses and celebrations.

PART II

ORGANIZATION

§ 1 - *Constitution, Academicians*

ART. 3 - The Academy is composed of seventy "Pontifical Academicians", appointed by the Supreme Pontiff.

Moreover because of their official activity, the following persons are "Supernumerary Academicians":

1. The Director of the Vatican Observatory,

2. The Director of the Astrophysical Laboratory of the Vatican Observatory,

3. The Prefect of the Vatican Apostolic Library,

4. The Prefect of the Secret Archives of the Vatican,

5. The Scientific Director of the Ethnological Missionary Museum.

These hold the title of Academicians during the time that they carry on the abovementioned official activity.

By way of exception, in addition to the seventy abovementioned Academicians, persons who have achieved outstanding merit by supporting the Academy and its scientific undertakings can be named "Honorary Pontifical Academicians".

ART. 4 - For the appointment of Academicians, the President proposes to the Supreme Pontiff the names of those who have received a favorable vote from the Academy, in accordance with Article 23.

The President can deviate from this procedure and propose the appointment of a person outstanding for the scientific fame which he has achieved.

The appointment of the Academicians is for life, except as described in the last paragraph of Art. 3.

ART. 5 - The Academicians participate in the sessions, they make Communications and present scientific papers (Notes and Memoirs); they discuss and they vote; they have the right to propose nominations and work subjects, as well as to use the Academic Library in accordance with its regulations.

The nonresident Academicians can be asked to express their vote in writing and to cooperate regarding questions in their particular field.

All will receive the Academic Proceedings and the *Memoirs* in accordance with the provisions of Art. 28.

ART. 6 - The Academicians may wear in the sessions of the Academy and in public ceremonies an academic medal which bears on its face the tiara and the crossed keys with the words *Deus Scientiarum Dominus* in memory of His Holiness Pius XI, the Pontiff who reformed the high ecclesiastic studies and the Academy, and on the back the name of the Academician surrounded by an olive branch and a laurel branch.

The Academicians can usually wear a badge which bears a small reproduction of the face of the medal.

The Academicians have a place reserved in the Pontifical Chapels for their attendance at ceremonies where the Supreme Pontiff will speak.

The Academicians have free access to the Pontifical Museums and Galleries.

§ 2 - *Academic Authorities*

ART. 7 - The Academy is under the high and direct vigilance of the Supreme Pontiff.

The direction and the government of the Academy are under the following authorities:

1. The President,
2. The Council of the Academy,
3. The Secretary,
4. The Treasurer,
5. The Librarian,
6. The Censors,
7. The Auditors of Accounts.

ART. 8 - The President is nominated *motu proprio* by the initiative of the Supreme Pontiff, from whom he directly depends.

He stays in office for four years and can be reappointed by the Supreme Pontiff.

The President:

a) represents the Academy;

b) directs the Academy in all the activities;

c) convokes and presides over the Council of the Academy and the sessions;

d) orders the execution of the Council's deliberations.

The President can be substituted, as president in the sessions, by other Academicians who are Council Members, and can delegate an Academician to substitute for a Council Member who is unable to be present, in cases where no provision exists. Finally, the President can delegate, when and as he deems opportune, one or more Academicians to represent the Academy.

ART. 9 - The Council of the Academy is composed of:

the President,
the last past-President,
five Academicians.

The Academicians constituting the Council are nominated by the Supreme Pontiff on the proposal presented by the President in accordance with the favorable vote of the Academy.

Only resident or nearly resident Academicians can be elected to the Council. They remain in office four years and can be reelected.

Among the Academicians composing the Council, the Secretary, Treasurer, the Librarian, and two Censors are selected.

The Council of the Academy:

a) assists the President in all that concerns the direction of the Academy;

b) prepares the plan for work to be done in the meetings and compiles the academic calendar;

c) attends to the financial and patrimonial administration;

d) makes decisions regarding the estimated and the final balance sheets of the Treasurer and submits them to the approval of the Assembly.

The deliberations are valid when the majority of the members are present and when approved by the majority of those present.

In case the outcome vote is even, the President's vote prevails.

The Council usually meets bimonthly, and extraordinary meetings are held whenever necessary or when two of the members request it.

ART. 10 - The Secretary of the Academy:

a) keeps up to date the list of the Academicians in accordance with the President's instructions;

b) acts as Secretary of the Council;

c) supervises the functioning of the offices of the Secretariat.

In the absence or impossibility of the Secretary of the Academy to attend, the President asks one of the Council members to take his place.

ART. 11 - The Treasurer:

a) is responsible for the administration and accounting of the Academy;

b) has custody of the scientific equipment and the household furnishings of the Institute;

c) prepares the budget and financial statements;

d) receives the income and, by order of the President, countersigned by the Secretary, makes payments;

e) supervises the purchases and cash.

ART. 12 - The Librarian:

a) supervises the Library;

b) sees that the Special Regulation is enforced.

ART. 13 - The Censors, under the direction of the President:

a) watch over the regular functioning of the Academy;

b) see that the Statutes and Regulations are observed;

c) examine the proposals for the nomination of new Academicians and report thereon to the Council.

ART. 14 - The Academicians who are auditors of the accounting are elected by the Academy from members who are not on the Academy's Council.

