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Educational Challenge

Frederick I. Ordway III

the educational challenge

By Frederick I. Ordway, III

Frederick I. Ordway, III, was educated in the geoscientific and geophysical fields at Harvard University and the University of Paris (Sorbonne). In France he received four certificates for work with the Laboratoire de Physique de l' Atmosphere. He has also studied specialized courses at other European universities and holds diplomas from the US Air University. He has lectured widely in both the US and Europe on rocketry, high altitude research and space flight. He is the author of dozens of articles on these and related subjects. At present, he is vice-president of the National Research and Development Corporation.

One of the most widely discussed subjects in the US today is education. For the first time in memory the nation has begun to think in terms of the *quality* of the "educated man" as well as the *quantity* (of which we in America are manifestly proud) of graduates churned out by our schools and universities. Although there is much about our system to justify pride, forward-looking educational authorities have realized there are many shortcomings in our schools; and strong efforts are happily being made to improve them.

True, there is no scarcity of "experts" who, while worshiping the status quo, defend their achievements and misguidedly think that everything American has to be best. These people are bound to fight improvement programs every inch of the way. Yet, it is clear to most of the thinking community that something has to be done, and done quickly, if coming generations are to yield leaders capable of maintaining America's position in the world.

Our educational problems stem from many causes. On the one hand we have been far too eager to achieve a mediocre education of the masses to the detriment of superior education for a brilliant minority. We tend to forget the supreme debt that civilization owes to the great intellects of science, the arts, and society, and unless we create the climate for such talents to nurture, our way of life is sure to wither.

On the other hand, we suffer from the fetish of insisting on thousands of bright, shiny and often gaudy new schools with little or no thought for the excellence (or even living standards, for that matter) of the teaching staffs within them. It has been far from obvious to many that a school or a university can be no better than its teachers. The physical aspects may be important, but they alone do not provide the climate of scholarship so necessary in a creative society. Great teachers, rather than great buildings, are necessarily the cornerstone of any system that calls itself educational.

In the paragraphs that follow we shall cover various general factors applicable to US and Soviet education, giving particular attention to scientific aspects and implications.

The availability of scientific and engineering talent is a crucial factor in today's world of ICBM's, H-bombs, and artificial satellites. All major nations are aware of the importance to their security of technically trained manpower, and at least some have well-planned programs designed to encourage youth to enter scientific fields of endeavor.

The US is the most important example in the world of a nation without a definitive educational program in science or technology. Some comparative figures are informative in this context. In 1954 American industry needed 30,000 new engineers, but only 18,000 were graduated that year from our colleges and universities. This shortage may or may not

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nave been completely real, but the general picture presented was far from satisfactory. To look at it from another direction, of the 250 physicists graduated in 1954 only half entered into the field of physics itself. A situation characterized by shortages has continued through to 1958; and while it seems somewhat less aggravated today we probably will continue to lack highly trained scientists for many years to come.

One prominent educator has noted "in school we work so hard with the youngsters who find learning difficult or who resist an education, that we fail adequately to deal with the sparks of genius when they appear." He went on to say that "our greatest failures in the schools of America are those youngsters who have the ability to become the creative leaders of tomorrow. The real major leaders of the future in science, industry . . . must be challenged to do their best, not merely to be better than the average."

One of our main jobs is to select potential talent early in life, and to nourish it carefully so that it may grow or achieve maximum development. Our leading educators are beginning to emphasize, more than ever before, the importance of obtaining more and better instructors; and they warn us not to rely on fancy new buildings and unplanned "crash programs" to achieve our educational aims.

Reduced to its essentials, an educational system consists of: (1) schools, (2) students, and (3) teachers. A knowledge of construction techniques permits us to build an acceptable school. The supply of students seems both plentiful and inexhaustable. Teachers, on the other hand, represent an entirely different commodity—one difficult to create, by no means plentiful, and decisively important.

We are troubled to learn that competent teachers are becoming harder and harder to get. There has been at least a 50 percent drop during the past five years in the number of college graduates whose educational programs have prepared them for high school science teaching; and of the relatively few persons qualified to instruct scientific subjects, only about half make teaching their career.

Some interesting percentages are available to demonstrate the fall of interest in science. For example, at least half of the nation's high schools do not offer courses in chemistry, and more than half do not give courses in physics. In the period since 1900 the percentage of high school students studying algebra dropped from 56 percent to 24.6 percent. Geometry students dropped from 27.4 percent to 11.6 percent in this period; and physics students declined from 19 percent to 4.5 percent. Perhaps even more discouraging is the feeling of many key educators that at least half a million high school students are taught mathematics by teachers not qualified to give instruction in the subject. Some 300,000 students are exposed to physics by nonqualified instructors.

A nationwide survey by the National Education Association shows that only 36 percent of persons who prepare to teach chemistry and who receive their certificates intend going into the teaching field. Furthermore, less than half those qualified to teach general science, biology, physics, and mathematics will actually teach. This situation has been described by many as "tragic." One interesting, though dismal, sidelight was shown by a survey demonstrating that the difficult subject of mathematics is often being taught by teachers qualified in such subjects as English, music, social science, and speech! Physics and chemistry classes are often taught by specialists in agriculture, physical education, or social science! Furthermore, it has been shown that only 148 of 303 chemistry classes in 30 states surveyed were being taught by teachers who had majored in chemistry! The implications of these figures should shock even the most complacent of an indifferent public.

Coupled with this, we find that today well over 50 percent fewer persons receive certificates to teach science as compared with only five years ago (the comparison would be even more startling if longer time period were presented.) About 51 percent fewer students receive mathematics certificates than only five years ago.

Estimates made for the year 1956 show that our schools were faced with a shortage of 6000 science teachers; and at the same time only 4000 were being graduated (out of which only *half,* as we saw, actually expected to go into teaching.) Thus, at a critical period in the history of science 2000 teachers were trying unsuccessfully to do what 6000 would normally be expected to do.

Naturally, such figures as these have evoked comment from authorities in the scientific and teaching fields. One important educator has said that "the staggering deficiency in scientists and engineers that confronts us will spell disaster to the American people unless we take action at once." Incidentally, these words were uttered three years ago, and it is discouraging to see that relatively little progress has been made since that time.

