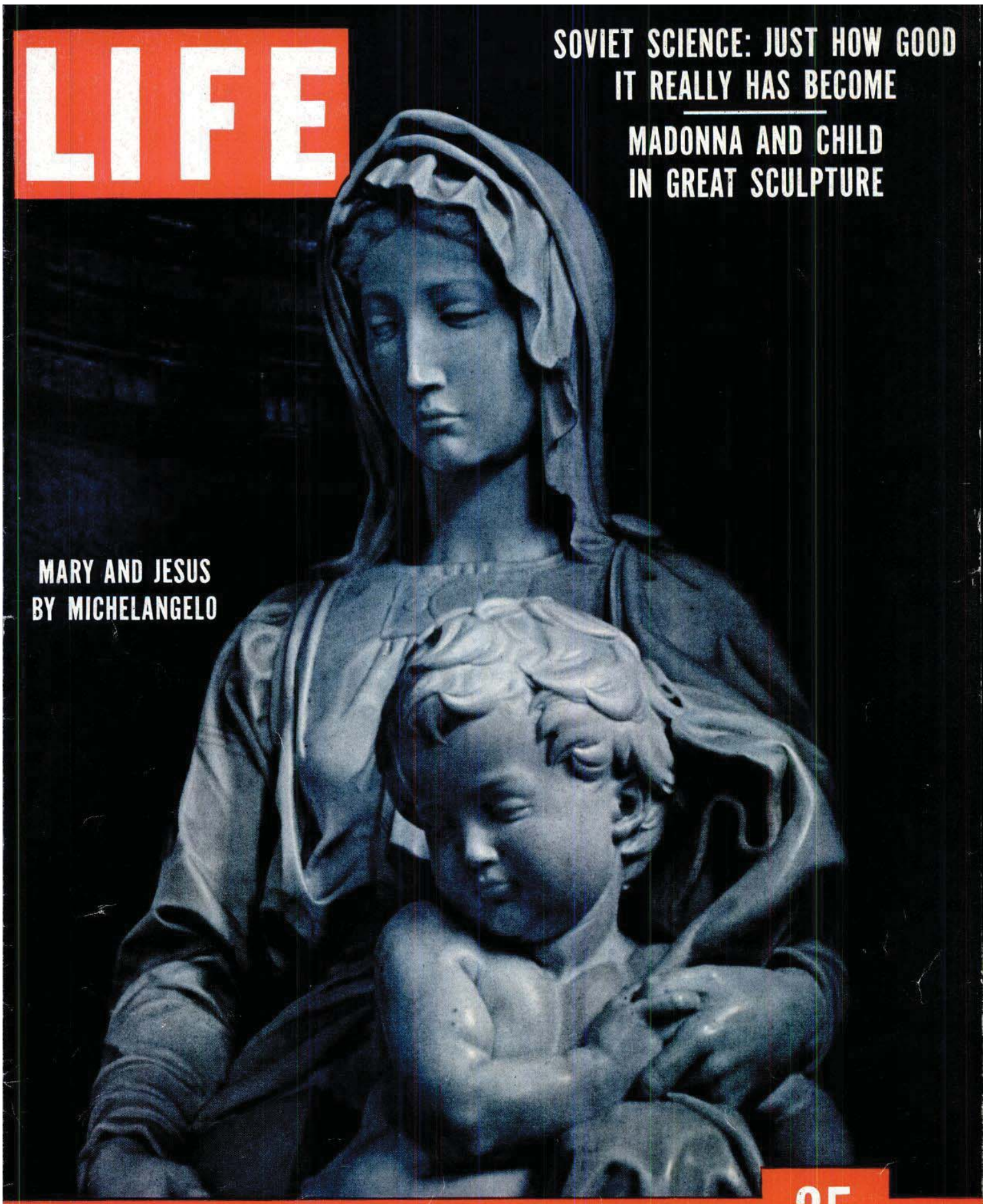
LIFE

SOVIET SCIENCE: JUST HOW GOOD IT REALLY HAS BECOME

MADONNA AND CHILD IN GREAT SCULPTURE



MARY AND JESUS BY MICHELANGELO

DECEMBER 16, 1957 25 CENTS

Vol. 43, No. 25

LIFE

December 16, 1957

REG. U.S. PAT. OFF.