They hold office for two years and can be re-elected.

They supervise the administrative and accounting activity of the Academy, examining the balance sheets and the accounts, which they sign and then report to the Academy.

§ 3 - *Means*

The means which the Academy has available for fulfilling its duties are:

a) an endowment assigned by the Supreme Pontiff, Pius XI, to the Administration of the Resources of the Holy See;

b) the scientific and bibliographic material and the equipment which is owned by the Institute;

c) eventual gifts and inheritances from public and private sources;

d) income from the activity of the Institute.

Every year 5% of the income will be set aside to constitute a reserve fund.

PART III

OPERATION

§ 1 - *Academic and Calendar Year*

ART. 16 - The academic year begins on December 1st and ends on July 1st.

It will be initiated:

1° - with a religious ceremony celebrated in the Pauline Chapel to receive God's benediction on the Academy's work, to thank Him, to pray for the Church and for the Supreme Pontiff and to pray for the deceased Academicians;

2° - with a solemn session to which will be invited the Supreme Pontiff. The President in this session will give a summary of the activity of the Institute during the preceding year and an outline of the work to be done in the course of the new year.

ART. 17 - In the last session of each academic year the President submits to the approval of the Academy the Calendar for the following year. In the Calendar, compiled by the Council, the dates for the convocation of the ordinary sessions are established.

§ 2 - *Academic Sessions*

ART. 18 - The sessions of the Academy include ordinary and special, public and secret ones.

The Academy meets in ordinary sessions on the dates established by the academic Calendar.

The special sessions are called by the President whenever he thinks necessary.

ART. 19 - In the public sessions:

a) announcement is made of the names of the new Academicians and of the new academic officers;

b) announcements are made, and Notes, Memoirs and publications are presented;

c) the award of prizes and the results of competitions are announced.

Academicians who, because of distance or any other reason, cannot attend the public sessions can appoint another Academician to make announcements or present Notes and Memoirs or publications in his name. Where such designation is not made, the President will provide.

The Academicians can also present announcements, Notes and Memoirs of non-members deemed worthy.

For the announcements, Notes and Memoirs, the use of the native language of the Academician presenting same is permitted; for all these a brief summary in Latin is required.

ART. 20 - In the secret sessions:

a) matters of ordinary and extraordinary administration are discussed;

b) balance sheets and accounts are approved;

c) all that refers to the internal life of the Academy is examined and settled;

d) the date and the subject of these sessions are decided by the President.

ART. 21 - Voting takes place only in secret sessions; it will take place after free discussion and with the majority of the Academicians present, who however cannot be less than ten in the first convocation and five in the second. The voting must be proposed by the President; but he cannot refuse it even in matters of ordinary administration, when one-third of the attendants request it; he can only postpone it in serious matters, regarding which he considers it wise to know beforeh and the opinion of the Supreme Authority.

In case of a tie, the President's vote prevails.

Secret voting is required for every deliberation which regards persons, assignments, employment and competitions, and whenever one-third of the attendants request it.

ART. 22 - The resident Academicians must be informed in due time of the program of the sessions which they are required to attend; those attending sign the attendance sheet.

Academicians who for three years in succession have been absent without justification, are considered as resigning.

ART. 23 - Elections for appointments to fill the Academicians' seats which have become vacant are held in the following way.

Within two months of the vacancy, written proposals, each one signed by at least two Academicians, are given in a sealed envelope to the President. Each one must be accompanied by a note giving the curriculum vitae and the scientific activity of the person proposed.

The President communicates the proposals and the descriptive notes, first to the Censors and then to the Academic Council. The Council prepares a report to be sent to all the Academicians. The proposals which are not rejected or postponed by the Council of the Academy are communicated to the Academy in a secret session and submitted to the vote in a subsequent secret session, which cannot be held less than a month later.

Those Academicians who, because of distance, cannot attend, can send their vote in writing.

As a rule, for each vacancy three names are voted upon, selected from among scientists in the same discipline.

When agreement is not reached, the designation is postponed to a time decided by the President.

ART. 24 - All the other rules concerning the subjects and the holding of the sessions are given in the Internal Regulation.

§ 3 - *Research and Promotion*

ART. 25 - The Academy can establish prizes, promote competitions, set up committees and commissions for the study of particular scientific subjects.

It can also undertake or promote work and research in the field of science.

ART. 26 - The Academy awards prizes, subsidies, medals, to Academicians and persons outside the Academy.

The number, the amount, the duration, the methods of making these awards are established by the Internal Regulation.

The Academicians cannot participate in the competitions announced by the Academy.

ART. 27 - The Academicians are given medals for attendance and reimbursement for their participation in the normal activities of the Academy. Special compensation can be given them for particular assignments.

The Secretary and the Librarian of the Academy will receive a special annual compensation for their activity.

The amount of such payments, compensation and indemnity is established in the Internal Regulation.

§ 4 - *Publications*

ART. 28 - The Academy publishes *Proceedings* and *Memoirs*.

The *Proceedings* come out in pamphlets, the frequency of which will be decided each year by the Internal Regulation. They contain the minutes of the public sessions, the scientific announcements and notes, a list of the publications received and news regarding the academic life.

