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# The USSR Academy of Sciences: History, Traditions, Latest Achievements (**)

On behalf of the USSR Academy of Sciences I have the privilege to extend our hearty congratulations and best wishes to the distinguished members of the Italian Academy of Sciences on the occasion of its 200th Anniversary. I would also like to thank your President Dr. G. B. Marini-Bettòlo for the kind invitation to take part in the bicentenary celebrations and to deliver a short report on the activities of the USSR Academy of Sciences. This is a rather difficult task since it is simply impossible to separate the development of science in the Academy from the entire national system of the organisation and management of scientific research in the USSR. The progress of science in general is considered to be of exceptional importance for the economic development and people's well-being. That is why the role of the USSR Academy of Sciences is so vital and meaningful for the Soviet state.

Before I turn to the recent achievements of our Academy allow me to invite you on a short excursion into the history of Russia of 1725, when Peter the Great founded the St. Petersburg Academy of Sciences, which was warranted by the objective needs and urgent demands of the quickened pace of the economic and cultural development of 18th-century Russia. From its inception the Academy attracted some of the best minds of that period, such as Leonard Eiler and Daniel Bernoulli for example.

But the real genius of the Russian and, as has become quite clear now, of world science was still to appear. It was Mikhail Lomonosov — brilliant theoretician, outstanding investigator and remarkable organiser of scientific endeavour — the first truly Russian enlightener and scholar of encyclopaedic knowledge, whose

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(**) Lecture delivered on the occasion of the Colloquium on "The Academies of Sciences toward the year 2000" (Rome 20-22 September 1982).

275th birthday will be widely celebrated in 1986. Even if he had not attained the pinnacles of knowledge in the natural sciences, technology, history — and even in poetry! — he would have ensured himself a permanent place in our national cultural heritage as an outstanding educator for one thing alone — the founding of Moscow University, where many future generations of Russian and Soviet scientists were educated.

The contemporaries and successors of this great scientist carried on the traditions he initiated. Here special mention should be made of Vassily Petrov, Nikolai Lobatchevsky, Herman Hess among many others. In some fields of knowledge they started "schools of science", which fully established themselves during the second half of the 19th century. The Russian Academy of Sciences can well be proud of such famous scientists as the mathematicians P. Chebyshev, A. Lyapunov, S. Kovalevskaya, A. Markov; the physicists E. Lentz, B. Yakobi, P. Lebedev, A. Gadolin; the chemists D. Mendeleyev, A. Butlerov, N. Zinin, N. Beketov; the biologists I. Mechnikov, K. Timiryazev, I. Pavlov, I. Sechenov; the astronomers V. Struve, F. Bredikhin, A. Belopolsky; the aerodynamics and mechanics experts K. Tsiolkovsky, N. Zhukovsky. Mention should also be made here of the outstanding specialists A. Popov (inventor of wireless telegraphy), D. Tchernov (metallurgist), A. Karpinsky and V. Vernadsky (geologists), and of some outstanding researchers in linguistics, history, oriental studies, ethnography etc.

And yet, despite all the efforts and achievements of those great men of science, scientists in Russia before 1917 had to contend with great difficulties. The role of the Academy and of science in general was limited. The tsarist regime tended to suppress all progressive thought, fearing the spread of education and scientific knowledge. Progressive men of science had to battle against reactionary theories, ignorance and prejudices implanted and fostered by the autocracy. The discoveries and inventions made by the aforementioned great scientists were much too often either ignored — recall the fate of the great Tsiolkovsky — or not put to practical use.

Research was impeded by the shortage of material resources and technical facilities; very often scientists had to finance their own research, which was mostly carried out at the Chairs in small laboratories of the universities and other places of learning.

In 1913 there were in all 11,600 research workers in Russia. The Academy of Sciences, which then consisted of 44 full members, had only one research institute, seven museums, five laboratories and 13 experimental stations with a total staff of 109 researchers and 179 auxiliary scientific personnel.

Let us for a moment compare these modest data with the similar Soviet science indicators of today. Of the country's total number of 1.5 million scientific personnel about 170,000 are working in the Academy's 252 research institutes and at other scientific centres and laboratories. More than 50,000 highly skilled researchers are headed by 269 Academicians and 536 Corresponding Members of the Academy. In 1982 alone, eight new institutes and some smaller research centres were added to the Academy's structure. The USSR

Academy of Sciences has indeed come a long way since the time of the Great October Socialist Revolution.

The status, pace and character of scientific development in the USSR have changed greatly since 1917. "From now on all the marvels of science and the gains of culture belong to the nation as a whole and never again will man's brain and human genius be used for oppression and exploitation", stated Lenin, the founder of the Soviet state. The Academy promptly and willingly responded to the scientific policies of the young socialist state. Only three months after the Revolution, the General Meeting of the Academy adopted the Declaration which said: "The Academy of Sciences is ever ready to meet the demands of life and of the State so as to engage in the study of the scientific and theoretical problems, posed by the needs of national reconstruction, while remaining the centre of organisation and attraction for all the scientific forces of the country".

Lenin personally developed the guidelines of the Communist Party's and the Soviet Government's policy with regard to science. He formulated methodological principles for determining the main trends in scientific research as well as for the planning and management thereof. Lenin's Draft Plan of Scientific and Technical Work was, in fact, the first guideline, both in our country and in the world, for a planned, comprehensive development of nation-wide scientific research. In the Draft Lenin defined the priority tasks of the Academy. They were:

— large-scale research on the most national distribution of the country's productive forces;

— full supply of the national economy with the necessary mineral raw materials;

— integrated electrification of industry, agriculture and transport.

The latter task was incorporated in the historical GOELRO Plan which was successfully fulfilled ahead of schedule.

The USSR Academy of Sciences steadily follows those guidelines in every aspect of its work. The three principal directions of the Academy's activities today may be summarised as follows:

1) *Solution of the most important problems that further national economic and social development.* In the early years, after the Revolution, it was, as I have already said, the GOELRO Plan. After the Second World War, in the 1950s, many completely new branches of nuclear science and technology were established in the shortest possible period of time. In fact, already in 1954 the Soviet Union firmly occupied a leading position among the industrially developed countries in this particular field.