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BY MICHELANGELO

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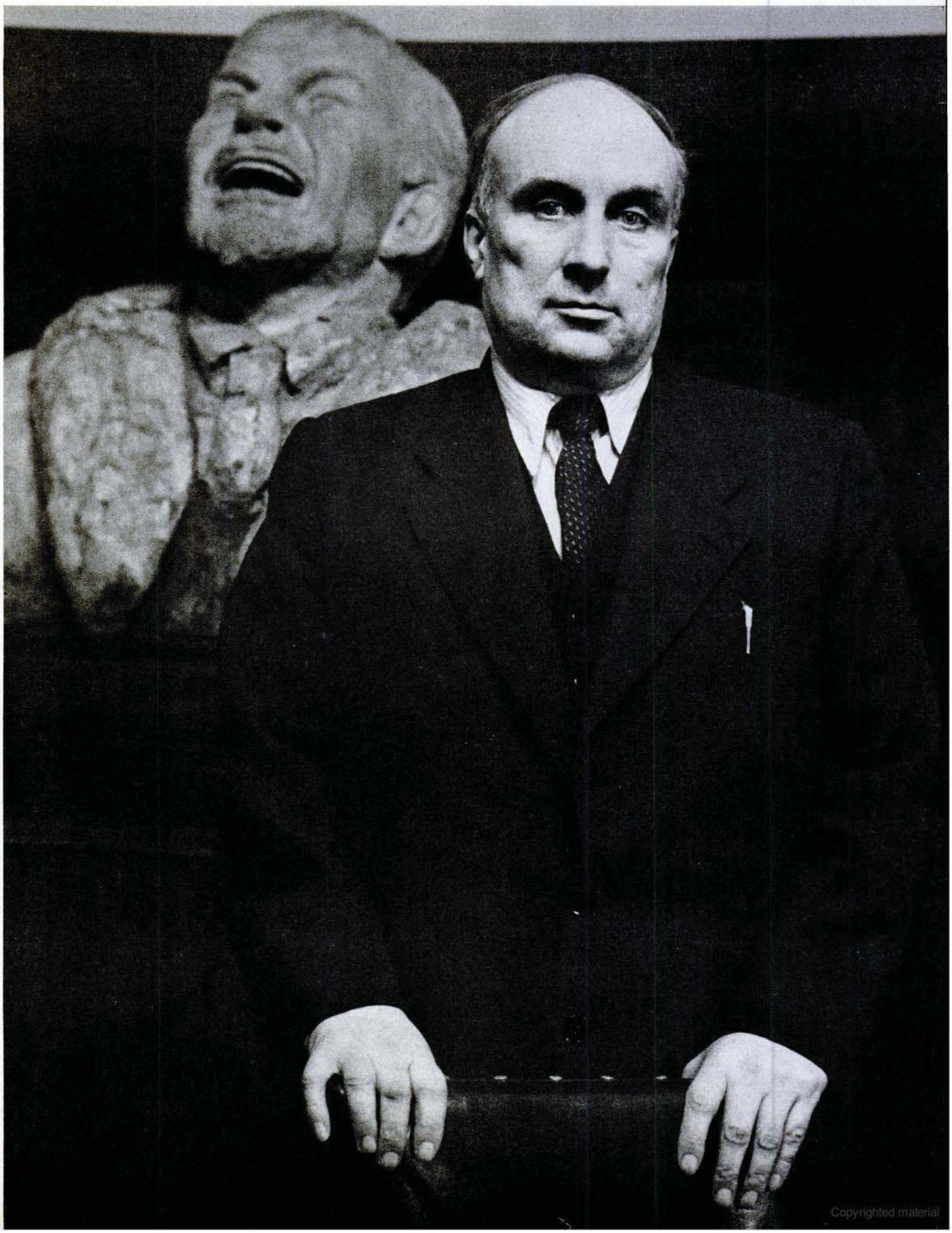
FIRST HARD FACTS ON



ALL RUSSIAN SCIENCES

Field-by-field survey based on U.S. experts' knowledge and Soviet words and deeds shows that Sputniks are but one example of amazing progress

by ROBERT WALLACE

ATMOSPHERICALLY the conditions are ideal for observing the Russian earth satellites as they whirl over the U.S. in the cool December twilight. It is not difficult to get a good look at them. But there is something more in the satellites than instruments and batteries and radios and the body of a dog.

To be impressed by the Sputniks themselves or even by the thought of the rocket fuels that threw them into the sky is to be impressed by a detail. It is as though a tourist in Egypt, having clambered up the Great Pyramid, were to go into raptures over the topmost stone. What is important about the pyramid is what lies below. What is important about the Russian satellites is the base of science beneath them.

Just how good is the base of Russian science? The Sputniks were technological accomplishments of a high order, favored projects into which the Russians chose to throw money and scientific endeavor at the expense of other projects. They reveal again, if there was any doubt of it after the Soviet successes in atomic weapons, that the Russians can do very well when they focus their efforts in one place. But where do the Russians stand over-all, in the many studies lumped together as "science"? What accounts for the progress they have obviously made since 1945? How good will they be in 1965?