Rise in Science Pupils

Changes in enrollments in mathematics and science in public secondary schools in the United States (grades 9-12) and related data, 1948-49 and 1956-67.

Item	Typical Grade	Enrollments 1948-49	Enrollments 1956-57	Per Cent of Increase
Subject				
General Science	9	1,074,000	1,518,000	41.3
Biology	10	996,000	1,430,000	43.6
Chemistry	11	412,000	520,000	26.2
Physics	12	291,000	310,000	6.5
Other Science	9-12	155,000	265,000	70.9
Total	9-12	2,928,000	4,043,000	38.1
Elementary Algebra	9	1,042,000	1,518,00	45.7
Intermediate Algebra	11	372,000	484,000	30.1
General Mathematics	9	650,000	976,000	50.2
Plane Geometry	10	599,000	788,000	31.6
Solid Geometry	12	94,000	160,000	70.2
Trigonometry	13	109,000	200,000	83.5
Other Mathematics	9-12	91,000	275,000	202.2
Total	9-12	2,957,000	4,401,000	48.8
Population				
Age 14		2,126,000	2,556,000	20.2
Age 15		2,140,000	2,393,000	11.8
Age 16		2,231,000	2,292,000	2.7
Age 17		2,206,000	2,300,000	4.3
Age 14-17		8,703,000	9,541,000	9.6
Enrollment				
Grade 9		1,641,000	2,254,000	37.4
Grade 10		1,491,000	1,933,000	29.6
Grade 11		1,242,000	1,513,000	21.8
Grade 12		1,026,000	1,263,000	23.1
Grade 9-12		5,399,000	6,963,000	29.0

Source: Offerings and Enrollments in Science and Mathematics in Public High Schools (Office of Education Pamphlet No. 120).

Moscow University students on their way to a lecture at the University.

Another educator cautioned that "science has become a neglected subject. We have not prepared enough high school students in the sciences to meet future needs." A still more astonishing warning came from Dr. M. M. Boring of the Engineering Manpower Commission who said, "It is an incredible and dangerous paradox that in the age of science and engineering, secondary school interest and activity in science and mathematics, the necessary prerequisites to technical careers, are decreasing proportionately. . . . This trend must be reversed, not only because our needs for vital and professional personnel are bound to increase, and must somehow be met, but also because our future citizens must have at least the fundamental background necessary to an understanding of the times in which they will live and work."

The deficiency of science teachers has led the American Association for the Advancement of Science to set up a $300,000 grant to study the shortage and the problems it poses. The final report resulting from the study showed that in one recent year about 250 persons were graduated from American colleges and universities capable and prepared to teach high school physics. Of these only half went into teaching. The situation was shown to be very similar in other areas of science and in mathematics. A number of reasons are given for this:

1. We were faced with an increasing population, making greater demands on our schools. This was coupled with the fact that relatively few

teachers were coming available (partially due to the low birth rate of the 1930's).

2. We must consider the extremely low salaries paid to teachers. This fact turned potential science teachers to other, more lucrative, fields.
3. During recent years the high school has changed from an educational institution whose primary function was to train relatively few students to pass college entrance examinations prior to going to college to a system designed to give terminal training to students not going on to follow university careers.
4. It has been frequently pointed out that many of the persons teaching sciences in schools are inadequately prepared to give instruction; such a situation can completely blunt the scientific inclinations of the student, or at least hamper his development.

It seems evident that, in order to improve scientific teaching, we must draw from the ranks of college graduates who have studied science but who may not have received formal courses in educational techniques. Such people know their science even though they may not have been trained in education. It is logical to believe that qualified scientist-teachers are preferable, even though they lack educational courses, to the hundreds of inadequately trained science instructors present in our schools today.

Fortunately, there are responsible individuals and organizations who have become deeply concerned with finding and cultivating as much scientific and engineering talent as possible. What the future holds in store for American education in science may be largely left in the hands of such groups as the Scientific Manpower Commission, Office of Scientific Personnel of the National Research Council, Engineering Manpower Commission on the Engineers Joint Counsel, the Chief of Engineering Education of the United States Office of Education, the American Association for the Advancement of Science, and educational committees and panels attached to industrial organizations and scientific societies.

There is an admitted and vast difference between the European and American concept of everyday life at the university. *American universities feel they are educating partially grown children, and accordingly often go to extraordinary lengths to care for them.* Thus we find elaborate rules of conduct, all types of administrative devices to insure that classes are attended, "dean's lists", and other such instruments as are believed necessary to take care of our young as they pass through university life. All this has resulted in the lamentable fact that the American student matures in his university at a far slower rate than the European does in his.

The average university in continental Europe takes little or no responsibility for the life of the student. There are generally no dormitories or other special houses for students to live in. Student unions, fraternities, dining halls, and similar activities may very well be absent; and, of course, there are unlikely to be college athletic facilities, sports arenas, and so forth. Therefore, being a student in Europe is a far more gruelling experience. One must forage for his own, so to speak, but the immature are quickly weeded out from the mature.

In Europe one is unlikely to see professors taking attendance; it is entirely up to the student if he does or does not attend a lecture. Nor are the universities interested in his personal life, his finances, his habits of study, and his home environment. If he pays, he can attend courses; if he does not pay, he cannot attend courses. It is his own responsibility to attend classes. If he passes his final exams, he gets credit towards a degree, regardless of whether or not he attended classes. There are no warning notes, and mid-semester grades on general course work prior to the final examination are rare or absent.