Right now the Academy is engaged in developing vitally important nation-wide economic projects such as the food and energy programmes. There is no doubt that these, like the previous programmes of equal importance, will be carried out successfully. Throughout the Soviet stage of its history the Academy has been following the same integral pattern, applying it to scientific investi-

gation and utilisation on a wide scale of the country's productive forces. The results of this extensive work are evident everywhere.

2) *Creation and expansion of a continuous front of science.* This means, on the one hand, wide-scale scientific research, both fundamental and applied, in the whole spectrum of knowledge without exception, all fields of science being encompassed. On the other hand, it means the complete coordination and cooperation with the Academy of every scientific research institution regardless of its nature, industrial or educational. In the course of the scientific and technological revolution many new forms of interaction have emerged between theoretical and experimental science, between research and development, between science and industry, science and the health services, science and social institutions.

3) *Full and active support and encouragement of the most promising directions in fundamental and pilot research.* However important the practical applications of today's science may be the Academy, and it alone, is responsible for the search for new exciting frontiers and attractive prospects of human knowledge. The highest authority and the indisputable expertise of the Academy's leading scientists are always at the service of young researchers in their bold scientific ventures.

In these three main directions of the Academy's activities one can clearly see the embodiment of Lenin's well-known principles of science organisation:

— close connection between scientific research and the development of the productive forces;

— research along the whole front of science;

— expansion of the social base of science.

Let us summarise, in the light of the aforementioned principles, the Academy's place in the structure of the Soviet state and the role it plays in the economic and social development of the country.

## The USSR Academy of Sciences

*Status*: Highest scientific institution of the USSR.

*Aims*: Fundamental research in leading directions of the natural, technical and social sciences;

— revealing new ways of technical progress and creating the scientific prerequisites for their implementations.

*Tasks*: Guidance and management of all scientific research in the Academy's institutions;

— coordination of all fundamental research in all other scientific institutions regardless of their affiliation.

Having established *what* are the functions of the Academy let us now consider the question of *how* it carries them out.

First of all let us turn to Fig. 1 showing the structure of the USSR Academy of Sciences. Although it may be said to be self-explanatory, it is worth noting, however, that the structure shown additionally illustrates the above-stated principles. For example, the continuous front of science manifests itself in the activity of the 14 divisions responsible for research in every branch of knowledge without exception. On the other hand, regional divisions, such as the Siberian, Far Eastern, Urals and others, are responsible for the development of science in every region of the Russian Federation.

There are also national Academies of Sciences in each Soviet national republic — the Ukraine, Byelorussia, Georgia, Uzbekistan, Estonia, etc. It is virtually impossible here to cover the whole range of the activities of the Republican Academies. Now we can proudly report that we have highly skilled scientific personnel where only 65 years ago it was hard to find even a dozen of simply literate persons. Here are some impressive data concerning the 14 Republican Academies of today. They have

370 research institutes, laboratories and centres;

193,000 research workers;

3,200 Doctors of Science;

1,400 Academicians and Corresponding Members of the Academies. When speaking of the outstanding scientists of the Republican Academies one cannot fail to mention the world-famed research in welding science carried out by B. Paton of the Ukrainian Academy, or the achievements in astrophysics by V. Ambartsumyan of the Armenian Academy. The scientists in Azerbaijan are the recognised leaders in petrochemistry and oil refining; outstanding scientific results have been achieved in Byelorussia in such sophisticated fields as computer technology and optics; in the Uzbek Academy major research has been carried out in such a vital area as comprehensive resource utilisation.

In short, the combined efforts of the Republican Academies, regional and central divisions of the USSR Academy of Sciences are indeed the best, reliable guarantee ensuring constant development of the "wide front of science".

Returning to the structure of the USSR Academy of Sciences we should perhaps also clarify the role of the numerous Scientific Councils which have been created especially for the coordination and guidance of some interdisciplinary research or complex programmes. These Councils include the best experts in different divisions of the USSR Academy as well as specialists from all other state institutions — universities, industry, government, the mass media, etc. The Scientific Councils are important channels of interconnection between pure science and industry. They also serve as advisory boards in implementing national economic and social programmes. The integral structure of the USSR Academy of Sciences also provides for a mechanism of cooperation with the country's institutions of higher education (more than 860 today), since many