In the preparation of this report these questions have been asked of many leading scientists in the U.S. and elsewhere in the free world. What follows is a science-by-science estimate of the whole field, sometimes in the words of a single expert, sometimes synthesized from the opinions of several. Perhaps the best general appraisal comes from Dr. Lee DuBridge, president of the California Institute of Technology. Dr. DuBridge, recalling that U.S. science did not start its real rise until a quarter-century ago, makes this rough comparison: "The Russians were in the position after World War II that we were in in the 1920s. They woke up, and they've been going like mad. Whenever that happens, you'll find progress is greater in some directions than in others. . . . It's not like a race between two horses but more like a race between two fleets of 100 yachts. Some of their yachts are ahead and some are 'way back. But their whole fleet is moving faster, and all their yachts could pull ahead."

Before the individual sciences are discussed there are two preliminary points. First, do Western scientists really know what is going on in Russia, and if so, how?

Yes, they do know. Since Stalin's death Russian scientists have been permitted relative freedom of communication with the West. They attend conferences outside the U.S.S.R., they publish articles in technical journals that are available to Western readers, and when they meet their American colleagues they usually speak with candor. In certain fields, at least, their freedom of communication seems greater than that permitted their counterparts in the U.S.—a situation which troubles many American scientists greatly. Dr. Detlev Bronk, president of the National Academy of Sciences, says, "Unless we have a far greater fund of new scientific knowledge and are making discoveries at a much more rapid rate than the Russians, which I do not believe, we should endeavor to learn from them. If people are our friends we will wish to know what they know and are discovering; if people are our enemies we desperately need to know what they know and think."

In conversation with Western scientists the Russians have been almost garrulous. They have keen professional pride and are wholeheartedly dedicated to their work. When they visit scientific institutions in the U.S., they are impressed by what they see—but soon begin to talk excitedly about what they are accomplishing at home. In this dedication the West should find a warning: the competition is far from spiritless.

A second point is the distinction between basic and applied science, between knowledge which is sought merely for its own sake, and knowledge sought for some specific purpose. The basic scientist examines the stuff of which the universe is made, seeking information about it that can be phrased in a formula which will be true everywhere and forever. In his wake come the applied scientist and the technologist, who seek to find a use for what their predecessor has discovered. The product of basic science, for example, was the information that nuclear explosions are possible. The product of applied science was the atomic bomb.

Basic science is always ahead of applied science. Sometimes the time gap is only a few months, sometimes years. The relationship is important in any evaluation of Russia's, or any other nation's, science.

With these points in mind, here is how we stand as compared to Russia.

MATHEMATICS: The Russians have traditionally been strong in theoretical mathematics. Today they are probably ahead of the West in this science from which the most extraordinary insights, such as Einstein's Theory of Relativity, are obtained. But the Russians may lag in the applied mathematics of automation and computers. When the last thorough comparison was made a few years ago, Russian computers were still slower and fewer than ours. Today Russia claims to be building the world's largest and most versatile computing machine, and American experts point out that an extraordinarily good computer must have been used in making calculations before the Sputniks were launched.

ATOMIC PHYSICS: Russian emphasis in atomic research has been in the spectacular high-energy field, the production of new particles and the study of the nucleus. Right now the Russians have the world's largest atom smasher, almost twice the size of the largest U.S. machine

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LEADERS OF RUSSIAN SCIENCE are depicted in this painting of the Presidium of the Academy of Sciences listening to a talk by a member (*right*). Today the academy, under Alexander N. Nesmeyanov (*standing, left*), directs the country's scientific projects with considerable freedom from Kremlin control.

←MOST POWERFUL SOVIET SCIENTIST IS ACADEMY PRESIDENT NESMEYANOV, SHOWN WITH BUST OF LENIN

HIGH STATUS OF SCIENTISTS in U.S.S.R. was emphasized when Igor Kurchatov (*center*), Russia's leading atomic physicist, visited British nuclear lab last year with Khrushchev and Bulganin, who let him hold center of stage.

SOVIET SCIENCE CONTINUED

now operating. Last week, commenting on the value of this Russian "phasatron" as a research tool, a group of U.S. scientists stated that "a discovery made with it could at any time create a furor similar to that caused by the launching of the satellites."

Other Russian research equipment has also impressed Western visitors. Dr. Robert R. Wilson of Cornell last year saw a 60-inch cyclotron which is virtually in mass production for educational and research purposes. Dr. Arne Lundby of Norway found a teaching laboratory in Moscow equipped with 10 commercially made mass spectrometers, worth perhaps $500,000 and far excelling any equipment available to students in the U.S. or in Europe for measuring the masses of atoms.

Moreover it is not merely the quality of Russian equipment that is high. The level of knowledge is commensurate. Dr. W.K.H. Panofsky of Stanford, an authority on the design of linear accelerators, last year was asked to chat with a few of his Russian counterparts during a visit to Moscow. "I thought there might be three or four of them," Panofsky said, "but found myself addressing some 30 men and women, all of whom seemed to be experts in my specialty."

