J. G. Mears, A. Bank, *Nucleic Acids Res.* **7**, 114 (1979); O. Smithies, personal communication.
33. E. H. Davidson and R. J. Britten, *Science* **204**, 1052 (1979).
34. W. Jelinek, R. Evans, M. Wilson, M. Salditt-Georgieff, J. E. Darnell, *Biochemistry* **17**, 2776 (1978); L. Lacy and T. Maniatis, personal communication.
35. C. Duncan *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **76**, 5095 (1979).
36. S. Sakonju, D. Bogenhagen, D. D. Brown, personal communication.
37. R. A. Flavell *et al.*, *Nucleic Acids Res.* **6**, 2749 (1979).
38. S. H. Orkin, J. M. Old, D. J. Weatherall, D. G. Nathan, *Proc. Natl. Acad. Sci. U.S.A.* **76**, 2400 (1979).
39. N. S. Young, E. J. Benz, J. A. Kantor, P. Kretchmer, A. W. Nienhuis, *ibid.* **75**, 5884 (1978); L. E. Mequat and J. Ross, personal communication.
40. A. L. Burns, S. Spence, F. Ramirez, J. G. Mears, A. Bank, *Blood* **54**, 51a (1979).
41. R. A. Spritz *et al.*, *ibid.*, p. 60a.
42. J. M. Taylor *et al.*, *Nature (London)* **251**, 392 (1974); S. Ottolenghi *et al.*, *ibid.*, p. 389.
43. Y. W. Kan, M. S. Golbus, A. M. Dozy, *N. Engl. J. Med.* **295**, 1165 (1977).
44. S. H. Orkin, *Proc. Natl. Acad. Sci. U.S.A.* **75**, 5950 (1978); _____, J. Old, H. Lazarus, C. Altay, A. Gurgey, D. J. Weatherall, D. G. Nathan, *Cell* **17**, 33 (1979); S. H. Embury, R. V. Lebo, A. M. Dozy, Y. W. Kan. *J. Clin. Invest.*, in press.
45. Y. W. Kan and A. M. Dozy, *Proc. Natl. Acad. Sci. U.S.A.* **75**, 5631 (1978); *Lancet* **1978-II**, 910 (1978).
46. J. Feldenzer, J. G. Mears, A. L. Burns, C. Natta, A. Bank, *J. Clin. Invest.* **64**, 751 (1979).
47. J. C. Chang, G. F. Temple, R. F. Trecartin, Y. W. Kan, *Clin. Res.* **27**, 457 (Abstr.) (1979).
48. Y. W. Kan, K. V. Lee, M. Furbetta, A. Angius, A. Tao, *Blood* **54**, 55a (1979).
49. M. Wigler *et al.*, *Cell* **16**, 777 (1979); M. Wigler *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **76**, 1373 (1979).
50. Supported by NIH grants GM-23143-04, CA-13696, and AM-25274-13, NSF grant 24120, a grant from the National Foundation-March of Dimes, and a grant from the Cooley's Anemia Foundation.

R & D Employment in the U.S.S.R.

Louvan E. Nolting and Murray Feshbach

In the face of labor shortages, growing inaccessibility of raw materials, rising capital needs and defense expenditures, and increasing economic complexity, the Soviet Union is relying heavily on scientific and technical progress to sustain its economic growth. Employment in research and development (R & D) is a prime indicator of a nation's reliance on science and innovation. This article examines the number and distribution of persons engaged in R & D in the U.S.S.R. and makes quantitative comparisons between Soviet and U.S. R & D employment.

The two main Soviet statistical series which relate to R & D personnel are the series on employment in the science and science services branch of the economy and the series on scientific workers. The first series covers the branch definition of employment in specialized scientific organizations engaged in R & D and science services. The second covers the functional definition by including all persons with advanced scientific degrees and titles, teachers in higher educational institutions, research managers, and highly educated scientists and engineers whose primary activity is research or general R & D under science plans approved by higher authority. Employment according to the branch definition is more than three times greater than that according to the functional definition. The first series serves in this article as the basis for estimating the number of personnel engaged in conducting and supporting various kinds of R & D; the second series is used to calculate personnel directly conducting R & D. Neither series is wholly comparable with Western data on R & D personnel, because they include some non-R & D employment and exclude some participants in R & D (Table 1).

Employment in Organizations

Conducting and Supporting R & D

The science and science services branch of the Soviet national economy embraces most of what are called scientific organizations (specialized organizations not incorporated into other enterprises or social institutions), which conduct or provide services for scientific research, development, and innovation, presumably in both the civilian and military sectors of the economy.

Scientific organizations are divided into two categories: (i) scientific institutions and (ii) a wide variety of organizations that do not carry out scientific research but are involved in development (in Soviet terminology, test-design work), in production and testing of prototypes and development of new processes, and in the provision of data and services required by scientific institutions. The first category includes only those institutions that (i) systematically conduct scientific research work in a scientific field, including the social sciences and humanities, (ii) work under science plans officially approved by higher authority, (iii) are funded under planned financing for science, and (iv) are staffed by scientific workers (*1*). Scientific institutions include scientific research institutes and laboratories; design organizations, industrial testing stations, and agricultural experimental stations engaged in research; and a variety of organizations—higher educational institutions, museums, observatories, zoos, natural parks, computer centers, libraries, and state archives—that conduct research in addition to their primary functions. Scientific organizations not classified as scientific institutions include nonresearch design organizations, experimental plants that do not produce industrial products for sale, maritime resources prospecting organizations, industrial testing laboratories, computer and information centers not engaged in research, hydrometeorological organizations, and geological survey and prospecting organizations.