The *Memoirs* come out at different intervals and include scientific writings of a certain importance accepted by the Academy, and works which have been awarded prizes.

ART. 29 - The Academy also announces its activities in the *Annuario* and the *Nuncius Radiophonicus*.

ART. 30 - The Academy, on deliberation of the Academicians in secret session, can sponsor or support publications, periodical or otherwise, which are in harmony with its aims.

PART IV

FINAL AND TEMPORARY PROVISIONS

ART. 31 - The Academy has a Chancellery, of which the Office of the Secretary, the Administrator and financial services are a part.

The Chancellery is headed by a Chancellor, under whose direction is the personnel of all categories assigned to the offices of the Academy.

The legal status and the economic treatment of personnel of all categories, as well as the rules for the functioning of the Chancellery are established by the Internal Regulation.

ART. 32 - Whenever some modification of the present Statutes becomes necessary, the Academy can study its appropriateness in secret session and approve the terms in which to present its vote to the reigning Pontiff; it cannot introduce any modifications on its own authority.

ART. 33 - The Internal Regulation contains, besides the norms mentioned specifically in the present Statute, every other necessary provision regarding the organization and the functioning of the Academy.

A special part of the Internal Regulation governs the functioning of the Library.

The Regulation is issued by the President after hearing the Academic Council.

ART. 34 - The members of the Pontifical Academy of the New Lincei, honorary, ordinary and corresponding members, if they are not appointed Pontifical Academicians, keep their title of honorary, ordinary and corresponding members. They will receive the Proceedings and Memoirs of the Academy. They will have the privileges mentioned in paragraphs 3 and 4 of Article 6 of the present Statute. They can make announcements and present their notes and memoirs. They can participate in competitions and prizes announced by the Academy.

REGULATIONS OF THE « STUDY WEEK »
1952

1. - The Academy invites a few illustrious scientists amongst those who, having studied a specific question carefully, have come to a different conclusion, to convene in Rome, at the "Casina di Pio IV" in the grounds of the State of the Vatican City, so as to proceed together, free of any other preoccupation, to a general study of all the findings related to the problem.

2. - The principal object of these discussions will be to try and formulate the exact reasons which form the basis of divergency of opinions. The scientists invited to these meetings pledge themselves beforehand to concentrate all their efforts towards this aim.

3. - A critical appraisal of these reasons will lead to either an agreement on a determined solution or to the acknowledgment that, at the present stage of findings, it is impossible to establish a uniform doctrine for the problem envisaged.

In the latter case, the scientists will have the task to:

a) specify the motives for which an agreement is at present unattainable;

b) define the kind of research which it would be desirable to undertake in view of the solution of the problem.

4. - The Academy shall only invite a very restricted number of representatives of each branch of science and these shall be chosen among illustrious scientists who do not belong to the Academy itself whilst Academicians versed in the same branch of science will also attend. Furthermore, this invitation is only related to the study of one specified question for each science.

5. - Discussions shall be of a strictly private nature; they shall take the form of specific conversations, without any assistance other than that of a few Pontifical Academicians particularly competent on the subject.

Interpreters, stenographers and precis writers will be placed at the disposal of the scientists convened.

6. - The conclusions of these discussions will be published in the form of a Collective Report (to which individual reports may eventually be added) and shall mention:

a) the points on which agreement may have been reached;

b) the points on which agreement may not have been deemed possible;

c) the reasons for which agreement may not have been reached;

d) proposals related to research which seems the most apt to solve difficulties.

7. - The conclusions shall immediately be printed and communicated by the Pontifical Academy of Sciences to all scientific centres which might be interested in receiving them.

8. - All travel and hotel expenses shall be met by the Pontifical Academy of Sciences. Hospitality will be tendered in one of the principal hotels of Rome.

The Academy will be pleased to extend the same hospitality to the wives of scientists, with the exclusion, however, of their travel expenses.

STATUTES OF THE PONTIFICAL ACADEMY OF SCIENCES

1976

PART I

CONSTITUTION AND AIM

ART. 1 - The Pontifical Academy of Sciences, founded by Pius XI of hallowed memory, is placed under the exalted and direct protection of the reigning Supreme Pontiff.

ART. 2 - The aim of the Pontifical Academy of Sciences is to promote the progress of the mathematical, physical and natural sciences and the study of epistemological problems relating thereto.

ART. 3 - For the attainment of its ends the Academy:

a) holds plenary sessions of the Academicians;

b) organizes meetings to promote the progress of science and the solution of important scientific-technical problems, which are fundamental for the development of mankind;

c) promotes scientific investigations and researches which can contribute, in the appropriate quarters, to the exploration of moral, social and spiritual problems;

d) arranges conferences and celebrations;

e) takes care of the publication of the Proceedings of its own meetings, of the results of the scientific researches and studies of the Academicians and of other scientists;

ART. 4 - With the object of promoting scientific research the Academy every two years awards the Pius XI Medal to a young scientist of international reputation.

PART II

THE ACADEMICIANS

ART. 5 - Candidates for a seat in the Academy are chosen by the Academy on the basis of their eminent original scientific studies and of their acknowledged moral personality, without any ethnical or religious discrimination, and are nominated for life by sovereign act of the Holy Father.