CHEMISTRY: The level of basic research in this field, as indicated by reports published in Russian technical journals, is not high. Last year a Russian chemist, N. N. Semenov, received a Nobel prize, but it was for a theory of combustions and explosions which he formulated in the 1920s. Apparently the Russians have not yet entered a number of fruitful fields, such as the application of quantum mechanics to chemistry, and they have neglected drugs, vitamins and antibiotics. "Most of their work," says Dr. John Turkevich of Princeton, "is just plain unimaginative."

Some Western chemists feel the apparent lack of progress may be deceptive. "Russian chemists are very close-mouthed, more so than men in other fields," reports Dr. John Flagg of General Electric. "At the Geneva Conference for peaceful uses of atomic energy, delegates from many nations gave papers on the chemical processing of uranium and plutonium—but not the Russians. We couldn't even get them to talk about it. And we were pretty sure they were doing as much as we were. Same thing with high-energy fuels. If Sputnik and Muttnik are any indication, they're ahead of us, but they haven't published anything on the subject." Nevertheless, Western authorities agree that Russia has not poured talent into chemistry as she has into physics. The reason is plain. The great stimulus for U.S. chemistry comes primarily from two sources: private industry, which does not exist in Russia, and medical research, which is neglected there.

ASTRONOMY: "Russian astronomy has always been good," says Dr. Otto Struve, head of that department at the University of California. "Ambartsumian, the dean of it, has done brilliant work on the formation of heavy elements at the surface of stars and on certain other ill-comprehended sources of energy. We have only two or three men who compare with him. But it is the young men who concern me. They are training more than we are now. They have caught up with us and will pull ahead in the next decade unless we double the number of youngsters we are training. It is difficult. Our funds have been heavily cut in the past year. . . . People forget how important astronomy is. Nuclear physics and a

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DISTINGUISHED TRIO of scientists (*from left*), Astronomer V. A. Ambartsumian, Sputnik expert Anna Masevich and Physicist P. L. Kapitza, talk with a visitor from India and a Russian colleague at 1955 meeting of Soviet Academy of Sciences, called to discuss the peaceful uses of atomic energy.

SOVIET SCIENCE CONTINUED

large part of mathematics wouldn't exist if it weren't for astronomy. We don't need much money, just a little bit more. . . ."

The U.S. possesses the world's largest telescope, the 200-inch instrument on Mount Palomar in California. But the Russians have a 100-incher under construction and are planning to surpass the U.S. with one of 220 inches.

CRYOGENICS: This science, the study of the behavior of matter at extremely low temperatures, yields information of the utmost importance to the science of the future. When matter is cooled toward absolute zero (−459°F.), its molecules lose speed and its structure is simplified. This makes possible insights which scientists have never before achieved. It is almost as though the tricks of a sleight-of-hand artist were photographed on fast film, then shown in slow motion. Liquid helium, for example, behaves in an extraordinary manner when it is cooled below −456°. It offers no resistance when solid shapes are pushed through it. It can turn some materials, such as lead, into perfect conductors in which electrons float from atom to atom without friction.

The world's great pioneer in cryogenics is Russia's Peter Kapitza, now 63, who heads a magnificently equipped research institute in Moscow. A versatile scientist, Kapitza has turned to other work in recent years—among his present posts is the chairmanship of the State Committee for Interplanetary Travel—but he has inspired a generation of younger men who now pursue his old specialty. Among them is L. D. Landau, generally acknowledged to be one of the two or three foremost theoretical physicists now living. In the 1940s Landau worked out the theory of liquid helium. Today he and his students publish many expert formulations of low-temperature phenomena. As a result, Russia's cryogenics is probably superior to that of the U.S. in basic theory and only slightly behind experimentally. Recently the British low-temperature physicist Dr. David Shoenberg visited the Kapitza-Landau institute and reached the inevitable conclusion: "They are bound to outstrip us."

SOLID STATE PHYSICS: In general, solid-state physicists do three things: they study crystals, their shape, arrangement, defects and response to various kinds of outside energy; they find out what magnetic and electric action takes place in metals and ceramics; and they study how to make and test metals with desirable properties. The worldwide interest in solid-state physics is intense. In the U.S. literally thousands of scientists work at it in universities and in the industrial laboratories which produce transistors, semiconductors, magnetic memories, stronger metals and faster computers.

In Russia the great emphasis in solid-state physics has been upon theory and experimentation rather than application. Three of the world's half-dozen pioneers in the field were Russians: Kapitza, Landau and Abram F. Joffe. Their basic research is as good as any to be found in the West, and this somewhat counterbalances the fact that Russia has fallen two to five years behind in application.