Table 2 gives the total number of Soviet scientific institutions and their distribution by type. The number of scientific institutions has increased from 3447 in 1950 to 5327 in 1975, or by more than 50 percent. The increase was primarily a reflection of a twofold increase in the number of scientific research institutes. The number of independent design bureaus

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engaged in scientific research dropped sharply.

There is no annual series of data on the number of scientific organizations that are not scientific institutions, but sporadic and incomplete data are available. In 1973, for example, there were 944 independent design organizations, 913 of which were not engaged in research. In 1969, 1089 independent experimental plants were reported (*2, 3*).

Employment statistics in the science and science services branch of the economy cover both scientists (scientific workers) and technical, clerical, and other support personnel in scientific organizations. Table 3 gives the number of workers and employees in the branch from 1950 to 1977 and their proportion of all the employees in the U.S.S.R. [In Soviet statistics the category workers (wageworkers) and employees (salaried professional, administrative, and clerical workers) includes all those employed in the state sector of the economy (that is, excluding collective and private farmers).] Employment in science and science services increased 5.7 times between 1950 and 1975 (old series) and 1.7 times between 1965 and 1977 (new series). In contrast, the total number of workers and employees increased by only 2.6 times between 1950 and 1977 and 1.4 times between 1965 and 1977. However, there has been a significant slowdown in the growth of employment in science and science services between 1975 and 1977, resulting in a slight decrease in the rate of growth during the 1970's as a whole.

Table 1. Scope and coverage of Soviet statistical series on R & D personnel (+, included in series; −, excluded from series).

Personnel	Statistical series	
	Science and science services (branch definition)	Scientific workers (functional definition)
R & D personnel		
In specialized scientific organizations		
Conducting R & D	+	+
Supporting R & D	+	−
In higher educational institutions		
Conducting R & D	−	+
Supporting R & D	−	−
In industrial enterprises		
Conducting R & D	−	+
Supporting R & D	−	−
In central state administrations		
Conducting (supervising and planning) R & D	−	+
Supporting R & D	−	−
Graduate students	−	−
Science administrators	+	+
Personnel not in R & D or only part in R & D		
Teachers in higher educational institutions	−	+
Social scientists and humanities specialists	+	+
Employees in hydrometeorological and geological organizations	+	−

Table 2. Number of scientific institutions by type in the U.S.S.R., 1950 to 1975 (at end of each year). N.A., not available.

Type of institution	1950	1955	1960	1965	1970	1974	1975
Scientific research institutes (affiliates and divisions)	1157	1210	1728	2146	2525	2773	2805
Higher educational institutions	880	765	739	756	805	842	856
Scientific and experimental stations	555	574	454	510	483	436	N.A.
Scientific research laboratories	122	142	180	237	134	102	N.A.
Design bureaus	N.A.	N.A.	N.A.	103	42	26	N.A.
Academies of science (affiliates, divisions, scientific centers)	N.A.	13	N.A.	30	34	40	40
Observatories	N.A.	38	N.A.	12	13	N.A.	N.A.
Museums	364	392	435	442	468	458	N.A.
Libraries	63	61	71	N.A.	N.A.	N.A.	N.A.
Botanical gardens, forest preserves	N.A.	74	N.A.	27	24	N.A.	N.A.
Natural parks, wildlife preserves	N.A.		N.A.	37	43	N.A.	N.A.
Testing fields, supporting stations, experimental bases	N.A.	184	N.A.	N.A.	N.A.	N.A.	N.A.
Other	306	109	589	567	611	592	1626
Total	3447	3562	4196	4867	5182	5269	5327

The categories most frequently used to classify scientific personnel by function are: (i) scientific workers, (ii) scientific/technical personnel, (iii) production personnel, (iv) minor service personnel or assistants in R & D, (v) administrative and other service personnel, (vi) library personnel, (vii) research trainees, (viii) instructors, and (ix) others, including security personnel (*4, 5*).

In 1970, the year for which the most precise data are available, scientific workers comprised 17.8 percent of employees in science and science services (*6*), a proportion that probably has not changed significantly. For the other functional categories of R & D personnel, there are no published national statistics. A distribution by functional categories for the U.S.S.R. Academy of Sciences (the Academy) alone is shown in Table 4.

The proportion of scientific workers in the Academy is approximately twice the proportion in the entire science and science services branch, since Academy personnel concentrate on fundamental research and few are engaged in development and science services. The ratio of scientific workers in the Academy (and, presumably, elsewhere) varies by branch of science. In 1970, the proportion of these workers at the Academy was lowest (26.3 percent) in the Section of Physical/Technical Sciences and Mathematics and highest (63 percent) in the Section of Social Sciences. Their proportion in the Section of Chemical, Technological, and Biological Sciences was 35.6 percent, and in the Section of Earth Sciences, 36.5 percent (*4*, p. 32).