The European university assumes it is educating an adult, not a child. The emphasis is on learning, not on techniques of teaching, as was pointed out by Harvard's Professor Howard Mumford Jones several years ago in a leading university alumni publication. It is assumed that if the European student does not take advantage of the great educational advantages given him, he is a fool, and if he wants to be one it is entirely his own business. The American system, on the other hand, spends much time and effort trying to keep him from being one. As Jones has said, ". . . in Europe it is universally assumed that a

N. S. F. Research Grants

National Science Foundation Research Grants by Fields of Science

Field	Fiscal years 1952-56 Number	Amount	Fiscal year 1957 Number	Amount	Total Number	Amount
Biological and medical sciences:						
Anthropological	18	$ 184,800	17	$ 153,500	35	$ 338,300
Developmental	70	586,182	32	382,750	102	968,932
Environmental	82	746,860	65	777,200	147	1,524,060
Genetic	75	994,700	41	659,250	116	1,653,950
Molecular	181	2,748,730	84	1,784,950	265	4,533,680
Psychobiology	134	1,659,550	54	783,100	188	2,442,650
Regulatory	215	2,921,145	114	1,870,400	329	4,791,545
Systematic	177	1,399,080	89	706,575	266	2,105,655
General	40	721,510	31	503,200	71	1,224,710
	992	$11,962,557	527	$ 7,620,925	1,519	$19,583,482
Mathematics, physical, and engineering sciences:						
Astronomy	75	1,261,800	33	453,900	108	1,715,700
Chemistry	254	3,106,200	147	2,653,700	401	5,759,900
Earth Sciences	102	1,318,275	54	770,150	156	2,088,425
Engineering	181	2,008,700	103	1,369,950	284	3,378,650
Mathematics	128	1,553,200	64	1,038,900	192	2,592,100
Physics	195	3,036,400	53	1,348,300	248	4,384,700
Sociophysical	8	105,100	12	154,100	20	259,200
General	1	7,000	4	119,000	5	126,000
	944	$12,396,675	470	$ 7,908,000	1,414	$20,304,675
Total research grants	1,936	$24,359,232	997	$15,528,925	2,933	$39,888,157

university . . . is a mature intellectual enterprise primarily concerned with preserving and extending knowledge and maintaining the great professional classes . . . without which no culture can survive."

In general it is far easier to gain access to an American university than to enter one on the Continent. A great many reasons exist for this, but they are beyond the scope of this article. However, I recall that when I first entered the University of Paris' Faculty of Sciences, I had to establish that my previous American college education was *equivalent* to the French Baccalaureate, or secondary system. I was perhaps lucky to have passed this and to have received additionally several credits toward an advanced degree. I remember a number of American college graduates whose work was not, in the eyes of the French authorities, considered of sufficient significance to warrant the all-important "equivalence." Though this may seem exaggerated, it at least affords a basis for comparison.

When we think of the dozens of diversionary activities associated with American university life (being invited into the proper fraternity, getting on various athletic teams, participating in club life, dances, dating, etc.), we often may wonder how academic progress is made. Our "normal," well-rounded, overprotected student is the average student, one whose extracurricular activities may often be more spectacular than his academic record.

He, and not the "brain," is the hero of the US campus.

Most of these outside distractions do not exist in the continental European counterpart, at least not to the extent as in America. Perhaps the great question that America has to answer is how it can mature its undergraduate student body, how it can dispense with its long-extended adolescence. That is the challenge that the European education gives the American system and is the particular challenge posed by the enormous progress of Soviet education today. The roots of a nation's scientific and technological greatness are found in its educational system. Our schools and colleges must produce the leaders of tomorrow's world of science. Our system must become second to none if our way of life is to survive.

Russian education is similar, but by no means identical, to that of continental Europe. The basic educational landmark in Russia is the ten-year secondary school, which handles children of the ages 7 to 17. During this period, a student would study ten years of Russian langauge and literature, a like amount of mathematics, five years of physics, four years of chemistry, six years of biology and botany, six years of geography, seven years of history, a year of astronomy, and various practical subjects such as metal working and engineering drawing. During the later years of the secondary education, the student is generally in class seven hours a day and has five hours of homework.

With a 12-hour day, the student must also count on a 6-day week and a 10-month academic year. It need hardly be pointed out that the US system is far more relaxed than this extremely difficult academic grind to which Soviet children are exposed. Another thing one should not forget is that a student is financed through his education by the state, and this, of course, allows Russia to pick out from the whole mass of its people the best available minds. The above-average students get the best training, while those of below-average abilities are weeded out rapidly so as not to pull the average down. There is apparently no acute teacher shortage in Russia, a fact which is not surprising considering the material benefits and prestige they derive from their career.

It is known that since 1927 the Russian educational system has grown by fantastic leaps, starting with 11 million arts and sciences students and numbering now 30 million. In the higher educational institutions they started in 1927 with a 169,000 enrollment and now have more than two million. In the secondary system the courses given are far more complete and difficult than in the US. For example, the Soviets teach algebra in the sixth grade and calculus starts in the ninth. A typical seventh grade student in the USSR is likely to have zoology, anatomy and physiology of man, mathematics, history, geography, biology, Russian language and literary reading, chemistry, foreign language, physical education, technical drawing, practical shop work, agriculture, and sex hygiene on his study program.

The actual secondary school graduates per year are 1,500,000 versus 1,300,000 in the US. Dr. Laurence G. Derthick, United States Commissioner of Education, has said that "it would be tragic . . . if the evolution of education in the USSR should be considered as any cause to question our basic concepts of freedom in education. Rather, it should challenge every American to re-examine the extent to which we as a people support our democratic system of education . . . . It should, in fact, challenge Americans to take new interests in meeting the needs of our schools, colleges, and universities as they serve the purposes of our society: freedom, peace, and the fullest development of the individual."

It is generally understood that to achieve the maximum benefit from a nation's total brain power resources, outstanding talent must be identified at an early age, encouraged to progress from the time it is identified, and above all be given the best conceivable training. Reports strongly suggest that the embryo scientist is far more readily identified in the USSR than in the US, and that when he is identified something is done about him. Outstanding students are pushed ahead

Cramming for an exam in one of the rooms of Moscow University's student dormitories. (Photo by D. Sholomovich)

rapidly and are not forced to follow the pace set by their intellectual inferiors.

Perhaps the most significant thing about the Soviet system is its very hard schedule and the fact that all students are under constant pressure to excel. The leisurely pace typical in our American schools cannot be tolerated in the Soviet Union. As has been pointed out frequently in recent years, school teachers and college professors form part of the Soviet social and intellectual elite, an almost diametrically opposite situation to that which prevails in the US. With a hard schedule, excellent teachers enjoying top prestige, and good facilities, it is not difficult to understand why Soviet progress in education is evoking such interest today.