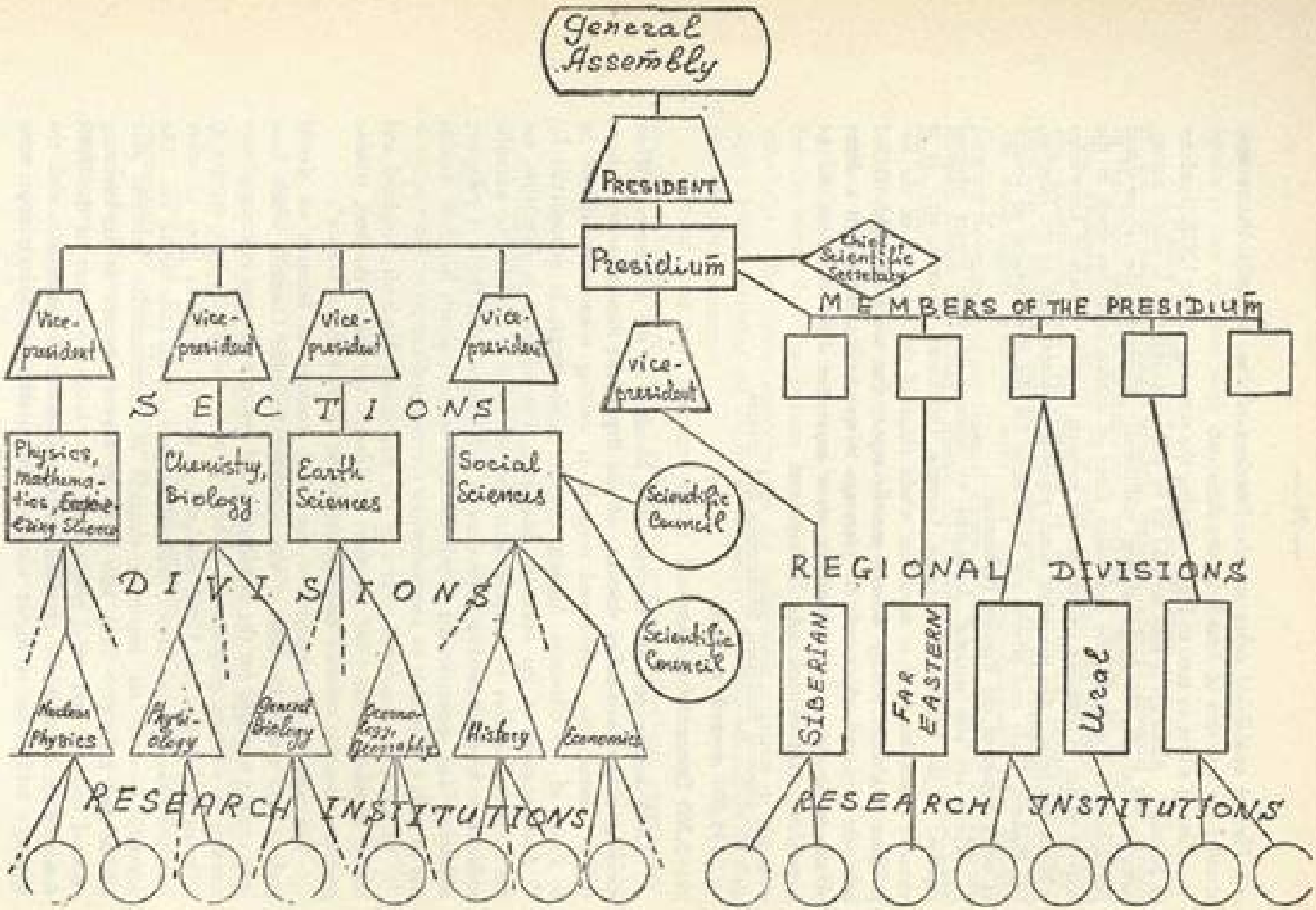
General Assembly
PRESIDENT
Presidium
Chief Scientific Secretary
MEMBERS OF THE PRESIDIUM
Vice-president
Vice-president
Vice-president
Vice-president
vice-president
SECTIONS
Physics, mathematics, Engineering Sciences
Chemistry, Biology
Earth Sciences
Social Sciences
Scientific Council
Scientific Council
DIVISIONS
REGIONAL DIVISIONS
Nuclear Physics
Physiology
General Biology
Economics
History
Economics
SIBERIAN
FAR EASTERN
Ural
RESEARCH INSTITUTIONS
RESEARCH INSTITUTIONS

FIG. 1

Academicians and Corresponding Members of the Academy are working there. The guidance and management of the complex system of Soviet science and its various institutions are anything but a simple task.

I would like to point out in particular that the one and only guiding principle accepted throughout the entire structure of the Academy, from its Presidium down to the smallest research group, is the principle of *democracy*. Table 1 shows who is elected in the Academy, by whom and how.

The USSR Academy of Sciences grew together with the Soviet state. The build-up of the country's present scientific potential was accomplished largely thanks to the sizeable contribution by the Academy of Sciences. Discoveries and inventions made by Soviet scientists have enriched many modern fields of world science. In many cases they were the starting points of new directions of scientific investigations. "Without any doubt", said the President of the Academy, Academician Anatoly Alexandrov, "Soviet science has the highest qualitative level of research in almost every field of science while in a number of them it holds indisputable first place".

TABLE 1 — *The USSR Academy of Sciences: the Principles of Democracy.*

| Who are elected | By whom | Confirmation of the election | Term of election | Manner of election |
|---|---|---|---|---|
| President, Vice-Presidents, Members of the Presidium | General Assembly | None | 5 years | by secret ballot |
| Chief Scientific Secretary | Presidium | None | 5 years | by secret ballot |
| Academician-Secretaries (Heads of the Divisions) | Division's Conference | General Assembly | 5 years | by secret ballot |
| Research Institutes' Directors | Division's Conference | Presidium | 5 years | by secret ballot |
| Academicians | Academicians of particular Divisions | General Assembly | permanent | by secret ballot |
| Corresponding Members | Division's Conference | General Assembly | permanent (unless elected to full membership) | by secret ballot |

This is largely due to the fact that nowhere else in the world does science enjoy such wide recognition, high respect and indisputable authority as in the USSR.

All this has its beginning in the 1920s, when Lenin's plan of drawing scientists into the all out effort of socialist reconstruction evoked enthusiastic

response. Before long the country began to explore the iron ore reserves of the Kursk magnetic anomaly, the chemical resources of the Kara Bogaz Gulf, the potassium salt deposits in Solikamsk, the apatite reserves of the Kola Peninsula, the possibilities of diamond and gold production in Siberia. All these projects were directed by such prominent Soviet scientists as I. Gubkin, N. Kurnakov, A. Fersman, S. Sobolev, N. Bilibin, E. Pavlovsky, K. Skryabin, D. Nalivkin, D. Shcherbakov. The efforts of those dedicated men of science yielded brilliant practical results since their work facilitated the rapid and efficient industrial development of the Eastern parts of the country, the creation of the second coal and metallurgical base of the USSR, as well as of other major fuel and energy systems.

Largely due to the work of those dedicated men of science and their numerous pupils and followers *the Soviet Union today is the only industrially developed country in the world fully self sufficient in raw material and energy resources.*

Suffice it to note that from 1946 to 1982 the Soviet Union's fuel and energy resources multiplied thirtyfold! This tremendous step forward was undoubtedly made possible by the achievements of Soviet scientists working in the field of geosciences.

The typical pattern of evolution from fundamental research to industrial production may be gathered from the following short historical survey of petroleum exploration in Siberia:

| | |
|---|---|
| 1949-1959 | Theoretical studies |
| 1959 | First prognoses for well locations |
| 1960 | Base drilling |
| March 1961 | First Siberian industrial oil deposits are discovered |
| June 1961 | Samotlor oil fields is discovered |
| 1980s | New oil deposits are explored. |

Development of oil production in Siberia is one example of how the energy resources problem is being solved. Here is another similar scheme showing the typical way from theoretical studies to industrial production with due account of export possibilities:

1) Fundamental studies of sea water salinity changes during geological history.