The proportion of scientific workers in industrial-branch scientific institutions usually falls somewhere between that found in the science and science services branch and that in the Academy. In 1968, the proportion of these workers in most of the scientific research institutes and design bureaus in the precision instrument industry ranged from 20 to 35 percent with a mean of 29 percent (*7*). In the oil industry, however, the percentage of scientific workers in scientific research institutes during the 1970's ranged from 38 to 40 percent (*8*).

In 1970, scientific workers comprised 57.4 percent of all persons (so-called specialists) with higher education in the science and science services branch. The remaining 42.6 percent consisted mainly of managerial personnel and of engineers engaged exclusively in routine engineering work or in development work not included in official science plans.

Employees conducting and supporting

R & D are employed in three sectors other than the science and science services branch: higher educational institutions (called VUZy), industrial enterprises, and central administrative scientific and technical departments (*9*). Although the VUZy scientific organizations include some scientific research institutes and design bureaus, they consist mainly of branch and problem laboratories that carry out contract industrial and fundamental research, respectively. The number of branch and problem laboratories has increased rapidly since the mid-1960's because of an expansion of contract research by VUZy and to a greater effort to draw the VUZy teaching staff into research work. Although VUZy account for only 5 to 6 percent of official science expenditures in the U.S.S.R., their share has increased during the past decade, primarily as a result of the increase in VUZy laboratory research (*10, 11*).

There are four major types of scientific and technical subdivisions in industrial enterprises: (i) enterprise laboratories, which are the most numerous and employ the largest numbers of unspecialized personnel and engineering technical workers; (ii) design organizations; (iii) test experimental organizations; and (iv) mechanization and automation departments.

Approximately 1,375,000 persons were employed in enterprise scientific and technical subdivisions in 1973 (*2*, p. 117; *12*). However, not all of these persons are classified as scientific workers. The work of scientific and technical subdivisions is not limited to R & D, but also includes innovation. Their activity includes the adaptation of prototypes, the installation of new manufacturing equipment, product and process improvement, and even routine control of quality and of manufacturing processes. As a result, industrial-enterprise scientific and technical subdivisions, although employing about 37 percent as many people as the branch of science and science services (Table 3), add only an estimated 6 percent to official R & D outlays in the U.S.S.R. (*10*, pp. 15 and 44).

Personnel Directly Conducting R & D

The Soviet statistical category of scientific workers includes scientific personnel who are directly engaged in or trained in scientific R & D in all branches of science. The following official criteria are prescribed for determining which employees should be counted as scientific workers.

1) All persons with advanced scientific degrees and all persons with scientific titles, regardless of current place or type of work.

2) Academicians (full members), acting members, and corresponding members of the U.S.S.R. Academy of Sciences, the republic academies of sciences, and the specialized branch academies.

3) Persons, with or without advanced degrees or titles, who perform scientific research work in scientific institutions or who are engaged in research and teaching (science-teaching work) in VUZy.

4) Specialists without advanced degrees or titles who systematically perform scientific work (R & D) in industrial enterprises and in project (nonresearch design) organizations, carrying out product design, process design, and construction design (*13*).

5) Persons holding management positions in scientific research (scientific supervisory positions) and persons without advanced degrees holding untitled positions as junior or senior scientific workers.

6) All persons who are engaged full-time or in conjunction with other duties in carrying out assigned research projects that are officially approved and are components of the overall science plans of the state or its ministries (*14, 15*).

Soviet science analysts generally agree that only persons with higher education should be recorded as scientific workers—that is, persons who, although perhaps not having an advanced scientific degree or title, possess at least a VUZy diploma equivalent to a bachelor's or master's degree in the United States (*1*, p. 142; *15*). Because of complaints from Soviet science economists about the inclusion in this category of employees without higher education during the 1960's and because of the growth in the number of graduates of VUZy since then, the proportion of scientific workers with only a secondary education has been considerably reduced; new employees classified as scientific workers probably all have higher education (*16*, p. 29).

Not designated as scientific workers are R & D technicians and laboratory assistants without higher education (*14*, p. 1), inventors not already classified as sci-

Table 3. Figures for total state sector employment and employment in science and science services in the U.S.S.R., 1950 to 1977 (numbers are in thousands, except percentages). N.A., not available.