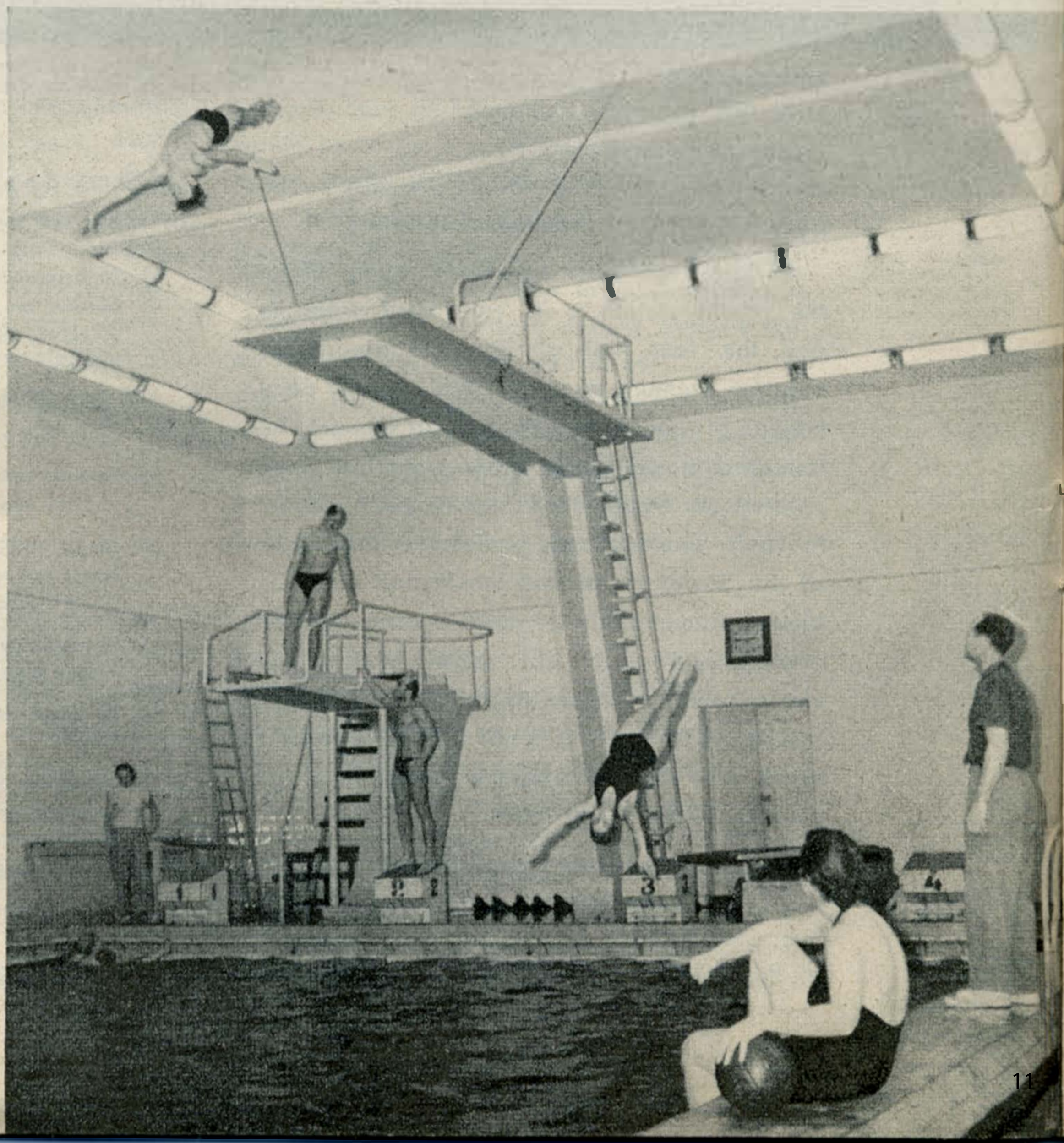
The rules of conduct applicable to pupils in the Soviet Union are interesting and informative. In 1943 the Soviet People's Commissars of the Russian Soviet Federation of Socialist Republics set up the following: "It is the duty of every school child:

1. To acquire knowledge persistently in order to become an educated and cultured citizen and to be of the greatest possible service to his country.
2. To study diligently, to be punctual in attendance, and not arrive late at classes.
3. To obey the instructions of the school director and the teachers without question.
4. To arrive at school with all the necessary textbooks and writing materials; to have everything ready for the lesson before the teacher arrives.
5. To come to school clean, well groomed, and neatly dressed.
6. To keep his place in the classroom clean and tidy.
7. To enter the classroom and take his place immediately after the bell rings; to enter and leave the classroom during the lesson only with the teacher's permission.
8. To sit upright during the lesson, not leaning on his elbows and not slouching; to listen attentively to the teacher's explanations and the

other pupils' answers, and not to talk or let his attention stray to other things.

9. To rise when the teacher or the director enters or leaves the room.
10. To stand at attention when answering the teacher; to sit down only with the teacher's permission; to raise his hand if he wishes to answer or ask a question.
11. To take accurate notes in his assignment book of homework scheduled for the next lesson, and to show these notes to his parents; to do all the homework unaided.
12. To be respectful to the school director ond teachers; when meeting them, to greet them with a polite bow; boys should also raise their hats.
13. To be polite to his elders, to behave modestly and respectfully in school, on the street and in public places.
14. Not to use coarse expressions, not to smoke, not to gamble for money or for any other objects.
15. To protect school property; to be careful of his personal things and the belongings of his comrades.
16. To be attentive and considerate of old people, small children, the weak and sick; to give them a seat on the trolley or make way for them on the street, being helpful to them in every way.
17. To obey his parents, to help them to toke care of his small brothers and sisters.
18. To maintain cleanliness and order in rooms, to keep his clothes, shoes, and bed neat and tidy.
19. To carry his student's record book with him always, to guard it carefully, never handing it over to anyone else, and to present it upon request of the teachers or the school director.
20. To cherish the honor of his school and class, and defend it as his own."