2) Estimations of probable locations of potassium ore fields.

3) Base and explorative drilling.

4) Discovery of potassium salts deposits in Western Siberia.

5) Project of potassium salts production (big enough to satisfy all demands of Siberia in fertilizers' raw material and for export, if necessary).

It is clear that fundamental science can take much of the credit for solving the problem of the fuel and energy resources and their discovery. But

now science can and should do more than just that: it should be able *to create* itself sources of unlimited supplies of energy. This is a long-range monumental project in which almost all fields of science are involved.

Yet, priority here should be given to such basic sciences as physics, mathematics and mechanics. Fortunately, the USSR Academy of Sciences has all the necessary prerequisites for a major breakthrough in these directions.

The Soviet school of *mathematics* is undoubtedly one of the most advanced in the world due to the works of

I. Vinogradov (theory of numbers),
N. Lusin (theory of functions),
A. Kolmogorov (probabilities theory),
M. Keldysh, A. Dorodnitsyn, M. Lavrentyev, A. Tikhonov, N. Muskhelishvili (in different modern branches of mathematics) and many other outstanding mathematicians.

In modern mathematics it is very hard to separate pure theoretical research from applied work which is not only close to mechanics but actually the foundation of many branches of modern technologies. Many of the above mentioned scientists may therefore be equally regarded as experts in the modern theory of mechanics along with such eminent scholars as S. Chaplygin, N. Zhukovsky, A. Andronov, L. Mandelstamm, N. Bogolyubov, N. Krylov, M. Millionschikov, S. Kristianovich.

Their investigations have prepared the ground for the development of high-speed aircraft, hydraulic and gas turbines, rocketry, hydrofoil craft and other machines and facilities extensively used now everywhere.

Soviet scientists have also scored notable successes in every area of *physics*. Here we pay tribute to

L. Landau (theoretical physics),
A. Friedman (modern cosmology, theoretical meteorology),
G. Landsberg (optics),
V. Fok (quantum electrodynamics),
N. Bogolyubov (theoretical physics),
I. Tamm (quantum field theory),
P. Kapitsa (superfluidity),
N. Basov, A. Prokhorov (the theory of quantum generators),
L. Artsymovich, M. Leontovich (Plasma physics),
L. Vereshchagin (physics of high pressure),
E. Savoysky (electron paramagnetic resonance),
A. Ioffe (semiconductors),
G. Kurdyumov, I. Frenkel (solid state physics),
J. Zeldovich (astrophysics).

However important and spectacular the individual achievements of these Soviet scientists, they deserve even greater praise for creating *traditions* in

science, for building up "schools" of their followers. Some of these "schools" have become world famous. This phenomenon is the most reliable guarantee of the continuity of scientific and technical progress. One can also speak in the broad sense of the word of the Soviet school of physics, the school which produced seven Nobel Prize winners: L. Landau, I. Tamm, P. Kapitsa, I. Frank, P. Cherenkov, A. Prokhorov and N. Basov.

Since the 1920s Soviet scientists have been engaged in extensive research of nuclear and elementary particles physics. The now classic works of L. Mysovsky, D. Skobeltsyn, I. Kurchatov, G. Flerov, K. Petrzhak and others have paved the way to the solution of the problem of mastering atomic energy. When it became necessary to create an atomic weapon — as a counterbalance to the American weapon which already existed at the time — it was created and in the shortest possible period.

But the same Soviet atomic physicists also created the foundation for the *peaceful* use of atomic energy.

| | |
|---|---|
| Late 1920s | Systematic studies of the atomic nucleus and elementary particles. |
| Late 1930s | Elaboration of the theoretical foundation of the feasibility of chain fission process initiation. |
| Late 1940s | Soviet Union was forced to develop its own nuclear capacity while continuing its large-scale research in the peaceful use of atomic energy. |
| 1954 | First Soviet atomic power plant. |
| 1958 | Siberian APP (100,000 kw). |
| 1960 | Shevchenko (fast neutrons) APP. |
| 1960 | First atomic icebreaker *Lenin*. |
| 1970s | Atomic icebreakers *Arktika* and *Sibir*. |

Since 1956 when Igor Kurchatov delivered his famous report at Harwell, Soviet scientists have persistently been striving for international cooperation in thermonuclear research and development.

Physicists of the USSR Academy of Sciences are engaged in large-scale research on economically profitable processes of hydrogen synthesis. The existing plans for research and development in this field include the construction of big experimental plants for steady self-regulating thermonuclear reaction, which is practically an inexhaustible future source of energy. It should be stressed that we are not simply contemplating this process but are concretely *planning* it.

The leading role of Soviet science from the very beginning of the development of hydrogen thermonuclear synthesis is internationally known and never disputed. Our country was the birthplace of the most promising and effective construction for plasma thermal insulation. Now the word "tokamak" is as well known in many languages as, for instance, is the word "sputnik".

Four large groups of scientists — in the USSR, the US, Japan and EEC

countries — are working intensively on the construction of larger and more efficient tokamaks. And again the USSR was the first to propose the international project of "INTHOR" tokamak, which is far more effective than any of the existing "national" tokamaks, and capable of bridging the enormous gap between pure physical experiments and the first experimental thermonuclear power plant.

In short, the history of thermonuclear synthesis development may be summarised as follows:

1956 Kurchatov's Report at Harwell

1958 2nd World Conference of Atomic Energy

1960 First basic conception of "tokamak"

1970s "Tokamak" becomes leading direction in research

1980s "Tokamaks"-7, -15 and -10 in operation

1980 "INTHOR" project.

Throughout its history and especially today energy is a determining factor in the existence of human society. Social development has always been accompanied and determined by the level of mastery of various forms of energy and largely depends on the degree of development of the energy base. This will be all the more so in the future.

The achievement therefore of a steady-state controllable fusion reaction, which is a practically inexhaustible source of energy would mean a final and long-term solution of the energy problem.