In addition, by reason of their office, the Director of the Vatican Observatory; the Director of the Astrophysical Laboratory of the Vatican Observatory; the Prefect of the Vatican Library; the Prefect of the Secret Archives of the Vatican, are nominated "Academicians pro tempore". The "Academicians pro tempore" enjoy the same rights and perform the same functions as the Pontifical Academicians.

By way of exception, and in a purely honorary capacity, on proposal by the Council of the Academy, persons who have deserved particularly well of the Academy, by honouring it and assisting it and its scientific undertakings, may be nominated by the Holy Father "Honorary Pontifical Academicians".

ART. 6 - The full complement of the Academy consists of 70 life members, chosen in such a way that as far as possible all the principal branches of science and all the major geographical regions are represented (*).

PART III

GOVERNMENT OF THE ACADEMY

ART. 7 - The Academy is governed by a President, nominated from among the Academicians, *Motu Proprio*, by the Supreme Pontiff, from whom he directly depends. The President remains in office for four years and may be reappointed by the Supreme Pontiff. The President guides and directs all the activity of the Academy and represents it before the Holy See and before every other Authority or Institution.

ART. 8 - The President is assisted by the Council of the Academy constituted as follows:

(*) The number of life members has been raised by John Paul II, on January 8th 1986, to 80.

a) the outgoing President for the period of four years;

b) the former President named by the Holy Father President Emeritus for life;

c) five Councillors nominated by the Holy Father, on the proposal of the President, for the period of four years, with the possibility of reappointment.

ART. 9 - The President is assisted directly by the Director of the Chancellery, who is nominated by the Holy Father for a period of four years and may be reappointed.

PART IV
FINANCIAL RESOURCES

ART. 10 - The financing of the Academy is assured by the Administration of the Patrimony of the Apostolic See.

ART. 11 - The Academy can also dispose of eventual gifts, legacies and income derived from its activity.

ART. 12 - The President with his Council considers the expenditure necessary for the life of the Academy and approves the estimates and balance sheet.

PART V
GENERAL REGULATIONS

ART. 13 - The present Statutes, promulgated by their publication in the *Acta Apostolicae Sedis*, replace the former Statutes published in the *Acta Apostolicae Sedis* of the year 1936, p. 427 ff. Every modification of the present Statutes is reserved to the Supreme Pontiff, who is the sole authority competent to dissolve the Academy.

ART. 14 - The present Statutes are supplemented by the Bylaws drawn up and approved by the President with his Council.

April 1st, 1976

DISCOURSES OF THE POPES TO THE PONTIFICAL ACADEMY OF SCIENCES (1936-1986) (*)

DISCOURSES OF HIS HOLINESS PIUS XI AND OF CARDINAL EUGENIO PACELLI

1936, January 12th	Discourse of His Holiness Pope Pius XI at the inauguration of the Academic Year of the Pontifical Academy of Sciences - Nuovi Lincei.
1937, June 1st	Discourse by Cardinal Pacelli on behalf of His Holiness Pope Pius XI on the occasion of the inauguration of the Pontifical Academy of Sciences.
1938, January 30th	Discourse of His Holiness Pope Pius XI on the occasion of the Solemn Audience for the inauguration of the second Academic Year.
1938, December 18th	Discourse of His Holiness Pope Pius XI on the occasion of the Solemn Audience for the inauguration of the third Academic Year.

DISCOURSES OF HIS HOLINESS POPE PIUS XII

1939, December 3rd	Solemn audience on the occasion of the inauguration of the fourth Academic Year.

(*) Discourses of the Popes from Pius XI to John Paul II at the Pontifical Academy of Sciences, 1936-1986. « Scripta Varia », *66*,1-188 (1986).

1941, November 30th	Solemn Audience on the occasion of the inauguration of the sixth Academic Year. Discourse by Pius XII on *Man, Creation and God.*
1943, February 21st	Discourse of His Holiness Pope Pius XII on *The Laws governing the world*, at the Solemn Audience for the inauguration of the seventh Academic Year.
1948, February 8th	Discourse of His Holiness Pope Pius XII on the *Immutability of the natural laws and the supreme role of God over the world*, on the occasion of the Solemn Audience for the inauguration of the twelfth Academic Year.
1949, June 7th	Discourse of His Holiness Pope Pius XII at the Solemn Audience granted to the Plenary session of the Academy and to the participants of the Study Week on *The Biological problems of cancer.*
1951, November 22nd	Discourse of His Holiness Pope Pius XII on *The proofs of the existence of God on the basis of modern science*, at the Solemn Audience granted to the Plenary session of the Academy and to the participants of the Study Week on *The question of microseisms.*
1955, April 24th	Discourse of His Holiness Pope Pius XII at the Solemn Audience granted to the Plenary session of the Academy and to the participants of the Study Week on *The problem of oligo elements in plant and animal life.*
1957, May 20th	Discourse of His Holiness Pope Pius XII on the occasion of the Solemn Audience granted to the Academy and to the participants in the Study Week on *The problem of stellar populations.*