Russian accomplishments in both the primary and secondary educational fields are impressive. The best results of their efforts move on into the universities, whose output is also impressive. For example, we know they produce one and a half million scientists and engineers out of two and a half million graduates. In the US we get about the same number of technical graduates from twice the number of college graduates, so the percentage of science and engineering output here is much lower than in Russia. On a yearly basis, the Russians produce between two and three times the number of scientists and engineers that the US does. The US awards about the same number of doctoral degrees as the



Moscow University's swimming pool. (Photo by D. Sholomovich)

Soviets, but in our case nearly 2½ to 1 are weighted in favor of the arts while in the USSR about 3 to 1 are in favor of engineering and science. We know that while in Russia technically-trained students are graduating at a higher rate than in the US, there is a decline in graduates from American universities taking place (corresponding with this increase in Russia). Dr. Alvin C. Eurich, vice president and director of the Ford Fund for the Advancement of Education, made the following comment after returning from Russia recently: "To me the accomplishments in the field of education which Russia has made in a relatively short time are much more frightening than announcements that come from Russia concerning atomic or hydrogen bombs, or guided missiles. From our point of view there is much one could criticize. There is no question, however, about the speed with which Russia has moved in the past and is now moving with its educational system. As much as we *dislike to place our educational developments in competition* we have to be realistic."

Last November the United States Office of Education released an excellent report entitled "Education in the USSR". The conclusions of this report are given in the belief that it is enormously important to understand what an important American body of educational authorities thinks about the situation. The information has been published in a two hundred and twenty-six page report which represents over two years of work.

Text of Conclusions of the U. S. Report on Soviet Education

Millions of school-age children, variety in racial strains and cultural traditions, diversity in climate and topography, concentrated center of population and sparsely populated remote areas are some of the factors affecting educational policy in the U.S.S.R. and in the U.S.A.

The principle of free and universal education has been adopted as a national policy and is in process of implementation in the U.S.S.R. today. The same principle is traditional with the people of the U.S.A., who have had it in practice for generations.

Diametrically opposed are the philosophical bases from which educational theory, programs and procedures have evolved in the two countries. Authoritarianism characterizes the Soviet philosophical base; the goal of education is to meet the needs of the state. Constitutional representative democracy characterizes the philosophical base on which the people of the U.S.A. govern themselves. In theory and in practice, the individual is of surpassing worth and the goal of education is the development of each person as an individual with freedom and with opportunity to choose his life's work in his best interests.

Many Entities in Soviet

The Soviet Union is an accretion of separate entities on which there is an overlay of Russian language and Communist party control. As a matter of educational policy, the U.S.S.R. one-party state capitalizes on the linguistic and cultural heritage of minority groups which resist assimilation. The U.S.A. is an amalgamation of heterogeneous nationalities electing to establish their homes in the United States, and of native-born population. The democratic educational systems in the U.S.A. are crucibles in which many nationalities fuse in language and in culture.

Neither country has a national ministry to control education. In the U.S.S.R. the Communist party, consisting of about 3 per cent of the total population, is the minority group which directly and indirectly controls education through a mechanism which centralizes power at the top. In the U.S.A. control of education is vested in the people in each of the states at the local and state levels.

The U.S. Office of Education provides leadership—not control. It encourages understanding of and responsibility for policy development, management and operation of local and state educational systems by the people themselves. It promotes agreements on common goals, and administers grants in specific fields and conducts educational research. On the basis of research findings, it provides authoritative information to the profession, the states and the general public.

Differences in Scope Noted

Soviet educational-cultural planned budgets embrace a range of activities which include on the one hand schools and institutions of higher learning, and on the other, clubs, radio, press, television, movies, theatres, and the like. Educational expenditures reported in the U.S.A. relate exclusively to schools and institutions of higher learning.

Education as it is understood in the U.S.S.R. has no exact parallel in the U.S.A. Preschool programs—nurseries and kindergartens—are an integral part of the national economy of the U.S.S.R. Nurseries are health centers for the care of children and the release of the time of mothers for work and other activities in the interests of the Soviet State. Kindergartens are educational centers providing similar child care and similar release of the mothers' time for productive activity deemed appropriate by the Soviet state.

In the U.S.A. child care establishments are social welfare centers, including in their programs child care assistance to those mothers who are breadwinners as well as homemakers. Nursery schools provide programs

to serve the health, social and educational needs of 4 and 5 year-olds. They are partly or entirely independent of the public school system, though an increasing number cooperate with the public school system and receive assistance in staff training, counseling and other services. Kindergartens are an integral part of the educational systems in the U.S.A.

School Six Days a Week

General primary-secondary education in the U.S.S.R. consists of a prescribed ten-year, six-day-a-week program of studies subordinated to the interests of the regime in the formation of a Communist society. In the U.S.A. the prescribed elementary curricula and the secondary curricula of prescribed and elective courses extend over a twelve-year period, five days a week, in the interests of the development of educated citizens able to contribute as individuals and in groups to their own welfare and to that of society as a whole.

In the U.S.S.R. pupils are expected to participate in extracurricular work-activities sometimes known as "voluntary-compulsory" programs. These work-activities are centrally controlled and intergrated with the primary-secondary curricula for the benefit of the state. In the U.S.A. extracurricular activities are school activities which usually develop in keeping with the interests of the children. In general, they originate spontaneously and result in educational dividends for the children. On their own initiative, youngsters who have reached the minimum age for work—generally 16 years for non-hazardous occupations—may engage in paid part-time work after school hours and in paid summer employment.

Student Has Little Choice

The U.S.S.R. party-state aims to determine, through its national planning mechanism, the skills which are needed and the proportion of the student population to be trained in each skill. The more brilliant student in the U.S.S.R. has some individual freedom of choice; the state retains control over curriculum content and methods of instruction and distribution of students among academic fields, adjusting all to suit prevailing political doctrine and current manpower requirements of the Soviet economy.

Political indoctrination normally is included in course content throughout the curriculum—in the natural and social sciences, in language and literature, in the arts and in other disciplines. In addition, specific courses in the fundamentals of the prevailing political doctrine are required of students regularly enrolled in institutions of higher learning. Students are expected to interpret their studies from the point of view enunciated by the state. Natural sciences and mathematics receive major emphasis.

Students in the U.S.A. are free to explore the various vocational and professional fields. According to their capacities, they are free to elect any field of employment in which they can meet the technical requirements; they may change their individual jobs or positions and shift from one field to another in keeping with their own interests and desires. Under the guarantees provided by the Bill of Rights in the Constitution of the U.S.A., they are free to make their own political interpretations, whether or not these interpretations are consonant with those of the political party in power.