Speaking of high energy physics one cannot fail to mention the excellent research conducted in this particular branch of physics by V. Veksler (autophasing), G. Budker (colliding beams and electron cooling), S. Vavilov and P. Cherenkov ("Cherenkov Radiation"), I. Frank and F. Shapiro (ultracold neutrons). This area of scientific endeavour requires sophisticated scientific equipment, instruments and installation. So the proper technical and material base for such research was created. That in itself can be considered a technical achievement. The "Meson Factory" (Moscow), high flocks reactor (Leningrad), neutrino observatories (Baksan, Artemovsk), radiation synchrotron (Moscow), and "Tevatron" (Serpukhov) appear.

Modern equipment often needs very expensive and unique research equipment. In order to meet these demands we had to create a very specialised branch of industry — machine building and instrument making for scientific research and development. A great number of people are employed in this branch and we are very grateful to them all for making it possible for scientists to have everything needed for carrying out sophisticated research. Among that modern scientific equipment are powerful accelerators of charged particles, research nuclear reactors, unique radiotelescopes (the famous "RATAN", for instance), powerful 50,000 t press, a large research fleet and all kinds of space lab facilities. That is one of the reasons why we were able to achieve such

spectacular success in space exploration, success of truly historical magnitude. Those achievements are so well known that there is no need to speak about them in detail here.

But mention should be made of one of the recent spectacular achievements — the record-breaking, longest flight in space of the two Soviet cosmonauts, A. Berezovoy and V. Lebedev. In orbit for more than half a year they have carried out a great number of important scientific and technical experiments. Their significance still has to be fully assessed, but already now it can be said that the USSR has scored yet another brilliant victory in space. Summing up the achievements in this area it should be stressed once again that accent is on the *peaceful uses* of outer space for the benefit of all mankind.

### Space Research History

| | |
|---|---|
| 1890s | Principles of cosmonautics formulated by K. Tsiolkovsky. |
| 1920-1930 | Fundamental research by Meshchersky, F. Tsander, Yu. Kondratyk, M. Tikhomravov. |
| 1930-1950 | More advanced theoretical and applied research by S. Korolev, V. Glushko, M. Keldysh. |
| October 4, 1957 | The First Sputnik. |
| April 12, 1961 | Yuri Gagarin was the first man to orbit the Earth. |
| 1960s-1980s | Flights by "Voskhod", "Soyuz" and "Salyut" spacecrafts. |
| July 22, 1972 | First softlanding of "Venera-8" on Venus. |
| January 16, 1973 | "Luna-21" delivered the "Lunokhod-2" to the Moon. |
| July 17, 1975 | The "Soyuz"-"Apollo" rendezvous. |
| 1978-1982 | "Intercosmos" space flights. |
| 1982 | Two Soviet cosmonauts worked aboard "Salyut-7" station orbiting the Earth for 211 days. |

Returning to the general situation in the natural sciences, we come to the conclusion that it is the successes of these sciences that have secured rapid progress in such fields as electronics, nuclear energetics, automation, computer technology, modern mechanical and aeronautical engineering, etc.

The range of research in those natural sciences is very broad. In physics, in particular, our scientists are engaged in research in every branch of this science, without exception. Everything that is being studied by physicists elsewhere in the world is also under study by Soviet physicists. The capacity and potential of Soviet physics are therefore so great that they can if necessary immediately join in the current research and begin working on any problem of urgency and importance.

I have dwelt at such length on the state of Soviet physics not simply

because I am myself a physicist by education and this is my field of research, but primarily because of my firm belief that modern physics is the foundation for developing many other branches of modern science.

When the physical methods of research began to be widely used in modern chemistry and biology it was a really revolutionary step forward in the quality and complexity of chemical and biological experiments.

I've already mentioned long-standing great traditions in the history of our Academy created by the Russian biologists and chemists. In chemistry those traditions were carried on and further developed by the outstanding Soviet chemists N. Semyonov, A. Arbuzov, A. Nesmeyanov, A. Favoursky, S. Lebedev, A. Grinberg, N. Zelinsky, N. Kurnakov, B. Kazansky and some others.

Among the latest achievements of Soviet chemical science one must note:

1) Further developments in theoretical studies of chain reactions, combustion and explosion processes.

2) Discovery of the new types of highly stable free radicals.

3) New methods of zeolite heterogeneous catalysis.

4) Further fundamental research in organo-element compounds and their technical application.

5) Synthesis of qualitatively new types of synthetic rubbers, as well as heat-resistant and highly durable polymers.

6) Making of new alloys and extra pure non-organic compounds.

The new developments in biology in the USSR in the last few decades are marked by the emergence of entirely new modern branches of biology-cytology, microbiology, biochemistry, biophysics, genetics, space biology and many others. Among the outstanding Soviet biologists we find K. Timiryazev, V. Komarov, N. Vavilov, L. Orbelli, A. Bogomolets, E. Pavlovsky, K. Skryabin, N. Koltsov, A. Bakh, A. Oparin, A. Belozersky, M. Shemiakin, P. Anokhin, H. Tsitsyn.

Among some of the latest developments in the Soviet biological sciences should be added:

— research in biophysics; proteins, nucleic acids, lipids, polysaccharides, numerous syntheses of physiologically active compounds;

— new pharmacological compounds and plant growth stimulants are synthesised;

— thorough studies of proteins' synthesis on ribosomes; the discovery of "informosome";

— fundamental research in genetic engineering;

— industrial microbiological synthesis of fodder proteins from petroproducts;

— computer modelling of biological processes;

— studies in transport mechanisms of neuroimpulses by neurotoxins;

— fundamental works: *The Flora of the USSR* and *The Fauna of the USSR*;

— compiling Red Data Books of rare and endangered species of plants and animals in the USSR.

Among the many branches of biological research the most important are those that make possible the rapid and effective practical application of their results in medicine, agriculture and industry, which is achieved by the accelerated developments in molecular biology and molecular genetics.

High priority is always given in the USSR Academy of Sciences to the research in the *social sciences* since they play so important a part in the development of the world outlook and culture of Soviet society; they also constitute the scientific base for decision making and management of social processes. Of the many individual directions of research in the social sciences I will list as a typical example some of the principal problems being tackled by Soviet economists:

— improvement of national economic planning and management;

— economico-mathematical methods and computer applications to economic research;

— elaboration of a 20 year comprehensive programme for the development of science and technology;

— socialist countries' economic integration;

— international economic relations and cooperation.