Year	Workers and employees (total number)	Number employed in science and science services		Percentage of total	
		Old series	New series	Old series	New series*
1950	40,420	714	N.A.	1.8	N.A.
1951	42,300	772	N.A.	1.8	N.A.
1952	43,900	829	N.A.	1.9	N.A.
1953	45,400	860	N.A.	1.9	N.A.
1954	49,100	926	N.A.	1.9	N.A.
1955	50,300	992	N.A.	2.0	N.A.
1956	51,900	1094	N.A.	2.1	N.A.
1957	54,500	1208	N.A.	2.2	N.A.
1958	55,505	1338	N.A.	2.4	N.A.
1959	57,909	1474	N.A.	2.5	N.A.
1960	62,032	1763	N.A.	2.8	N.A.
1961	65,861	2011	N.A.	3.1	N.A.
1962	68,300	2213	N.A.	3.2	N.A.
1963	70,526	2370	N.A.	3.4	N.A.
1964	73,258	2497	N.A.	3.4	N.A.
1965	76,915	2625	2401	3.4	3.1
1966	79,709	2741	N.A.	3.4	N.A.
1967	82,274	2860	N.A.	3.5	N.A.
1968	85,100	2990	N.A.	3.5	N.A.
1969	87,922	3128	N.A.	3.6	N.A.
1970	90,186	3238	2999	3.6	3.3
1971	92,799	3374	N.A.	3.6	N.A.
1972	95,242	3544	N.A.	3.7	N.A.
1973	97,466	3735	N.A.	3.8	N.A.
1974	99,780	3864	N.A.	3.9	N.A.
1975	102,160	4046	3790	4.0	3.7
1976	104,235	N.A.	3860	N.A.	3.7
1977	106,393	N.A.	3969	N.A.	3.7

*The new series for personnel in science and science services was adopted in 1976 and projected back to 1963 for selected years by Tsentral'noye statisticheskoye upravleniye pri Sovete Ministrov SSSR. This series excludes employees in agricultural experimental stations not conducting research.

entific workers (*14*, p. 10), graduate students (*14*, p. 9), and research trainees prior to their registration as regular employees of a scientific organization.

In view of the imprecision of the Soviet definition of scientific worker, the absence of regularly reported statistics on employment by stage of R & D, and the constant combination of R & D work within individual institutions, it is impossible to establish the relative proportions of fundamental and applied research workers on one hand and development workers on the other. However, the definition includes development specialists with advanced degrees or participation in R & D projects that are a part of ministerial or state science plans. Therefore, Soviet figures on the number of scientific workers embrace employment in both R & D and, with appropriate refinements (such as exclusion of humanities specialists), can be adjusted to be roughly comparable with Western statistics on R & D employment.

The number of scientific workers from 1950 to 1977 are given in Table 5. Their number has increased 7.9 times since 1950, 3.6 times since 1960, 1.6 times since 1965, and one third since 1970 (*17*). The statistical definition of scientific workers was significantly broadened in 1962, when persons who lacked advanced degrees but performed R & D in industrial enterprises and nonresearch design organizations were included. Therefore the rate of growth in the number of scientific workers implied by comparing figures for the years before 1962 with more recent figures is somewhat overstated.

Although the number of scientific workers has steadily increased since 1962, the annual rate of growth has gradually declined to less than one half that of the mid-1960's. The average annual rate of growth was 7.8 percent from 1963 to 1968, 6.1 percent from 1968 to 1973, and 3.2 percent from 1973 to 1978.

The percentage of workers with advanced degrees dropped sharply in 1962 as a result of the definitional change in the scientific worker category; since 1966, however, their proportion has increased from 23.7 to 30.8 percent—more rapidly than the total number of scientific workers. Although the number of scientific workers with titles has increased, their percentage of the total has declined from 38.0 to 17.5 percent. This decline reflects in part the decrease since 1966 in the proportion of scientific workers in VUZy, in which most persons with titles (especially pedagogic titles) are found (*18*).

Table 4. Distribution of personnel in the institutions of the U.S.S.R. Academy of Sciences (excluding the Siberian division) by function, 1970 (*3*).

Work category	Percent of total
Scientific workers	36.2
Scientific technical personnel	29.7
Production personnel	16.4
Minor service personnel	7.4
Administrative and service personnel	6.1
Library personnel	2.2
Research trainees	0.9
Instructors	0.3
Others	0.8

Since all employed persons with advanced degrees and titles are included in the ranks of scientific workers regardless of place or type of work, the number of scientific workers in the U.S.S.R. is overstated, and many such employees are not actually engaged in R & D. A survey in 1970 determined that there were only 5,000 to 10,000 persons with advanced degrees who were not engaged in R & D, or 0.5 to 1.0 percent of all scientific workers. The Central Statistical Administration of the U.S.S.R. reportedly felt that such a small proportion was not worth a separate statistical entry (*19*).

Table 5. Total number of scientific workers and number with advanced degrees and titles in the U.S.S.R., 1950 to 1977 (absolute numbers in thousands for the end of each year). Some unknown proportion of the advanced degree holders is included among the scientific workers with titles.