DISCOURSES OF HIS HOLINESS POPE JOHN XXIII

1961, October 30th — Discourse of His Holiness Pope John XXIII on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Macromolecules of biological interest with special reference to nuclear proteins.*

1962, October 5th — Discourse of His Holiness Pope John XXIII on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *The problem of cosmic radiation in interplanetary space.*

DISCOURSES OF HIS HOLINESS POPE PAUL VI

1963, October 13th — Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *The econometric approach to development planning.*

1964, October 3rd — Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Brain and Conscious Experience.*

1966, April 23rd — Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Molecular forces.*

1968, April 27th	Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Organic matter and Soil fertility.*
1970, April 18th	Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Nuclei of Galaxies.*
1972, April 15th	Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Use of fertilizers and their effect on the increase of crops.*
1974, November 13th	Comments of His Holiness Pope Paul VI at the solemn commemoration of the centenary of the birth of Guglielmo Marconi.
1975, April 19th	Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Biological and artificial membranes and desalination of water.*
1976, October 23rd	Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Natural products and plant protection.*

1977, October 22nd — Discourse of His Holiness Pope Paul VI on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *The role of non-specific immunity in the prevention and treatment of cancer.*

DISCOURSES OF HIS HOLINESS POPE JOHN PAUL II

1979, November 10th — Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the Plenary session of the Academy for the commemoration of the centenary of the birth of Albert Einstein.

1980, November 14th — Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the participants in the Study Week on *Energy and Mankind.*

1981, October 3rd — Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the Plenary session of the Academy and to the participants in the Study Week on *Cosmology and Fundamental Physics* and in the Working groups on *Perspectives of Immunization against Parasitic Diseases* and on *The Consequences of the Use of Nuclear Weapons.*

1982, October 23rd — Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the participants in the Study Week on *Modern Biological Experimentation.*

1983, November 12th	Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the Plenary session of the Academy dedicated to *Science in the Service of Peace* and to the participants in the Study Week on *Chemical events in the atmosphere and their impact on the environment*, and the Working group on *Specificity in biological interactions.*
1984, June 1st	Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the Working Group on *Immunology, epidemiology and social aspects of Leprosy.*
1984, October 2nd	Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the participants in the Study Week on *The impact of space exploration on Mankind.*
1985, October 21st	Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the participants in the Study Week on *Remote sensing and its impact on developing countries.*
1986, June 20th	Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the participants in the Working groups on *The artificial prolongation of life and the determination of the exact moment of death*, and on *The interaction of parasitic diseases and nutrition.*
1986, October 25th	Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the participants in the Study Week on *The molecular mechanisms of carcinogenic and antitumor activities.*

1986, October 28th — Discourse of His Holiness Pope John Paul II on the occasion of the Solemn Audience granted to the Plenary session of the Academy for the celebration of the Fiftieth anniversary of its restoration by Pius XI.

PUBLICATIONS OF THE ACADEMY

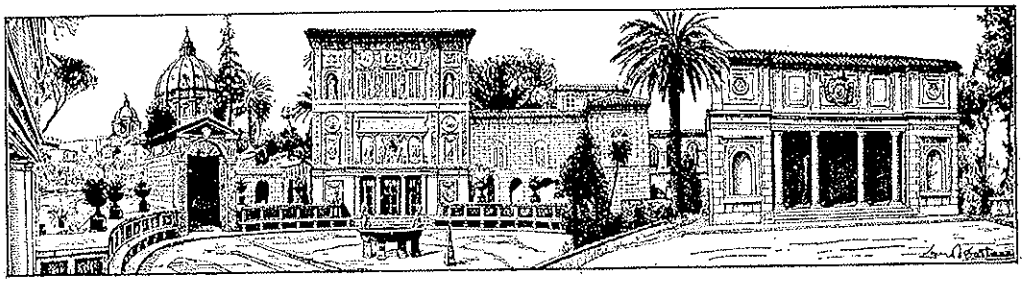
The Academy has collected its Proceedings and Memoirs in publications (some appearing periodically) which are listed below.

ACTA PONTIFICIAE ACADEMIAE SCIENTIARVM - This is a series of periodical publications from 1957 to 1959, sixteen volumes containing the reports on the meetings and brief works presented at the various sessions (fig. pag. 13).

COMMENTATIONES PONTIFICIAE ACADEMIAE SCIENTIARVM are periodical publications which include memoirs of Academicians and non-member scientists presented by the Academicians. These began in 1937 and continued through 1955; they consist of seventeen volumes (fig. pag. 11).

SCRIPTA VARIA PONTIFICIAE ACADEMIAE SCIENTIARVM, a non-periodical series, was initiated in 1942 to collect particularly the presentations and discussions of the Study Weeks and Working Groups. The current volume of this collection is No. 67. Because of the importance of the Scripta Varia, many of the volumes have come out in co-editions with foreign publishers (fig. pag. 149).

COMMENTARII PONTIFICIAE ACADEMIAE SCIENTIARVM, another non-periodical collection, was started in 1957 and includes three volumes. The first goes from 1961 to 1964 and includes 49 numbers; the second from 1965 to 1972 consists of 60 pamphlets; and the third series covers the years 1974 to 1986, with 29 works. These consist of single papers which were published separately, each one completely independent of the others but with consecutive page numbering so that they could be bound in volumes, as had already been done with the COMMENTATIONES (fig. pag. 98).