In most cases the Western scientists objectively and highly assess the achievements in the Soviet natural sciences (mathematics, physics, etc.), and yet sometimes they tend to cite unfounded and biased assessments of the quality of research in the social sciences in the USSR, for example, of psychology where such outstanding scientists as L. Vygotsky, A. Luria, and A. Leontyev achieved tangible results.

Let us hear what S. Tulmin of the University of Chicago, noted American philosopher and science historian, has to say on that matter: "A considerable part of what has been done in Russia in the twenties and thirties corresponds to American research of today... After Vygotsky — the Mozart of psychology — Luria became another Beethoven... The historico-materialistic approach secured his (Luria's) success in scientific research; it was philosophy, which armed him and gave him a solid basis for the integration of such diverse fields of science as development psychology, clinical neurology, cultural anthropology, the psychology of art... This is what we here, in the West, should get to seriously" (*New York Review*, September 1978).

Real progress in science has always been the result of close cooperation of all scientists of the world, has always depended on the exchange of ideas, findings and forecasts. This is even more so in our times, when the most vital and important problems of science and technology have assumed a global char-

acter and can be solved only by the common and united efforts of many scientific organisations and scientists in different parts of the world. That is why the USSR Academy of Sciences maintains intensive cooperation with the scientists of different countries.

I am particularly pleased to note here the successful development of the scientific and technical cooperation programme between the USSR Academy of Sciences and some Italian scientific organisations; this programme was signed in 1977 for a 10 year period. The programme provides for cooperation and joint research in plasma physics and controlled thermonuclear fusion process, solid state physics, mathematical physics methodology, informatics, molecular biology, forecasting of earthquakes, and in a number of areas in the social sciences.

The Institute of Nuclear Studies in Moscow is engaged in some very interesting and promising research in cooperation with the Institute of Cosmogeophysics in Torino. Soviet and Italian nuclear physicists are studying the proton decay processes and dynamics of a rather rare phenomenon — star collapse in our Galaxy, which can be traced and recorded by neutrino radiation. The physical installations facilities at Mont Blanc will start operation in the spring of 1983.

On the whole the cooperation between the USSR Academy of Sciences and Italian scientific organisations is constantly improving. This is undoubtedly to the mutual interest of both our countries.

In conclusion, allow me to draw your attention to an important, maybe the most important, aspect of the activities of Soviet scientists.

Of all the great and complex problems which face mankind and our civilisation the most crucial is the preservation of peace on earth. This is not simply a humanistic goal, but a vital task of every thinking person, of everyone who holds dear the achievements of our science, technology, the arts and culture in general. Not only millions of lives are at stake — which in itself warrants that every effort be made to avert this danger. At stake is our very civilisation, mankind's very existence. "In the struggle for Peace", as John Bernal justly said, "science reasserts its essence and regains the confidence of the masses".

The scientists of the world, and especially such highly authoritative organisations as the national Academies of Sciences, are doing much today and, I hope, will do even more in future, to prevent the danger of mankind being destroyed in a nuclear war. Together with the entire Soviet people, Soviet scientists are fully resolved to do everything possible for the successful and final solution of this most important and noble task — the preservation of peace on earth.

Allow me once again to use this opportunity to congratulate all the members of the Italian National Academy of Sciences on the occasion of its 200th anniversary and to wish all its members every success in the development of science in the name of peace and human progress.

# DISCUSSION

MONTALENTI

The two models of Academy described in the speeches by Sir Andrew Huxley and Professor Velikhov seem to me to have little more in common than their name. They perform totally different functions, pursue totally different aims, except of course, that all of them are interested in science. But as general models they seem to me to be totally different.

VELIKHOV

I think that it is not very different. In the budget for Science and Technology of the USSR about 5% is for the Academy of Sciences, and thus its influence is very important. Nevertheless the Academy, through scientific councils, research programs, and even through the activity of scientists devoted to individual programs, is similar to other Academies such as the National Academy of Sciences or the Royal Society.

MARINI-BETTÒLO

The lecture of Professor Velikhov gave a complete picture of the Academy of Sciences of the USSR and its very complex organization.

I think that it may be one of the solutions for the Academies of Science of the future. It represents — in my opinion — a particular form of integration between the Academies and the Research Councils, and in some cases has the function of special Agencies. In other countries a great part of these tasks has been given to the National Research Councils.

I should like to learn something more about the traditional academic activity, where, as I learn, institutes and laboratories are operating which are doing a very important research work. But what is the role of the Academicians in this context? Are they only coordinators and leaders of the research projects or do they participate in programming and discussion of research? The point is just this: how does tradition fit in the frame of the Academy you have organized in your country?

VELIKHOV

The Academy of Sciences is just the main place for scientific discussions in the USSR. As an example in the physical division we have general discussions organized by Academician Ginsburg. We also have official meetings where

we discuss the development of physics and astronomy and where scientific papers are presented.

Moreover, the Presidium of the Academy of Sciences meets every week on Thursday; this has been so for the last forty years. The first hour is devoted to scientific presentations, and after that organization questions are discussed, on purely scientific problems. We have one and a half months vacation in summer, but during the rest of the year we have scientific presentations, followed by discussions in any field of sciences: history, social sciences, psychology astronomy, physics, mathematics, chemistry, etc.

The Academy issues special publications but generally our papers appear in the scientific journals which operate with referees. Only the members of the Academy have the right to publish in the Memoirs of the Academy their papers without being submitted to referees.

The activity depends very much on each member. For example Academician Kapitza now over 88 years old, works every day in his laboratory on small experiments, on the other hand he is not much involved in organization problems. His activity is nevertheless very important because he has a very critical mind. Other academicians are connected with big programs and this is important because we need a rapid connection between the scientific results and the practical applications.

MARINI-BETTÒLO

I have two more questions which are related. The first: what is the relation between the Academy and the Universities? And the second: Does the Academy take graduate students to work for a doctoral degree?