Year	Total	Workers with advanced degrees (%)	Workers with titles (%)
1950	162.5	33.1	38.0
1951	170.2	33.9	36.4
1952	179.1	34.7	35.4
1953	191.9	35.4	34.3
1954	210.2	37.2	31.3
1955	223.9	39.1	31.0
1956	239.9	39.8	30.4
1957	261.6	37.1	30.2
1958	284.0	35.3	29.3
1959	310.0	33.7	28.6
1960	354.2	30.8	26.3
1961	404.1	28.2	24.3
1962	524.5	23.0	23.0
1963	566.0	22.6	22.6
1964	612.0	22.5	21.8
1965	664.6	22.4	21.0
1966	712.4	23.7	20.2
1967	770.0	24.4	19.5
1968	822.9	25.1	19.4
1969	883.4	25.7	19.0
1970	927.7	26.7	18.8
1971	1002.9	27.5	18.4
1972	1056.0	28.2	18.0
1973	1108.5	28.7	17.8
1974	1169.7	29.2	17.4
1975	1223.4	29.4	17.1
1976	1253.5	30.3	17.3
1977	1279.6	30.8	17.5

Distributions of scientific workers by type of position are generally not published for the U.S.S.R. as a whole. Some data on supervisory personnel are available, however. Scientific supervisory personnel were reported to account for 20.5 percent of all scientific workers in 1960, a drop from 28.6 percent in 1950 (*20*). According to a distribution by position of scientific workers in the Ukraine, published in 1973, the proportion of supervisors was 17.4 percent, suggesting a continuing decline for the U.S.S.R. nationwide (*21*).

The distribution of scientific workers by major place of work from 1962 to 1977 is shown in Table 6. The table shows that economic-branch scientific institutions have employed nearly half of all scientific workers since 1962, and that VUZy have employed more than one third. The proportion of scientific workers in the entire academy system (the U.S.S.R. Academy of Sciences, the republic academies of sciences, and the specialized branch academies) dropped slightly after 1962 because many of the system's scientific research institutes engaged in technical and industrial research were transferred between 1961 and 1963 to agencies in charge of branches of industry. There has been a small rise in the share of scientific employment in the residual category.

The VUZy account for nearly half of all scientific workers with advanced degrees, although their share has declined slightly since 1971. The academy system also has a disproportionate share of scientific employees with advanced degrees—nearly double its share of total scientific workers. The proportion of scientific workers with advanced degrees who are employed in the residual category is nearly as high as its share of total scientific workers in spite of the sparsity of advanced degree holders in industrial enterprises and project design organizations. This is due to the high proportion of persons with advanced degrees in the administrative apparatus of state agencies.

Most branch scientific institutions are subordinate to ministries in charge of industry, but some fall under ministries for other branches of the economy, such as construction and social services. These institutions conduct primarily applied R & D in areas related to the specific ac-

tivity of each branch. Nearly half of all scientific workers (46.6 percent in 1973) are employed in branch scientific institutions. If one adds to this the approximately 3.2 percent of scientific workers employed in nonresearch design organizations (*22*), which are also subordinate to the appropriate branch ministries, the proportion of scientific workers employed in all branch scientific organizations more closely approximates one half. The economic significance of the branch sector of science employment is even greater than the employment figures indicate, because about 85 percent of official science expenditures is accounted for by branch scientific organizations (*10*, pp. 9 and 38).

In 1968, industry employed 51.8 percent of all scientific workers. This figure probably included workers in industrial enterprises as well as those in industrial-branch scientific organizations (*10*, pp. 12–13 and 45–47). About 85 percent of scientific workers in industry were concentrated in the machine-building and metalworking branch and the chemical and petrochemical branch (about 71 percent in machine-building and metalworking alone) (*23*). If the individual branches of industry are ranked according to the proportion of scientific workers to total employment, the order is as follows: machine-building and metalworking, chemical and petrochemical industry, nonferrous metallurgy, ferrous metallurgy, glass and chinaware industry, fuel industry, light industry, food industry, timber, woodworking, and pulp and paper industries, and construction materials industry (*24*). In the early 1970's, about 5.0 percent of all scientific workers were employed in the construction branch of the economy, 5.5 percent in agriculture, and 6.0 percent in health services (*25*).

From 1969 to 1975, the percentage of scientific workers in industry, forestry, communications, trade and agricultural procurement, and the municipal economy reportedly remained relatively constant while the percentage in construction, agriculture, transportation, material-technical supply, education, and culture rose slightly (*26*). The percentage of scientific workers in geological prospecting and health services declined during the same period (*27*).

The scientific institutions in the academy system are engaged primarily in fundamental research and applied R & D on broad technological topics. Approximately 60 to 85 percent of the Soviet Union's fundamental research during the 1970's was conducted by these institutions. The academy system is composed of three general sectors, each with its own research institutions: (i) the U.S.S.R. Academy of Sciences, which conducts planning and coordination for the entire academy system; (ii) the academies of sciences of the separate republics (except the Russian Soviet Federated Socialist Republic, which is covered by the U.S.S.R. Academy and its regional divisions); and (iii) the specialized branch academies, which are subordinate to separate ministries but are supervised by the U.S.S.R. Academy (*10*, pp. 12–13 and 45–47). In 1977, the system employed 111,730 scientific workers (8.7 percent of all scientific workers), including 58,057 workers with advanced degrees (14.7 percent of the total with advanced degrees) (*28*). Scientific workers comprised 39.5, 41.1, and 19.4 percent of the employees in the U.S.S.R., republic, and specialized branch academies, respectively.

Scientific workers in VUZy include personnel whose time is divided between teaching and research and full-time research workers in VUZy institutes and laboratories. The proportion of full-time researchers has grown since 1965 from 7.7 to 17.9 percent, reflecting a rapid growth in the number of research laboratories and an effort to utilize VUZy scientists for practical economic purposes. From 1950 to 1976, VUZy research and teaching personnel increased 5.1 times while full-time R & D scientific workers increased 38.3 times (*29*).