PONTIFICIA ACADEMIA SCIENTIARVM

ANNUAIRE

AJOURNÉ AU XXXI MARS MCMLXXXIII

CITÉ DU VATICAN

In 1981, because of the necessity to diffuse rapidly the Pope's speeches addressed to the Academy, the conclusions of the Study Weeks and of the Working Groups as well as other publications, there was begun a new series entitled DOCVMENTA (fig. pag. 163). Among these we might mention the addresses of John Paul II to the Academy 1981 and 1983 and the Declaration on the Prevention of Nuclear War (1982).

In addition to those mentioned above there are also the EXTRA SERIEM publications, which include the Yearbooks, or *Annuaires*. The General Yearbook, *Annuario Generale*, of 1937 contains the biographies of the seventy new Academicians. This *Annuario* has had updatings when new Academicians were appointed (in 1961, 1964, 1968, 1970, 1974, 1975, 1978, 1981-83, 1986). Moreover these contain the address and brief curriculum concerning each Academician (see foot-notes at page 37, 42, 46, 48, 55, 57, 58, 67, 71, 72, 74). *Annuaires* and *Elenchus* have been published periodically during these years in an abbreviated form reporting the names of the Academicians, the dates of birth and appointment, as well as their position and address (Fig. pag. 221). In October 1986 the new *Annuaire Général* was published (1).

Among the *extra seriem* publications there are the *Relationes de Auctiis Scientiis tempore belli* in 1945, the *Siège* (2), and more recently *The Building* (3), describing the Casina of Pio IV. Also *extra seriem* are the special pamphlets, in quarto, regarding the award of the Pius XI Gold Medal, the one in memory of Father Gemelli on the tenth anniversary of his death, the *Mnemosynon*.

(1) *Annuaire*, pp. XII-390 (1986).

(2) Pontificia Academia Scientiarum: *Le Siège*, pp. 48 (1969).

(3) Pontifical Academy of Sciences: *The Building*, edited by G. Delfini-Filippi, pp. XII-66 (1986).

PRESIDENTS

Fr. Agostino GEMELLI o.f.m. (October 28th, 1936 - July 15th, 1959)
Mons. Georges LEMAITRE (March 19th, 1960 - June 20th, 1966)
Fr. Daniel O'CONNELL S.J. (January 15th, 1968 - January 15th, 1972)
Prof. Carlos CHAGAS (November 3rd, 1972)

CHANCELLERY

Prof. Dr. Pietro SALVIUCCI (October 28th, 1936 - December 31st, 1973) Chancellor

Dr. Francesco SALVIUCCI (February 8th, 1948 - October 31st, 1972) Assistant

Fr. Enrico di ROVASENDA (November 16th, 1972 - April 3rd, 1974) Co-Director; (April 3rd, 1974 - December 31st, 1986) Director

Dr. Ing. Don Renato DARDOZZI (July 5th, 1985 - December 31st, 1986) Co-Director; (January 1st, 1987) Director

MEMBERS OF THE COUNCIL OF THE ACADEMY

ARMELLINI G.	1936-1941; 1944-1948
LEPRI G.	1936-1941; 1944-1948
Mons. ALBAREDA A.M.	1936-1962
BIANCHI E.	1936-1941
BOTTAZZI F.	1936-1941
AMALDI U.	1940-1944
GIORDANI F.	1940-1961
LOMBARDI L.	1944-1954
SEVERI F.	1944-1961
QUAGLIARIELLO G.	1944-1948
BOLDRINI M.	1958-1969
BONINO G.B.	1958-1980
CROCCO G.A.	1958-1965
PISTOLESI F.	1958-1968
O'CONNELL D.	1962-1982
BRÜCK H.	1965-1986
LEPRINCE-RINGUET L.	1965-1969; 1980-
DE BROGLIE L.	1969-1980
MARINI-BETTÒLO G.B.	1969-
TUPPY H.	1972-
PUPPI G.P.	1980-
COYNE G. S.J.	1986-

HONORARY ACADEMICIANS

BISLETI Cardinal Gaetano	1936
CHIGI ALBANI Della Rovere Ludovico	»
DE SANCTIS Pietro	»
MARCHETTI SELVAGGIANI Cardinal Francesco	»
PACELLI Cardinal Eugenio	»
MAGLIONE Cardinal Luigi	1939
PIZZARDO Cardinal Giuseppe	»
GALEAZZI-LISI Riccardo	1949
PASCHINI Mons. Pio	1957
TARDINI Cardinal Domenico	1960
TISSERANT Cardinal Eugenio	»
CICOGNANI Card. Amleto Giovanni	1961
VALLETTA Vittorio	»
RANZI Silvio	1981
SALVIUCCI Pietro	1984
DI ROVASENDA Fr. Enrico	1987

ACADEMICIANS « PERDURANTE MUNERE » *

ALBAREDA Card. Anselmo Maria	1936
GATTERER Fr. Aloysius	»
MERCATI Mons. Angelo	»
SCHMIDT Fr. Wilhelm	»
STEIN Fr. Johan Wilhelm	»
O'CONNELL Fr. Daniel S.J.	1952
JUNKES Fr. Joseph	1953
SCHULIEN Fr. Michael	1954
GIUSTI Mons. Martino	1956
RAES Fr. Alfonso	1962
TREANOR Fr. Patrick	1970
STICKLER Fr. Alfons M.	1971
COYNE Fr. George S.J.	1978
METZLER Fr. Joseph	1984
BOYLE Fr. Leonard E.	»

* During the period of their office.