Vocational education in the U.S.S.R. usually is terminal training for a specific job or type of work needed by the state. Vocational education is provided in schools administered by the Chief Directorate of Labor Reserves under the U.S.S.R. Council of Ministers and in schools organized by the ministries and agencies for their own employees and for workers for whom they are operationally responsible.

Semi-Professional Training

Vocational education in the U.S.A. is an integral part of public school offerings at the secondary and technical levels. Vocational training in the U.S.A. is on-and-off-the-job training provided by organizations and agencies concerned with the specialized training of their employees by institutions assisting individuals in their efforts to advance themselves.

Semiprofessional schools and technicians in the U.S.S.R. are responsible for preparing students to render a single specific "support" service to persons considered qualified in a professional field. Advancement from semiprofessional to professional status is unlikely in the U.S.S.R.

Semi-professional training in the U.S.A. is sufficiently broad to help individuals acquire professional knowledge and techniques essential for employment in their chosen field and is prerequisite to study leading to full professional status. Advancement from semiprofessional training to professional training and status is common in the U.S.A.

Higher education in the U.S.S.R. aims to prepare qualified specialists—with the accepted political point of view—to serve the needs of the state. Diploma work for which no degree is awarded roughly approximates the level of the thesis requirement for the first professional degree in the U.S.A.

Degrees Given at 2 Levels

For researchers and teachers a degree may be awarded at each of two successive levels after advanced or postgraduate study. The first, or candidate of sciences, degree may be awarded after a three-year course roughly approximating the level of the doctoral programs in the U.S.A. Those recognized in the Soviet scientific and academic world may be permitted to enroll in the advanced postgraduate program leading to the second, or doctor of sciences, degree.

In summary, service to the Soviet state is exacted from students in the U.S.S.R. in return for state-provided educational programs. As a surcharge on their economy, the people of the U.S.A. provide educational programs for their own advancement and welfare and, in turn, for the welfore of society as a whole."

Hand in hand with progressive educational policies and superior teaching staffs go the physical plants. The showplace of Soviet edu-

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cation is the University of Moscow, which is certainly one of the most imposing centers of learning in the world. The main building is 32 stories high and it has over 2,000 rooms. In fact, one authority has likened it to a typical large American hotel. The central building is called the Palace of Science, which is bounded on each side by dormitories capable of housing 6,000 students. The edifice includes museums, auditoriums, classrooms, libraries, laboratories, and a wide variety of small conference rooms. Other buildings are scattered throughout the city to house various faculties. It is suspected that already something like three-quarters of a billion dollars have been spent on this enormous project.

The professors who teach the university's 25,000 students are well paid. The basic monthly salary of a professor is reported to be $1,500 and an additional amount of money is earned if he writes a textbook (the rate of compensation here is 2000 rubles, or approximately $500.00 for each 23 typewritten pages. This is indeed a wonderful remuneration.)

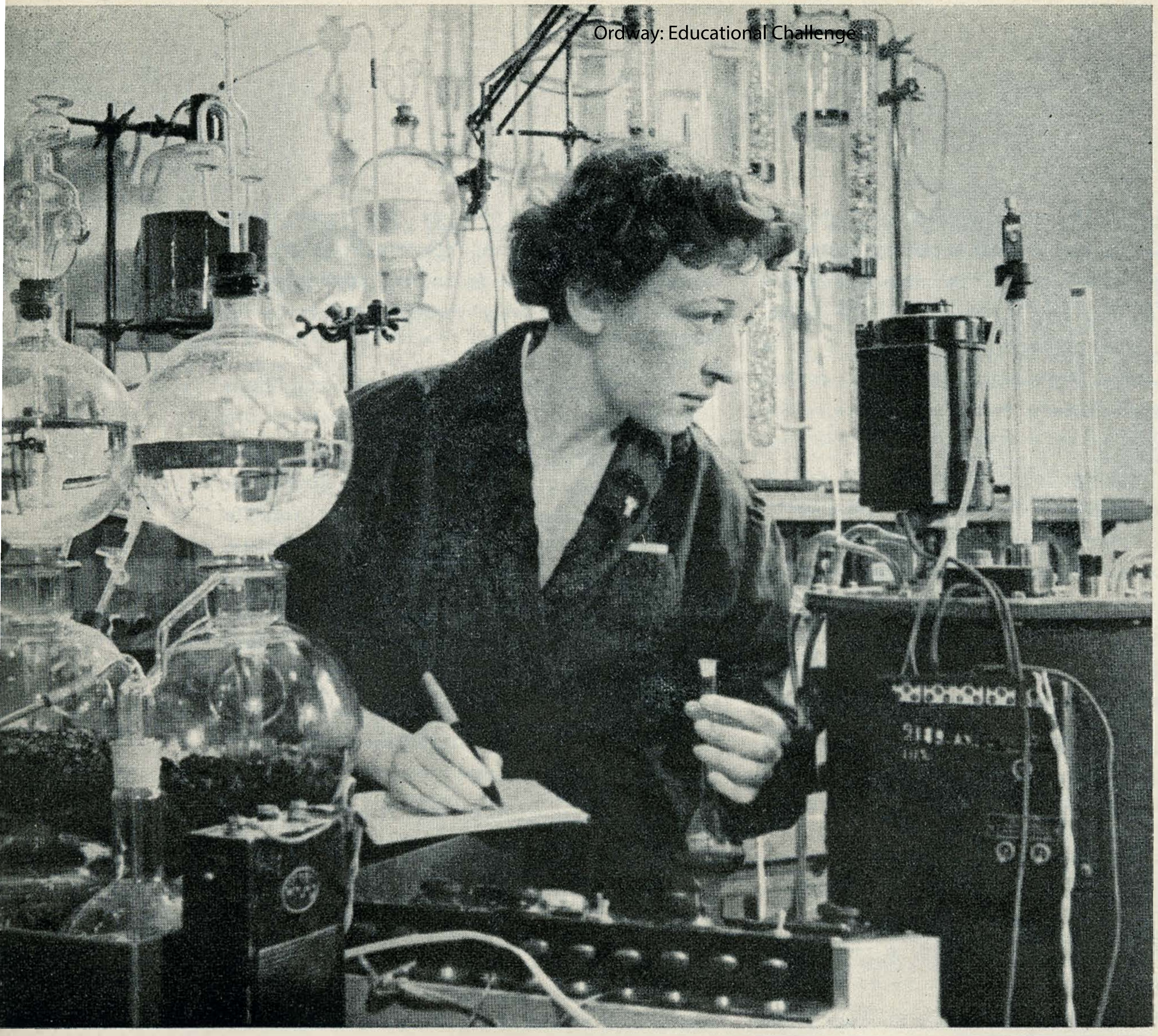
Should a professor become a member of the National Academy of Sciences he would pick up another 2500 rubles a month. This is more than $500.00 a month and is a very respectable addition to his salary. Should he become academician it would bring him up to an even higher salary, and he may be able to get up to $50,000 a year for all his accomplishments (Harvard's top professorial salary is $20,000 a year.) It is reported that his medical expenses are handled by the government and that his children can be educated at no cost, thereby affording him further savings. Taxes and rent are also low. Surely the life of a scholar is attractive in Russia. Incentives are plainly high to encourage academic careers.