Soviet statistics do not include systematic data on the hours of R & D work by VUZy research and teaching personnel (*14*, p. 8). A number of surveys and estimates indicate that the average is well under one half of all working time and that the minimum is one third (*30, 31*).

The scientific research of research and teaching personnel includes a wide range of writing, editorial, supervisory, and research activities (*32*). Consequently, the time spent on actual research is one third or less of total working time, and it may

Table 6. Distribution of scientific workers by category in the U.S.S.R., 1962 to 1977 (numbers are in thousands for the end of each year; percentage of total is given in parentheses). N.A., not available.

Year	Total scientific workers					Scientific workers with advanced degrees				
	Total	Branch ministries and other state agencies	Academy system	VUZy	Residual*	Total	Branch ministries and other state agencies	Academy system	VUZy	Residual*
1962	524.5	244.1 (46.5)	54.9 (10.5)	179.5 (34.2)	46.0 (8.8)	120.6	N.A.	N.A.	N.A.	N.A.
1963	566.0	273.1 (48.2)	53.7 (9.5)	196.8 (34.8)	42.4 (7.5)	127.9	N.A.	N.A.	N.A.	N.A.
1964	612.0	300.1 (49.0)	56.6 (9.3)	206.3 (33.7)	49.0 (8.0)	137.6	N.A.	N.A.	N.A.	N.A.
1965	664.6	329.1 (49.5)	61.3 (9.2)	221.8 (33.4)	52.4 (7.9)	149.2	N.A.	N.A.	73.4 (49.2)	N.A.
1966	712.4	330.6 (46.4)	65.5 (9.2)	263.6 (37.0)	52.7 (7.4)	169.0	N.A.	N.A.	N.A.	N.A.
1967	770.0	355.9 (46.2)	69.9 (9.1)	285.7 (37.1)	58.5 (7.6)	187.6	N.A.	N.A.	N.A.	N.A.
1968	822.9	377.3 (45.8)	75.3 (9.2)	307.8 (37.4)	62.5 (7.6)	206.4	N.A.	32.6 (15.8)	N.A.	N.A.
1969	883.4	407.1 (46.1)	81.4 (9.2)	327.2 (37.0)	67.7 (7.7)	227.2	N.A.	N.A.	N.A.	N.A.
1970	927.7	419.1 (45.2)	85.9 (9.2)	348.8 (37.6)	73.9 (8.0)	248.1	67.1 (27.0)	39.8 (16.0)	122.7 (49.5)	18.5 (7.5)
1971	1002.9	463.0 (46.2)	90.4 (9.0)	366.7 (36.6)	82.8 (8.2)	275.3	N.A.	42.9 (15.6)	132.2 (48.4)	N.A.
1972	1056.0	490.6 (46.4)	94.6 (9.0)	378.8 (35.9)	92.0 (8.7)	297.6	83.9 (28.2)	45.6 (15.3)	143.0 (48.1)	25.1 (8.4)
1973	1108.5	516.8 (46.6)	97.0 (8.8)	394.4 (35.6)	100.3 (9.0)	318.1	N.A.	47.9 (15.1)	N.A.	N.A.
1974	1169.7	N.A.	100.4 (8.6)	410.8 (35.1)	N.A.	341.2	N.A.	50.4 (14.8)	148.8 (43.6)	N.A.
1975	1223.4	N.A.	105.5 (8.6)	427.8 (35.0)	N.A.	359.1	N.A.	53.4 (14.9)	168.9 (47.0)	N.A.
1976	1253.5	N.A.	107.7 (8.6)	441.5 (35.2)	N.A.	380.0	N.A.	55.5 (14.6)	179.0 (47.1)	N.A.
1977	1279.6	N.A.	111.7 (8.7)	N.A.	N.A.	394.4	N.A.	58.1 (14.7)	N.A.	N.A.

*The residual category includes industrial enterprises, nonresearch project and design organizations, central administrative departments, and others.

Table 7. Number of scientific workers by branch of science in the U.S.S.R., 1950 to 1974 (absolute numbers in thousands at end of each year). Architecture is not included with the technical sciences, since it includes only history and theory, building design, city planning, and landscape architecture, whereas architectural engineering falls under construction engineering in the technical sciences. Psychology is placed under the social sciences: it excludes psychiatry, which is under medicine in the Soviet classification. Geography is placed under the social sciences since there are no available statistics separating physical geography and socioeconomic geography.