VELIKHOV

First of all, many members of the Academy have a chair at the University, and many other people of the Academy are involved in teaching. For example, at the Moscow Physico-technical Institute the teaching is organized not by professors but mostly by personnel of the scientific institutes of the Academy, mainly in the new fields.

In the above mentioned Institute the students spend two years in the study of physics, mathematics and other general courses, which are very intensive. After this first stage the teaching goes into a specialization, where students are trained in particular fields.

Graduate students have the possibility to work not only in the laboratory at the University but also in research institutes of the Academy to develop their thesis. In the USSR we have also another degree — because we have a two step system — i.e. *candidature*, which is similar to the Ph. D. When you wish to become a candidate, you have to spend at least three years in a research institute. In this case we have a system according to which the stipendium is paid in part by the University and in part by the Research Institute. Once he has obtained his degree the candidate may join the staff of the Institute if there is place for him.

MALONE

Given the substantial reserves of coal in the Soviet Union, the views of the Government on the possibility that using fossil fuels might increase $CO_2$

content in the atmosphere and change the climate would be important. Has your Academy a position or view on the hazard that utilization of fossil fuels over the next hundred years might produce unacceptable changes in the climate?

VELIKHOV

We have had many discussions on this issue; and the answer is yes, but we do not know exactly the figures of the rise and it may be over quite a long period of time. For us more important is the local change, not in climate but in conditions. For example, our very cheap coal use is connected with surface production. In this case we have a big local problem of land restoration, of water supply. Our main problem is transportation, because it is necessary for us to transport this coal for long distances. Today we try to solve the problem with the transportation of energy with very high voltage, e.g. 2 Megavolt. But the solution is not cheap either. Transportation just by rail-roads is quite expensive, and this is why we try to prepare from coal products of higher quality; one way is just to prepare synfuels. Even in this case in our estimation the synfuels constitute a very expensive research and development project. And as we start now we do not hope to have a solution in a short period of time. In any case our solution is to organize the energy program to exclude if possible burning the oil and mostly convert it to chemical production. This is the reason why we try to increase in all possible ways nuclear power. But in this case we have other problems, just the problem of capital investments in the machinery. The limiting factor for our nuclear power development is just machinery. Another limit connected with the application of nuclear power for technology, is the production of electric power which represents only about the 25% of the consumed energy. Therefore our next step will be the development of reactors for industrial heat. By these means it is possible to use fossil fuel just for producing chemicals. But all this is not quite connected with the rise of $CO_2$ in the atmosphere.

MARINI-BETTÒLO

I should like to pose a question, not only to Professor Velikhov but also to all the Presidents and representatives of the Academies in the Socialist Countries. I think that the model established in the USSR has been followed by most of the Academies in Socialist countries. I should like to know if these Academies run directly scientific research or, as the Academics in our country, promote research and discuss the results of science. I should like to have the answer by our distinguished colleagues representing the Academies of the Socialist Countries.

PAL

I think I can answer this very important question by two sentences. It is quite sure that the example of the Soviet Academy had a very great importance for the transformation of the Hungarian scientific life and in the reform of our national Academy. The Hungarian Academy was founded in 1825 and we had a very important reform some years after the second World War and we made use of the experience of our Soviet colleagues. Second point: I think that we tried to follow our national peculiarities. We have an Hungarian Academy of

Sciences, which is a single institution but is divided in two branches. One is the Hungarian Academy of Sciences which is a body of scholars. If you are a body of Quaranta (Forty) we have a body of about two hundred, which is the maximum for our Academy. They are divided in ten sections: humanities (I beg your pardon for starting with humanities because it is my field of research), social sciences, technical sciences, natural sciences, etc., which hold regular meetings every month. The activity of the Academy is headed by the President and the Presidium.

On the other hand we have a system of Institutes — that is another aspect of our activities — formed by 40 Institutes; which is directed by the General Secretary of the Academy. The reports of the Institutes are discussed by the Presidium and by the other body of the Academy.

I think that that has some connection with your question and that means that we have followed our national Hungarian traditions.

We have taken a number of experiences from our Soviet colleagues as well as from the experience from the classical Academies all over the world, among others from Italy. So I should like to express our gratitude both to our colleagues here in Italy and to those in the Eastern European Countries and in the Soviet Union.

BALEVSKI

The Bulgarian Academy of Sciences has the same type of organization as the Academy of Sciences of the USSR but there is a great difference due to the fact that we are only 6 million people, so we cannot develop a continuous front in Sciences as in the Soviet Union.

There are at the Bulgarian Academy of Sciences about 11.000 persons. All the Sciences are represented including humanities. In some fields we are developing special schools, e.g. physico-chemistry.

The Academy naturally depends on the State for financial support. The Academy is formed by 54 Academicians and 60 corresponding Academicians. The scientific research is carried on by about 2000 persons, whereas 3000 persons work in collaboration with universities. The other people are technicians. In the Academy there are 73 Institutes or independent Centres. Some Institutes are very large, for example the Institute for the technologies of metals, directed by me, has 900 persons working in the field of metallurgy. Other institutes are smaller but some groups have reached high scientific level.

The Institutes are divided into classes: physics, chemistry, biology and earth sciences. They collaborate with the Academies of the other Socialist Countries and in particular with the Academy of Sciences of the USSR. This is also due to the fact that our young scientists are sent for specialization to the USSR. At present we have also in Bulgaria centres for training in particular research fields.

I wish also to mention that our young scientists have been in Rome at the Istituto Superiore di Sanità to learn the techniques of microbiological chemistry for the production of antibiotics. The Bulgarian Academy of Sciences has at present contacts with 80 Institutions all over the world for the training of Bulgarian researchers: for example with the Consiglio Nazionale delle Ricerche in Rome, with the Conseil National de la Recherche Scientifique in France and with the Royal Society in Great Britain for the collaboration in bilateral and multilateral projects.

KALWEIT

I would like to inform you about our experiences in the Academy of Sciences of the German Democratic Republic. We are following exactly the Soviet model as described by Professor Velikhov. Our Academy of Sciences has a double function. One is to produce scientific spirit and the other to produce scientific results.

To produce scientific spirit is the main task of the 90 members of the Academy, and the production of scientific results is the task of the 30 Institutes which are in our country and in which about 20.000 collaborators are employed.