Many Western authorities feel that, contrary to popular belief, there is a considerable amount of freedom of science in the Soviet Union. This feeling has been considerably strengthened during recent years, particularly since the death of Stalin. It is evident that Russian scientists are now traveling to foreign countries in greater numbers than was previously customary, and by the same token Americans and other Western scientists are attending Russian technical meetings and traveling extensively throughout the Soviet Union.

Evidence shows that despite the conditions imposed by a dictatorship, the Russians are quite strong in a wide variety of fields from mathematics, astronomy, and solid state physics to atomic energy, rocketry, and satellite technology. Many Western scientists believe that freedom in the sense we know it is not essential to scientific progress, and such authorities as Dr. von Braun, of the Army Ballistic Missile Agency, and Dr. Furnas, of the University of Buffalo, have clearly demonstrated that important progress can be and is being made in a dictatorial community.

Dr. von Braun has pointed out that the Germans made enormous headway in rocketry and aeronautics while under the political dictatorship of Hitler. He emphasized that "as far as personal freedom of movement is concerned, as well as free exchange of ideas in the strictly scientific and technological sphere, it would simply be misleading to assume that things (in wartime Germany) were much different than in a free country." Dr. Furnas said, at a meeting considering what we may expect during "The Next Hundred Years," that he had a confession to make: "For a long time I have felt that freedom in initiative played a part in science. I have heard true science could only grow in comparative freedom. The demonstration of what has been accomplished by Soviet science, in terms of objectives obtained over a 30-year period, have disproved this. I do not think that the results obtained by the Soviets are the types of scientific achievement that is going to benefit humanity in the long run—over one hundred years. For this, freedom is best. But in particular areas, science can grow and flourish in an atmosphere not free." Western science is beginning to heed such warnings.

Turning now to the diffusion of technological and scientific knowledge, we have again found ourselves in a rather awkward situation. Since World War II we have lived in a state of semi-isolation from world science, largely



Dilia Asipova, assistant of the optics department of Moscow University's physics faculty conducting scientific research on the influence of temperature on intensity of infrared absorption. (Photo by D. Sholomovich)

because of the partial, and temporary, eclipse of Western European scientific output. The US was not immediately prepared for the postwar Soviet technological onslaught, and unfortunately reacted to it slowly and halfheartedly. It took Russian MIG's, ICBM's and Sputniks to change our minds about achievements in science and technology in the Eurasian heartland.

In recent years, and particularly since Sputnik I, American scientists have become more than conscious of the value and desirability of knowing about what the Russians are writing and publishing. We know there are thousands of Soviet scientific reports and journals which have been received in the United States (particularly by the Library of Congress), but they generally serve no purpose other than to gather dust. Few scientists in the US read Russian, and translation facilities are lacking. This has resulted in an appalling lack of knowledge of what they are doing, and, as a consequence, there has been an enormous amount of duplication in research: many things we should know we simply do not know of because our scientists do not read Russian and translations are few.

There is good evidence that the Russians have developed very efficient methods of translating and diffusing foreign knowledge. They have a large, centralized clearing agency which collects and disseminates scientific information prepared and distributed by scientists and engineers from all corners of the world. It is reported that Soviet scientists often have a Russian translation of an important French, German, English, American, or other foreign publications before the scientists in the country of its origin have read the original editions.

The Soviet Union's All Union Institute of Scientific and Technical Information has a

permanent staff of about 2300 translators, abstractors, and publishers. These are supplemented by a part time staff of 20,000 translators and abstractors. The institute releases thirteen abstract journals that contain each year more than 400,000 abstracts of scientific articles appearing in journals representing more than 80 countries. The institute translates, indexes and abstracts some 1400 of the 1800 scientific journals which are released in the United States of America.[1]

Compared with this system, what have we done in the US to facilitate the diffusion of knowledge of foreign scientific and technological progress and developments? Fortunately, the American government is beginning to realize the extent of the problem and some important efforts have been made. There is a variety of organizations of a public and private nature that do some work in the field of interest, and, while much remains to be accomplished, we have moved ahead. For example, the House Subcommittee on Government Information has held hearings on the subject and it is expected that progress will be rapid towards establishing a necessary government clearing agency. The Government Office of Technical Services is planning to increase its contributions very rapidly. Probing efforts are being made in many distinct areas, and it remains to be seen if we end up with a large central clearing house run by the government, or rather, a series of smaller, privately managed operations.

We receive about 20,000 Soviet scientific reports and journals a year, but only a small fraction is translated or even summarized. An example of the duplication of work resulting from the lack of knowledge of Russian scientific progress is given by a case cited by the National Science Foundation. It was learned that several American industries spent five years of research and hundreds of thousands of dollars on the design of electrical circuits only to discover that the work had been fully described in a Soviet scientific publication well before the research had begun in the US.

By the same token, it is interesting to know that, contrary to general belief, the radio frequencies used in Sputniks I and II were publicized well before the October and November, 1957, launchings. Indeed, in the Soviet journal *Radio,* the frequencies were published at least four months prior to the launchings of the vehicles. Much has been made in this country of the supposed fact that we were not informed of the frequencies prior to the establishment in orbit of Sputnik I. Good translation and diffusion services would have kept our scientists up to date on Soviet progress and planning. Russia may not release much, but it does release something. This "something" cannot be ignored.