LIFE SCIENCES: In these areas—microbiology, biophysics, biochemistry, plant and animal physiology, cytology (cell research), botany, zoology and paleontology—Russia is generally far behind us. Her once excellent genetics research is still recovering from the

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SOVIET SCIENCE CONTINUED

great damage caused by "Lysenkoism." Trofim Lysenko, a biologist who was a favorite of Stalin's, championed the mistaken theory that environment, not heredity, is the dominant force in changing and maintaining the forms of life. At Stalin's insistence all Russian biologists were obliged to support this theory, at least publicly. Today Lysenkoism has been denounced by Communist leaders, but Russian genetics has been set back 10 years. Even if the Russians devote the same effort to the life sciences that they now give to others, it will probably be a generation before they can catch up with the West.

EARTH SCIENCES: What Russia is capable of accomplishing in a few years is well illustrated by her progress in the sciences of the atmosphere, the oceans and the earth. In prewar Russia oceanography was a scientific stepchild. But since 1945 she has launched an oceanographic fleet with a total tonnage 10 times that of the U.S.'s and a staff of scientists two to three times as large. Russia has assumed one third of the worldwide oceanographic effort connected with the International Geophysical Year, a larger share than that of the U.S. Qualitatively Russia's work does not yet equal that of American oceanographers, but her quantitative lead may soon translate itself into superiority in quality as well.

In the sciences of the atmosphere Russia may already have achieved superiority, although in some areas the U.S. still holds a lead. Dr. Harry Wexler, director of research for the U.S. Weather Bureau, makes this comparison of Soviet and U.S. meteorology: "Our best minds and best instruments are still superior to theirs, but they have more minds, more instruments and more money, as well as more expansion planned for the future."

Russian research in the solid earth itself is not up to the U.S. standard in several particulars. She is weak in many branches of geology, and her theoretical work on the composition of the earth's crust and core is not impressive to Western scientists. But in some areas Russia is ahead. Her applied chemical prospecting—the detection of mineral deposits by the trace elements washed out of them and found farther down the watershed—is being copied by U.S. geologists. Russia's seismology, the study of quakes and other shock waves in the earth, is better coordinated and staffed than that of the U.S. The Soviets are probably also ahead of us in geodesy—the measurement of the earth's size, shape and gravitational field.

Russian drilling rigs available for geophysical studies are remarkably good. At a recent conference in Canada, U.S. Geophysicist Roger Revelle remarked wistfully that it would be nice if a hole could be drilled 10 miles into the earth so that scientists might at least know exactly what lies beneath the submarine and subcontinental coating of basalt. Up spoke a Soviet scientist who said that Russia already has perfected the necessary drilling rig and is only looking for a good place to sink the shaft.

AS the foregoing brief roundup indicates, Russia stands very well in most of the sciences. In some sciences where she lags, the lag may be intentional: her science is encouraged and subsidized not for the benefit of the people but for the state. The recent Russian advances are not merely isolated technological breakthroughs; they are the result of a long-term emphasis on basic research which is the great strength of Soviet science. An estimated 20,000 Soviet workers annually enter this field, where the great discoveries (including those leading to new weapons) are made. By contrast the U.S. increases its basic research staff by fewer than 10,000 workers a year, concentrating instead on applied research leading to the better air-conditioner and the noiseless commode.

Russia has assumed her challenging scientific position only since the end of World War II. But Russia is no intellectual parvenu. Her scientific tradition extends back at least to the time of Peter the Great. The Russians have always been excellent theoreticians—Einstein's relativity, for example, is rooted in the abstruse non-Euclidian geometry which was developed by the Russian Mathematician Lobachevski around 1830. The sudden flowering of Soviet science may seem startling to Americans who like to think of Russia as a nation of peasants, but in fact the new blossom hangs from an old bough. It is only the impetus that is new.

At the end of World War II the Russians deliberately set out to obtain world domination through science. Their scientific effort is organized like a pyramid with the Soviet Academy of Sciences, headed by A. N. Nesmeyanov, at the top. The academy has some 500 members, all leaders in the various sciences, who act as a huge board of directors in channeling the national program. Scientific projects are assigned to various institutes for development, and there is little duplication of effort. Such national control of science would be wholly unpalatable in the U.S., but some over-all direction may be required

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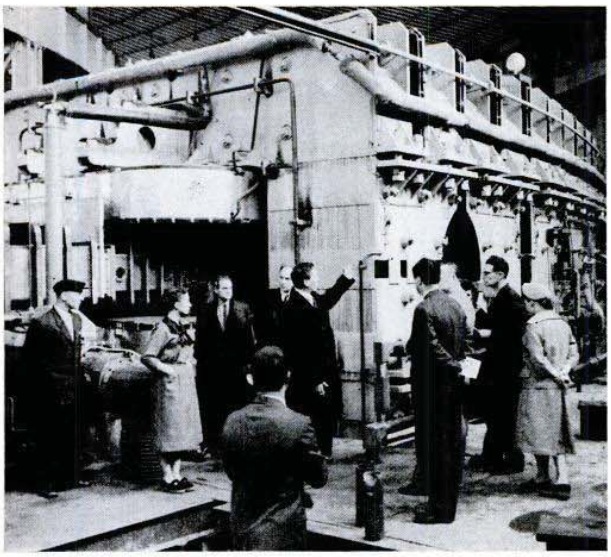

WORLD'S MIGHTIEST ATOM-SMASHER at Dubna, Russia is powered by huge 36,000-ton electromagnet whose operation is explained for Western newsmen by Soviet nuclear scientist Valentin Petukhov (*center*).