Branch of science	1950				1960				1974			
	Total number	Percent of total	Number with advanced degrees	Percent of total with advanced degrees	Total number	Percent of total	Number with advanced degrees	Percent of total with advanced degrees	Total number	Percent of total	Number with advanced degrees	Percent of total with advanced degrees
Physical and life sciences	70.8	43.7	29.0	54.0	134.4	38.0	52.4	48.1	341.3	29.1	156.4	45.9
Physics/mathematics	10.2	6.3	3.1	5.7	29.0	8.2	7.8	7.1	116.9	10.0	36.5	10.7
Chemistry	12.9	8.0	3.6	6.7	26.2	7.4	6.3	5.8	53.7	4.6	19.5	5.7
Biology	8.6	5.3	4.3	8.1	15.1	4.3	7.9	7.3	45.5	3.9	25.3	7.4
Geology/mineralogy	3.6	2.2	1.9	3.5	10.7	3.0	3.6	3.3	24.5	2.1	11.6	3.4
Medicine	21.0	13.0	11.1	20.6	31.4	8.9	18.2	16.7	57.6	4.9	42.3	12.4
Pharmaceutics	0.4	0.3	0.1	0.2	0.8	0.2	0.2	0.2	1.4	0.1	0.7	0.2
Agriculture	11.9	7.3	3.9	7.3	18.0	5.1	6.6	6.0	36.5	3.1	17.1	5.0
Veterinary sciences	2.2	1.3	1.0	1.9	3.2	0.9	1.8	1.7	5.2	0.4	3.4	1.1
Technical (engineering) sciences	41.5	25.5	14.2	26.4	129.8	36.7	28.7	26.3	548.0	46.9	102.9	30.1
Social sciences and humanities	45.8	28.1	10.0	18.6	81.2	22.8	26.4	24.1	237.6	20.3	73.7	21.6
History	8.5	5.2	2.4	4.6	16.5	4.6	7.2	6.6	28.7	2.5	13.4	3.9
Economics	4.6	2.8	1.9	3.5	13.9	3.9	5.2	4.8	80.1	6.9	23.3	6.8
Philosophy	2.7	1.7	0.6	1.1	3.4	1.0	2.0	1.8	15.1	1.3	8.0	2.3
Language and literature	13.6	8.4	2.1	3.9	21.2	6.0	5.5	5.1	51.6	4.4	12.6	3.7
Geography	2.6	1.6	0.8	1.5	4.3	1.2	1.8	1.6	8.3	0.7	3.6	1.1
Law	1.1	0.6	0.5	1.0	2.2	0.6	1.5	1.3	6.3	0.5	3.6	1.1
Education	8.8	5.4	1.2	2.2	14.1	3.9	2.4	2.2	30.2	2.6	6.2	1.8
Psychology*									2.8	0.2	1.3	0.4
Art	3.9	2.4	0.5	1.0	5.6	1.6	0.8	0.7	14.5	1.2	1.7	0.5
Architecture	0.8	0.5	0.3	0.5	1.4	0.4	0.5	0.5	3.3	0.3	1.1	0.3
Other sciences (military and military-related)	3.6	2.2	0.3	0.5	7.4	2.1	1.2	1.0	39.5	3.4	7.1	2.1
Total	162.5	100.0	53.8	100.0	354.2	100.0	109.2	100.0	1169.7	100.0	341.2	100.0

*Employees under psychology were not reported separately until 1968. Before that date they were grouped with employees in education studies ("pedagogical sciences").

in fact, be lower. For this reason, and because all VUZy scientific workers engaged full-time in R & D will be included in the estimate of the total number of scientific workers given in this article, the proportion of one fourth, originally suggested by Robert Campbell (*33*), has been used to calculate the full-time research equivalents of VUZy research and teaching personnel (*34*).

Additional R & D work is performed by graduate students who are not included in the standard scientific worker category. A Soviet commentator indicated that one fourth of the study time of a graduate student is devoted to research (*14*, p. 9); hence a full-time equivalent of one fourth is assumed here for full-time graduate students. Since the study time of part-time graduate students makes up an estimated 42 percent of combined working and study time (*31*), their full-time equivalent may be set at one fourth of 42 percent.

Between 1950 and 1977, the number of graduate students, including both full-time and part-time students at VUZy and other scientific institutions, increased from 21,905 to 96,668. Since the mid-1960's the number of graduate students has remained stable, but there has been a sharp decline in the number of full-time students. As a result, the estimated full-time equivalent number of graduate students participating in R & D has decreased somewhat in recent years.

Some undergraduate students also engage in scientific research, particularly those in senior classes (*35*). Estimates of the number of undergraduate students participating in R & D during the 1977-1978 academic year ranged from 697,000 to 1,116,000 (*36*). None of the estimates, however, make allowance for full-time equivalents. The research work of undergraduate students is less likely to involve original, creative R & D than that of graduate students, and the actual participation of undergraduate students in research projects is more likely to consist of support activities, auxiliary work, and training, so they are not included here in the calculation of the total number of persons engaged in R & D.

In 1970, the proportion of the employees of industrial-enterprise scientific and technical subdivisions classified as scientific workers was 3.3 percent; of non-research design and project organizations, 3.2 percent; and of central administrative scientific and technical departments, 1.5 percent. The total proportion was highly stable at around 8.0 percent between 1963 and 1970, but increased to 8.6 percent in 1972 and to 9.0 percent in 1973. The main reason for the

increase is that the proportion of scientific workers employed in central administrative departments and other organizations increased from 1.5 percent in 1970 to 2.5 percent in 1973 (*12*, p. 86; *37*). Another reason may have been the drive to augment the number of scientific workers in industrial enterprises during the recent effort to improve the application of science to production.