ACADEMICIANS
1936 - 1986

ABDERHALDEN Emil	1936
AMALDI Ugo	»
ARMELLINI Giuseppe	»
BARROIS Charles	»
BIANCHI Emilio	»
BIRKHOFF George David	»
BJERKNES Vilhelm Frimann K.	»
BOHR Niels	»
BOLDRINI Marcello	»
BOTTAZZI Filippo	»
BRANLY Edouard	»
BUYTENDIJK Fredrik Jacobus J.	»
CARATHEODORY Constantin	»
CARREL Alexis	»
CASTELLANI Aldo	»
COLONNETTI Gustavo	»
CROCCO Gaetano Arturo	»
CUENOT Lucien	»
DAL PIAZ Giorgio	»
DE FILIPPI Filippo	»
DE LA VALLÉE POUSSIN Charles Jean	»
DEBYE Pieter Josef William	»
FAUVEL Pierre	»
GEMELLI Agostino	»
GHERZI Ernesto	»

GHIGI Alessandro	1936
GILSON Gustave	»
GIORDANI Francesco	»
GIORGI Giovanni	»
GODLEWSKJ Emil	»
GOLA Giuseppe	»
GREGOIRE Abbé Victor	»
GUIDI Camillo	»
GUTHNICK Paul	»
HOUSSAY Bernard Albert	»
KEESOM Wilhelmus Hendrikus	»
LEMAITRE Georges	»
LEPRI Giuseppe	»
LEVI-CIVITA Tullio	»
LOMBARDI Luigi	»
LUIGIONI Paolo	»
MARCONI Guglielmo	»
MENDES CORREA Antonio Augusto	»
MICHOTTE VAN DEN BERCK Albert Edouard	»
MILLIKAN Robert Andrews	»
MORGAN Thomas Hunt	»
NOBILE Umberto	»
NOYONS Adrian Karel Marie	»
PANETTI Modesto	»
PARRAVANO Nicola	»
PENSA Antonio	»
PETRITSCH Ernst Felix	»
PICARD Emile	»
PISTOLESI Enrico	»
PLANCK Max	»
RASETTI Franco	»
RONDONI Pietro	»
RUTHERFORD OF NELSON Ernest	»
SCHROEDINGER Erwin	»

SHERRINGTON Charles	1936
SILVESTRI Filippo	»
SPERI-SPERTI George	»
TAYLOR Hugh Stott	»
TONIOLO Renato Antonio	»
TSCHERMAK-SEYSENEGG Armin	»
VALLAURI Giancarlo	»
VERCELLI Francesco	»
VOLTERRA Vito	»
WHITTAKER Edmund	»
ZEEMAN Pieter	»
CONWAY Arthur William	1939
SOMIGLIANA Carlo	»
DAINELLI Giotto	1940
PIERANTONI Umberto	»
SEVERI Francesco	»
URSPRUNG Alfred	1941
CARDOSO FONTES Antonio	»
BONINO Giovanni Battista	1942
DE BLASI Dante	»
GARCIA SINERIZ José	»
HEYMANS Corneille Jean F.	»
MAROTTA Domenico	»
QUAGLIARELLO Gaetano	»
TONELLI Leonida	»
RUZICKA Leopold	»
FLEMING Alexander	1946
ALBAREDA HERRERA Don José Maria	1948
APPLETON Edward Victor	»
CRUZ-COKE Eduardo	»
DE CASTRO Aloysio	»
DOISY Edward Adelbert	»
LANGFELD Herbert Sidney	»
BEST Charles Herbert	1955
BRÜCK Hermann Alexander	»

DE BROGLIE Louis	1955
GARCIA OTERO Julio Cesar	»
HAHN Otto	»
HEISENBERG Werner Carl	»
HESS Walter Rudolf	»
JULIA Gaston Maurice	»
KARMAN (von) Theodore	»
LAUE (von) Max Theodor Felix	»
NIEHANS Paul	»
TISELIUS Arne Wilhelm Kaurin	»
VIRTANEN Artturi Ilmari	»
WEYL Hermann	»
CHADWICK James	1961
DE ALMEIDA Antonio	»
DE HEVESY George Charles	»
ECCLES John Carew	»
FISHER Ronald Aylmer	»
GIACOMELLO Giordano	»
HESS Victor Francis	»
HINSHELWOOD Cyril Norman	»
YUKAWA Hideki	»
CHAGAS Carlos	»
CONWAY Edward Joseph	»
DIRAC Paul Adrian Maurice	»
HORSTADIUS Sven	»
HURTADO Alberto	»
LEPRINCE-RINGUET Louis	»
MIZUSHIMA Sanichiro	»
OORT Jan Hendrik	»
SANDOVAL-VALLARTA Manuel	»
RAMAN Chandrasekhara V.	»
HEISKANEN Weikko-Aleksanteri	1964
HERZBERG Gerhard	»
LECOMTE Jean	»