SOVIET SCIENCE CONTINUED

if the U.S. is to compete successfully with Russia. At any rate, there is strong sentiment among American scientists for the setting up of a national department of research and development, perhaps headed by a scientist with Cabinet rank, so that the U.S. can eliminate some of the waste which Russia has already eliminated.

When money is required for scientific projects, the Soviet Academy of Sciences sees that it is supplied. Scientific equipment is extraordinarily expensive: a single atom-smasher may cost $100 million, the firing of one large rocket as much as $10 million. But whatever Soviet scientists request of their government, they get. For example, the huge Soviet phasatron is driven by a magnet containing 72 million pounds of iron. Had Soviet scientists been in less of a hurry for the phasatron, they would have discovered, as Western scientists have, that such a mountain of iron is not necessary. But they were in a hurry, and they got precisely what they requested. Today a standard wisecrack among Soviet scientists, showing off the machine to Western visitors, is, "We had to melt down the Iron Curtain to make it."

Dr. Maurice Stacey, head of the department of chemistry at the University of Birmingham, England, last year visited Leningrad's Institute of High Polymers (plastics) and reported that "the amount of equipment is incredible. There was five or six times as much as in the comparable department of a British institution. . . . One wondered if they could use it all."

A clearinghouse for information

IN addition to furnishing whatever equipment may be requisitioned the Soviet government provides lavish support in research services. Theoretically a scientist can keep abreast of world developments by wide reading of technical journals, but in practice this is almost impossible. There are too many journals in too many languages. To solve this problem the Russians have established an Institute of Scientific Information, described by a British zoologist, Dr. D. R. Newth, as "the really shattering thing" he saw during a visit to Moscow last year. The institute abstracts about 8,000 scientific journals from all over the world, including 1,400 from the U.S. and 800 from Great Britain, annually publishing a well-indexed mass of information larger in volume than a set of the *Encyclopaedia Britannica*. Said Dr. Newth, "When a journal comes in, all the papers in it are put on filing cards and each is allocated to a senior scientist, not a hack, to abstract. The delay between the time a paper is received and the time its abstraction is completed is well under a year, and they are bringing it down to six months. No other agency in the world is doing this job. I wish to God I could read Russian."

Newth found that Soviet scientists had an impressive knowledge of developments in the Western world. "In an argument with some of them," he reported, "I quoted the works of two Britons named Biggs and King. One of the Russians replied, 'Yes, but you haven't

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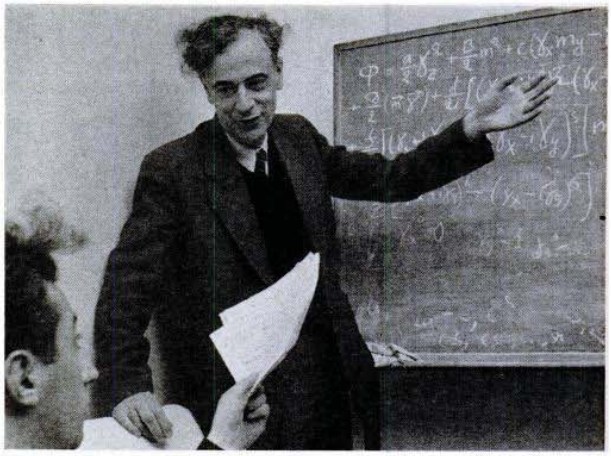

RENOWNED PHYSICIST Lev D. Landau, who ranks as one of world's two or three top theorists studying the behavior of matter at extremely low temperatures, teaches at the Institute for Physical Problems in Moscow.

SOVIET SCIENCE CONTINUED

seen their latest paper. It qualifies their previous conclusions.' " To his chagrin Dr. Newth later discovered that the Russian was right.

The U.S. has nothing comparable to the Russian Institute of Scientific Information and is therefore grievously handicapped. The Atomic Energy Commission supports translation of several foreign publications, and many scientific societies publish abstracts covering foreign work in their own fields. Private industries also maintain their own libraries. But of 1,200 Russian scientific journals subscribed to by the Library of Congress, only 30 are regularly translated and made available to U.S. scientists. Thus there is no central clearinghouse where a scientist can quickly find out what he needs to know.

This lack of current information is frustrating and costly. Recently, for example, the National Science Foundation reported that a group of American laboratories spent five years and more than $200,000 researching a problem in electrical circuitry, only to discover after the conclusion of the work that the research had long since been done, and the results published in Russia.