Compare the Russian clearing house discussed earlier with its present counterpart in this country, called the Office of Technical Services. This boasts a total of less than 40 persons who index and abstract technical re-

Senior student Galina Kolenchuk working on her graduation paper "Electrochemical methods for defining uranium" in the polargraphy and ammeter laboratory of the analytical chemistry department of Moscow University. (Photo by D. Sholomovich)

[1]Including SPACE Journal.

ports. It operates on research programs which are carried out under contract for our government, and releases about 700 reports a month on sponsored projects.

There is a considerable belief that the Department of Commerce, which has the responsibility to maintain a clearing house for information of a scientific and technical nature, does not operate very efficiently. However, many officials say that, rather than build up a large government institution similar to the All Union Institute in Soviet Russia, it would be better for private groups to prepare their own journal and abstracting indices for the scientific world. Possible financial assistance from the government and foundations could, of course, be accorded. Others feel that the government should directly aid in the translation of journals and indices[2], particularly those from the Soviet Union, thereby assuring a nationwide distribution of material to contracting agencies, private enterprises, research centers, and universities.

There is some encouraging information suggesting that more Russian material is being translated in the US. The National Research and Development Corporation of Atlanta, Georgia, has recently added to its technical staff one of the nation's leading authorities on Soviet Russia, and other firms have taken similar steps. The Pergamon Institute of New York is busy translating technical documents, and the Consultant's Bureau, Inc., does a considerable amount of work in this field. The Soviet's journal of *Applied Mathematics and Mechanics* is to be translated and results of importance for designers of airplanes and rockets should become more readily available. Financial support to both Pergamon and the American Society of American Engineers has reportedly been arranged. At the present time up to 40 Soviet scientific journals are regularly translated within the country, both with government and with nongovernment support.

[2]It is interesting to know that there are about 15,000 scientific journals appearing each month throughout the world, and such journals contain anywhere from a few to a hundred or more articles and reports.

The Consultant's Bureau, Inc., yearly publishes about 48,000 pages of Soviet scientific translations, which moves into a region of some 12 million words. It translates 28 major Soviet journals in chemistry, metallurgy, electronics, biology, physics, and geology, as well as certain books and articles of related fields. The Pergamon Institute translates about 20,000 pages of material on Soviet scientific progress in biology and medical science. It has a summary review of 200,000 pages and during 1958 it is expected to increase its production to 30,000 pages of material taken from 400,000 pages of research in geophysics, atomic energy, and electronics.

In 1953 the Association of American Universities made the following statement in a series on the "Rights and Responsibilities of Universities and Faculties": ". . . to fulfill their functions the members and university faculties must continue to analyze, test, criticize, and reassess existing institutions and beliefs, approving when the evidence supports them, and disapproving when the weight of evidence is on the other side. Such investigations must not be confined to the physical world. The acknowledged fact that moral, social, and political progress have not kept pace with mastery of the physical world shows the need for more intensified research, fresh insights, vigorous criticism, and inventiveness. The scholar's admission requires the study and examination of unpopular ideas, of ideas considered abhorrent and even dangerous. For just as in the case of deadly disease, or the military potential of an enemy, it is only by intense study and research that the nature and extent of the danger can be understood and defenses against it perfected." Today, the very basis of our educational system is being probed in this light, and current investigations and criticisms across the land give promise of producing far-reaching results.

The US is now taking stock of its educational situation and several foundations are sponsoring searching studies of our system. Our private, and free, universities are proud of their rich heritage and know they must work hard and long to survive in a socialistic

In a laboratory of Moscow University—Left to right: Emilia Perevalova, M.Sc. Chemistry; Academician (one of top Soviet scientists) Alexander Nesmeyanov, and Tatyana Tolstaya, M.Sc. Chemistry. (Photo by D. Sholomovich)

world. One of the greatest endeavors in history to obtain privately subscribed support is the "Program for Harvard College," which will attempt to raise $82 ½ million.

First and foremost, $16 million will go to support new faculty salaries, not including $5 million for additional professorial appointments. This is a very respectable amount of money going to further the support of teachers and to bring their salaries up to a significant level. For students, $8 ½ million in scholarships and other financial aids will be made available. The library endowment will be increased by $15 million, and approximately $15 million will go into facilities. To improve the so-called "climate of scholarship" about $25 million will be spent. There may be some doubts as to the validity of establishing so much money for "climate of scholarship," rather than further increasing the amount for faculty salaries, but at least this is a step in the right direction, and may be indicative of what we are to expect from enlightened American educational circles in the age of science and technology into which the world has progressed.

In a commencement address at Harvard University, President Kirk of Columbia stated the following, "The primary function of a great university is the pursuit and the transmission of knowledge, that knowledge which is the basis of genuine wisdom because it may be regarded hopefully as valid for all time. A search for such truth is never ending, but the true university . . . is the foremost institution devised by man, in which this quest can be carried on free from the limitations of conforming in teaching or in research to any currently accepted ideas, and free as one may ever be from the influences of special pleading and vested interest and selfish ambitions. Such a university is the arsenal—the one greatest arsenal—with which men's minds can be equipped to battle against the forces of ignorance and prejudice which are forever reaching out of the mire to clutch at the human soul and drag it down. A university like this—is the focal point of the hopes of mankind."

Recommendations for National Science Foundation Research and Amounts Voted by Congress

Fiscal Year	Appropriation	Presidential Recommendation
1951	$ 225,000	$ 475,000
1952	3,500,000	14,000,000
1953	4,750,000	15,000,000
1954	8,000,000	15,000,000
1955	12,250,000	14,000,000
1956	16,000,000	20,000,000
1957	40,000,000	41,300,000
1958	40,000,000	65,000,000

With this we can close our inquiry into the educational background to the Russian challenge. We believe our great, free universities have no peers on the planet, but beneath and around them lies an immense zone of uncertainty. Will our primary, scondary and university systems (which must provide us with the bulk of our educated men) become sufficiently strong to answer the requirements of the Space Age? We can only hope that the many weaknesses inherent in these schools will be discovered, analysed and corrected. This is the one great answer to the Russian Space Challenge to the free world.