So far we can follow both these lines. We believe on the basis of our experience that this system works well. We consider that the main advantage of such system is that we have a very short distance between the scientific spirit of the Academy of Sciences and the real scientific work of the Institutes of the Country; in effect the work in the Institutes is very strongly influenced by the ideas of the members of the Academy. Another advantage, I think, is to have a very clear and efficient organization. Therefore I would support the system described by Professor Velikhov because of our experiences.

HUXLEY

I would like to ask Professor Kalweit what is the role of the Leopoldina Academy. As far as I understand it is a quite independent scientific academy in the German Democratic Republic I think there is a need for a fully independent body of that kind, with — I think — minimal connection with government, in parallel with the organization of the Academy of Sciences similar to that in the USSR.

KALWEIT

Our experience finds us growing on two bases: on the tradition and on the organization. The Leopoldina is one of the traditional institutions in the German Democratic Republic, and therefore we give much importance to this institution on one hand and on the other to the Academy of Sciences which is the center of our research.

RYSAVY

The structure of the Czechoslovakian Academy of Sciences has a structure very similar to that of the Academy of Sciences of the Soviet Union, but we have a particularity: we have a part of our Academy the Slovak Academy of Sciences, operating only in the territory of the Slovak Republic. The Czechoslovak Academy of Sciences is a federal Academy. In the Presidium 20% of the members belong to the Slovak Academy of Sciences. Our scientific societies are linked to these Academies which pay the expenses of these Societies in their budgets. The scientific societies working in the field of basic research, are more independent, but from a scientific point of view they are protected by the Academy of Sciences: i.e. they have their own executive committees and their scientific journals but they, depend, from an administrative-organization point of view from the Academy of Sciences. In Czechoslovakia there are now 44 scientific societies, with about 30.000 members, which

deal with basic scientific research. There are also societies which operate in the field of applied science, which depend from the *Scientific-Technical Society*, an organization with different sections and branches, to which belong not only scientists but also technicians of different levels.

Both Institutions, the Academy and the Scientific Technical Society cooperate very well for the coordination of research.

PRESS

I would like to make a comment on the last two papers. I think we heard descriptions of extreme ends of academies of sciences. From Professor Velikhov we heard a description of an academy which I would call interventionist — not in a pejorative way but just describing it — in the sense that it is an academy which operates large enterprises and is concerned with scientific education and research. From Sir Andrew we heard a description of an academy that is concerned with the health of science in his country and that restricts its input to the government as I understand it, to questions in which science is of paramount importance and only in a limited sense.

I would like to describe something that is perhaps in between, namely the functioning of the U.S. National Academy of Sciences. Our philosophy is somewhat different. We do not operate institutes, we do not manufacture anything, but we feel that government decision making today, more even than before, and increasingly in the future, will require the kind of scientific and technological advice that is mostly outside of our government. From the President to his ministers or cabinet officers, they are faced almost daily with decisions on energy, environment, health, where the expertise lies most outside the government. We believe that it is the duty of the scientific community to respond and provide advice to these policy-making officials where science and technology is involved. For example, how does one evaluate the risks and benefits of a new drug? What techniques does one use? Are there ways to manage nuclear wastes today, or is more research necessary? What is the higher priority for research: the inner planets or the outer planets? What is the relationship between diet and cancer? a very important question. Most of these questions involve policy-making, they have incomplete scientific answers at the present time, but nevertheless decisions are being made by public officials. We feel that it is better that these decisions be made with the advice of the scientific community rather than by lawyers or political officials without the knowledge of the scientific method or the scientific facts. And we feel that it is our duty as an academy to provide that kind of advice. And so this is another model in addition to the two you have heard.

MESON

I would like to ask Academician Velikhov a question related to the functioning of the USSR Academy, namely, the USSR has a planned economy. A large part of the planning of science regarding the areas supported, the properties assigned, the decisions on the investments and on the allocation of manpower is done on a centralized basis, because it is not possible to work in every field of science with the same degree of investment in terms of financial resources and men.

I was wondering if there is a documentation from the USSR Academy of

Sciences which analyses the relative importance, priorities, perspective for scientific growth, new areas which need to be supported, the criteria on which decisions are taken on investments.

VELIKHOV

That is not a very easy question because the connection between development and science in the USSR is quite complicated. First of all, I give you some examples of the national programs. We work very closely with the plan for electrification of the USSR , i.e., the energy program, which is connected with the development of all fields of energy. The State Planning Committee has the obligation to take in account the results of this analysis and prognosis. Another program is that of development of new technologies for the next twenty years. In such case the State planning Committee has to discuss with our committee all the programs and then the agreed plan which becomes important in the decision making of the "Five year plan". We have also many other connections. For example in the matter of National planning we have already almost 100 national programs, which are directed by the State Planning Committee of the Academy of Sciences, which is in charge of the investment and budget, and the State Committee of Science and Technology which is in charge for the applications of science to new technologies. There are also 100 national programs plus about 40 national five-year programs and 160 oriented programs for special goals. In such programs the Academy has scientific advisers in which as rule, a member of the academy is chairman. An example is the program for leather technology development for manufacturing or the program for synthetic fuel research and development. We have also the electrical program which is connected with many Departments.

We have also horizontal problems in which many Departments are involved. The knowledge of the Academy of Sciences contributes greatly to the solution of many problems. Moreover whenever we have a very new and very important idea we go directly to the Council of Ministers and to the Central Committe of the Party and discuss with the officials our ideas. In such cases we have a possibility to make special decisions. An example: the Central Committee and the Council of Ministers discuss the microbiology and the physico-chemical biology development and make a special decision in the field which becomes the law for all the organization and for the State Planning Committee also for the allocations of funds and so on.

This happens in many fields; for example a special program signed by the President of the Academy of Sciences and by a Minister — for example of the electronic or radiotechnical industry or the chemical industry. This is the way the Academy is connected with the development of science in the field of its interest and which occurs at various levels and stages through the process of development.

MONTALENTI

I thank very much all the speakers and discussants for their very important contributions and for the interesting problems which were here raised and I declare closed the Session.