LEPINE Pierre Raphael	1964
LORA-TAMAYO Manuel	»
MORGAN William Wilson	»
O'CONNELL Daniel Joseph Kelly	»
SIDDIQUI Salimuzzaman	»
VENING-MEINSZ Felix Andries	»
BULLEN Keith Edward	1968
HODGKIN Alan Lloyd	»
LELOIR Luis Federico	»
MARINI-BETTÒLO Giovanni Battista	»
SIERPINSKI Waclaw	»
UBBELOHDE Alfred René John P.	»
CHAUDRON Georges	1970
DE DUVE Christian	»
FEIGL Fritz	»
GARNHAM Percy Cyril Claude	»
GENTNER Wolfgang	»
JOACHIMOGLU Georges	»
MÖSSBAUER Rudolf Ludwig	»
PICONE Mauro	»
ROCHE Marcel	»
STONELEY Robert	»
SZENT-GYORGYI Albert	»
TUPPY Hans	»
LAMBO Thomas Adeoye	1974
LEJEUNE Jérôme	»
LEVI-MONTALCINI Rita	»
NIRENBERG Marshall Warren	»
OCHOA Severo	»
PORTER George	»
CROXATTO Hector R.	1975
PALADE George Emil	»
RYLE Martin	»
SEGRE Beniamino	»

WINNERS OF THE PIUS XI GOLD MEDAL
1961-1986

Year	Name	Country of origin	Research
1961	WOODWARD Robert. B.	U.S.A.	Advanced synthesis in organic chemistry
1962	ANDERSSON Bengt E.	Sweden	Mechanisms of hunger and thirst
1963	BOHR Aage	Denmark	Structure of atomic nucleus
1964	GROS François	France	Mode of action of antibiotics
1966	SANDAGE Alan R.	U.S.A.	Distances between Galaxies
1970	KANATANI Haruo	Japan	Reproduction of starfish
1972	NEMETHY George	Hungary	Intermolecular forces
1975	HAWKING Stephen W.	Great Britain	Theory of « black holes »
1976	LUZZATTO Lucio	Italy	Research on malaria
1978	PAES DE CARVALHO Antonio	Brazil	Physiology of miocardium
1981	LEHN Jean-Marie	France	Photochemistry
1983	't HOOFT Gerard	The Netherlands	Theory of particles
1986	BERNAYS Elizabeth A.	Australia	Plant-insect interactions

STUDY WEEKS HELD AT THE PONTIFICAL ACADEMY OF SCIENCES

1949-1986

The biological problem of cancer	June 1949
The problem of microseism	November 1951
The problem of oligo-elements in the vegetal and animal life	April 1955
The problem of stellar population	May 1957
The problem of macromolecules of biological interest with special reference to nuclear proteins	October 1961
The problem of cosmic radiation in interplanetary space	October 1962
The econometric approach to development planning	October 1963
Brain and conscious experience	Sept.-Oct. 1964
Molecular forces	April 1966
Organic matter and soil fertility	April 1968
Nuclei of galaxies	April 1970
Use of fertilizers and its effect in increasing yield with particular attention to quality and economy	April 1972
Biological and artificial membranes and desalination of water	April 1975
Natural products and the protection of plants	October 1976
The role of non-specific immunity in the prevention and treatment of cancer	October 1977
Nerve cells, transmitters and behaviour	October 1978
Mankind and energy: needs, resources, hopes	November 1980
Cosmology and fundamental physics	Sept.-Oct. 1981
Modern biological experimentation	October 1982
Pattern recognition mechanisms	April 1983
Chemical events in the atmosphere and their impact on environment	November 1983
Energy for survival and development	June 1984

The impact of space exploration on mankind	October 1984
Interaction of parasitic diseases and nutrition	October 1985
Remote sensing and its impact on developing countries	June 1986
Persistent meteo-oceanographic anomalies and teleconnections	September 1986

WOORKING GROUPS HELD AT THE PONTIFICAL ACADEMY OF SCIENCES

1974-1986

Oriented mutations in man	November 1974
The effects of ionizing radiation in man	November 1975
Molecular aspects of the origin of life	October 1978
The dangers of a nuclear war	April 1980
Mental deficiency	November 1980
Perspectives on immunization in parasitic diseases	Sept.-Oct. 1981
The consequences of the use of nuclear weapons	October 1981
Recent advances in the evolution of primates	May 1982
Peace and the rights of man	June 1982
The Gregorian reform of the calendar	Aug.-Sept. 1982
The prevention of nuclear war	September 1982
Biological implications of optimization in radiation procedures	May 1983
Specificity in biological interactions	November 1983
Modern biology applied to agriculture	November 1983
Effects of a nuclear explosion in the atmosphere: nuclear winter	November 1984
Immunology, epidemiology and social aspects of leprosy	May-June 1984
Extra corporeal fecundation	October 1984
Weaponization of space	January 1985
Developmental neurobiology of mammals	June 1985
The artificial prolongation of life and the determination of the exact moment of death	October 1985
Molecular mechanisms of carcinogenic and antitumor activity	October 1986

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