The rewards of Russian research

THE mere provision of equipment and research services was not of course sufficient to produce a thriving science in Russia. Something had to be done for the scientists themselves. This, too, the Soviet leaders have done. Upon the traditional base of respect for intellectuals in Russia has been grafted an official system of material rewards. The head of the Academy of Sciences, A. N. Nesmeyanov, receives about $20,000 a year, a sum which in Russia makes him the equivalent of a top U.S. executive. A high-ranking Soviet professor like Landau may draw $18,000. Soviet scientists, almost alone among Russians, may equip their homes with refrigerators, TV sets and record players. They may maintain weekend cottages in the country and spend their vacations on the Black Sea Riviera. They are, except the topmost political and industrial brass, the most favored class in the Soviet Union. "Class distinctions are greater than anything I had ever imagined," reported a British chemist last year. "Scientists and professors always seem to have a host of servants, maids and chauffeurs." It is a remarkable paradox: by serving Communism scientists receive capitalistic-size rewards. As Dr. M. H. Trytten of the U.S. National Academy of Sciences has remarked in wonderment, "Somehow a system of government based on materialism has found a way to bestow its highest rewards on men who deal in abstract ideas."

But the lavish satisfaction of professional and personal wants still cannot assure that scientists will produce great work. Freedom of thought and communication are also required. A few years ago, while Stalin still lived, Dr. Vannevar Bush predicted in his book *Modern Arms and Free Men* that the scientists of the free Western world, in the very nature of things, were bound to surpass the strait-jacketed scientists of Russia. This seemed to be a safe forecast when Dr. Bush wrote his book, but times have changed. The case of Peter Kapitza serves as an illustration.

From the mid-1930s to 1946, Kapitza was popularly regarded as the supreme scientist of Russia. But then he gradually fell from favor

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and was finally placed under house arrest. No one in the West knows precisely why, but the best guess is that he objected to Russia's post-war isolation of science, its secrecy and Lysenkoism, and spoke up about it. Then in 1955, as suddenly as he had been downgraded, Kapitza was restored to favor. He was reinstated as director of his institute, and according to rumor he ran up the steps of the building, followed by a crowd of students, shouting "No more secrets!"

Here the paradox expands: by performing well for a slave state some Soviet scientists are paid off in freedom. Within limits which would be intolerable to Western scientists but seem tolerable to them, Soviet scientists may do and say what they please. When their science collides with Marxist dogma, it is the dogma and not the science which finally yields. For years Stalin frowned on the teaching of Einstein's theory of relativity because he considered it to be based on decadent premises with which Marx and Lenin would not have agreed. Today Soviet scientists teach the theory openly (as they always did covertly), and the Party holds its tongue.

Needless to say, not all Soviet scientists enjoy freedom. Mathematicians and physical scientists have the most, social scientists the least. It would be a foolhardy sociologist or psychologist who chose to differ with Communist doctrine. For this reason the best Russian brains go into the "safe" physical sciences, the second-rate brains into the "unsafe" social sciences and the humanities. Herein lies a long-range danger for the West: an unbalanced Soviet culture, capable of producing fearsome weapons and space ships but untempered by the humane studies and virtues, is a child with a knife.

But in the giving of freedom lies a long-range danger. Freedom spreads. Will the scientists infect others? What happens then?

A call for peace

RECENTLY a group of 196 Soviet scientists, headed by such men as Kapitza, Nobel Prize winner Semenov and academy head Nesmeyanov, sent out a highly interesting communication. It suggested that "a broad international conference of scientists" be held to discuss the dangers of thermonuclear war. "We Soviet scientists express our full readiness for common effort with scientists of any other country to discuss any proposals directed toward the prevention of atomic war, the creation of secure peace, and tranquillity for all mankind."

The communication repeated some of the old Communist propaganda demands, such as cessation of atomic bomb tests, but it appeared to have something more in it. Dr. Eugene Rabinowitch, editor of the U.S. *Bulletin of the Atomic Scientists*, thought that it did and urged that Western scientists meet the Russians half way. So did U.S. industrialist Cyrus Eaton (C & O Railroad, West Kentucky Coal, Portsmouth Steel). It "indicates a willingness on the part of scientists to do their part toward cooling the passions of statesmen," Eaton said. It may indicate something else too: Khrushchev's dilemma. In order to make scientists produce he must give them freedom, and with freedom comes responsibility and a sense of the worth of man. When scientists start thinking about such things, perhaps the whole Communist contrivance goes up the spout.

The foregoing may be too long-range a hope—Khrushchev may provoke war before the scientists provoke peace. But it is a hope. Setting it aside, one can leave Khrushchev chewing on his paradox and his problem and look at another aspect of Soviet science, its future, which involves the Soviet educational system.

Most of the leaders of Soviet science today are men in their 50s and older who received their training in the West before World War II. In the near future Russia must begin to rely on home-trained products. It is too early for anyone to make an accurate estimate as to their quality, particularly their capacity for independent thinking, but their quantity will obviously be great. Earlier this month, addressing a NATO conference in Paris, U.S. Senator Henry M. Jackson pointed out that "scientific manpower is being graduated in the Soviet Union at a present per capita rate approximately twice that of the NATO community as a whole. Russia now turns out more scientifically trained people than any Western nation, and is accelerating the output at a higher rate than any nation."

Needing scientists, the Soviet simply trains them, and the individuals have no choice. Even if Russian students had unlimited choice they would doubtless choose science in any case. Students can see the rewards given to scientists. Moreover there are not many other fields a bright young Russian can enter. There is no demand for talent in private industry, advertising, salesmanship or marketing. There are comparatively few lawyers in Russia. Medicine is not a highly regarded profession: practicing physicians, roughly 70% of whom are women, rank only slightly above factory foremen. Science is the thing.

The entire Soviet educational system is geared to discover and develop potential scientists. All Soviet children attend the "Seven-Year

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SOVIET SCIENCE CONTINUED

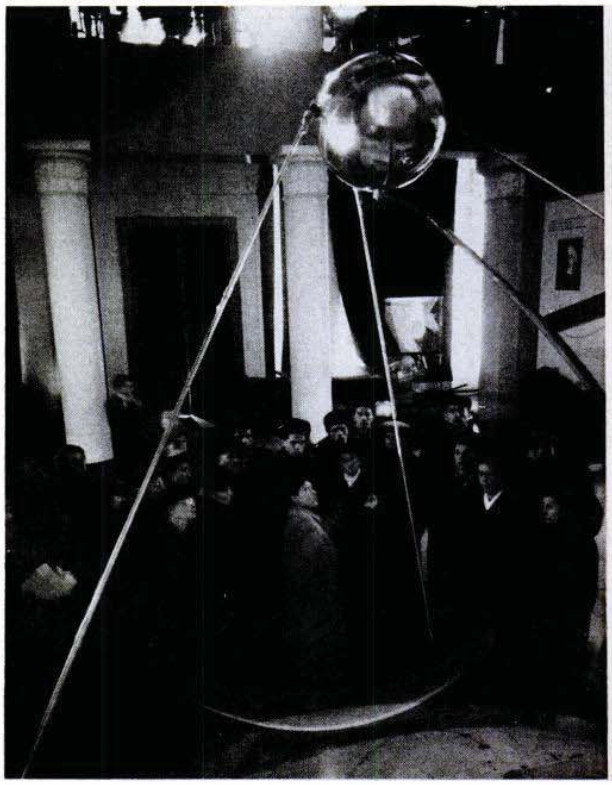
School." The brightest go on for three more years, graduating at about 17. These schools operate on a six-day week and a 10-month year. By graduation, the Russian child has absorbed a tremendous amount of science education: 10 years of mathematics through trigonometry, five years of physics, four years of chemistry, five years of biology and one year of astronomy.

As the Russian student goes through school, he is watched closely for signs of intellectual ability. If he has talent, he is sent on to an institute of higher education where the Soviet incentive system takes hold. He is paid to study, and the higher his grades, the more his pay. The brightest students continue studying and continue to be paid until they are full-fledged scientists. In sum, the Russian system of science education is a frighteningly good one, for Russian purposes. It can only be assumed that it will produce an even greater challenge in the future than the challenge that exists now.

As to where Russian science is heading and what its status will be in another generation, no one can say. Some Western scientists suggest that the Russians suffer from an inferiority complex which is distilled in the arrogance and the rudeness of Khrushchev. Now that the Russians have shown the world, through the Sputniks, that they too can produce technological wonders, they may become a little easier to live with and may begin to direct more of their scientific effort toward peaceful projects. Others suggest just the opposite: that the Russians will continue to concentrate on weapons, hoping to defeat the West or blackmail it into surrender.

In any case the West has no choice but to assume the worst. It may come in two forms: in military conquest, the primary concern right now, or in peaceful conquest, through the Soviet state-controlled system of education.

In its hundreds of thousands of trained technicians Russia is producing men and women who know how to operate uranium mines, to build and run power plants, to do laboratory work, to put science to practical use. Within a generation the Soviet Union will have an enormous pool of such technicians, far more than she needs domestically, who can be used as a living export commodity. Sent into Africa, India, Indonesia, they may develop these areas according to the Communist scheme while the U.S., still talking bravely about free enterprise and Point Four, declines. It is this prospect, in addition to the purely military implications, that Americans may consider as they watch the Sputniks tumbling through the cool twilight over their secure and perhaps still somnolent country.



SCIENTIFIC SYMBOL, Sputnik I was displayed in full-scale replica in Moscow last month to fascinated crowds at a Soviet industrial exhibition.