The difference between the proportion of scientific workers in industrial enterprises in the U.S.S.R. (only 3.7 percent in 1970) and in Western countries (a much higher percentage) is misleading. Most industrial R & D in the U.S.S.R. is first conducted in industrial-branch scientific research institutes and design bureaus; then the results are transferred to the enterprises. Furthermore, a number of the central plant laboratories, especially those in major enterprises, are officially designated as scientific institutions, in which case their scientific workers are statistically entered as employees of the institutions under the science and science services branch rather than industry (*14*, p. 18).

Scientific workers employed in nonresearch design organizations numbered about 29,300 in 1970 and an estimated 34,900 in 1973. The number of scientific workers in central administrative scientific and technical departments and in other institutions and organizations increased from 14,300 in 1970 to 27,700 in 1973; this increase probably reflected the heavy emphasis since 1968 on integrated planning of science and technology and on more systematic coordination of this planning with general economic planning. This policy has evidently led to increased employment of scientific workers in the central administrative and consultative departments that deal with decision-making and planning in science and technology (*38*). Additional weight is lent to this assumption by the fact that all scientific workers in this subcategory have advanced scientific degrees (*12*, p. 86) and are therefore more likely to be involved in planning and in advising on science policy.

The official list under which scientific workers are categorized contains 21 branches and 486 specialties, of which 214 are in the technical or engineering sciences (*39*, *40*). Table 7 shows the distribution of scientific workers by branch of science from 1950 to 1974 (*41*, *42*). The undesignated residual employment category (labeled other branches in Soviet sources) given in Soviet statistics apparently consists of military or military-related sciences not otherwise included in the technical sciences. This can be assumed because the only remaining branches in the official nomenclature of specialties that are not listed in the breakdowns of scientific workers are military and naval sciences; these are probably not limited to theoretical military studies (*43*), but may include some military hardware R & D.

Table 8. Reported and adjusted Soviet data on R & D personnel, 1970. The number of personnel conducting R & D was adjusted by reducing the number of VUZy teachers to full-time equivalents, adding full-time equivalent graduate students, and eliminating personnel with advanced degrees not working in R & D. The number of personnel conducting and supporting R & D was obtained by adding to the figures on employment in the science and science services branch the estimated R & D personnel of VUZy, industrial enterprises, and central administrative staffs and subtracting personnel in the hydrometeorological and geological survey services. N.A., not available.

Employment category	Personnel	
	Reported	Adjusted
Personnel Conducting R & D (total)	927,709	713,434
Excluding the social sciences and humanities	726,897	590,760
Excluding the humanities	829,629	661,929
Personnel Conducting and supporting R & D (total)	2,999,000	3,021,268
Excluding the social sciences and humanities	N.A.	2,826,547

However, most military-related technology undoubtedly falls under appropriate subbranches of the technical sciences. To our knowledge, statistics have never been published on the distribution of scientific workers in military R & D, let alone by specific branch. Therefore, we can only presume that a large, indeterminate proportion of scientific workers in the technical sciences are employed in military-related R & D. Presumably, a large proportion of scientific workers in the "other branches" are teachers in military academies and military faculties of civilian VUZy, perhaps in both theoretical military science and military technology (*44*).

The largest growth in the number of scientific workers since 1950 has taken place in the technical sciences (25.5 percent in 1950 to 46.9 percent in 1974), physics and mathematics (6.3 to 10.0 percent), economics (2.8 to 6.9 percent), and "other sciences" (2.2 to 3.4 percent). The employment of scientific workers in some fields has decreased. For example, the number in physical and life sciences dropped from 43.7 to 29.1 percent and the number in social sciences and humanities dropped from 28.1 to 20.3 percent. Significant proportional declines occurred in specific branches of science, including chemistry, biology, medicine, agriculture, veterinary sciences, history, language and literature, geography, education, and art. These changes, however, are due in part to the addition in 1962 to the scientific workers category of certain R & D employees, most of whom were technical scientists. Since 1965, the distribution of R & D employees among the branches of science has remained stable, although there has been a trend in favor of the technical sciences, physics and mathematics, economics, and the "other sciences."

The physical and life sciences have by far the largest share of scientific workers with advanced degrees. The percentage of advanced degree holders in the technical sciences is much lower than the percentage of all scientific workers in these sciences. The percentage of all advanced degree holders employed in the social sciences, the humanities, and architecture is approximately the same as the proportion of the total number of scientific workers in these fields. The proportion of advanced degree holders in the "other sciences" is quite low (18.0 percent compared to 31.2 percent for all scientific workers in 1974).

The concentration of scientists in the physical and life sciences is much higher in the U.S.S.R. Academy of Sciences and slightly higher in VUZy than in the U.S.S.R. as a whole (*45*). The proportion of scientific workers in the technical sciences is very low in the Academy, while the proportion in the VUZy falls between that in the Academy and that in the entire country. The percentage of scientific workers in the social sciences and humanities is highest in VUZy, except in history, economics, and geography, fields in which the proportion in the Academy is higher (*4*, p. 113; *44*, p. 155). Approximately 70 percent of technical scientists and 40 percent of physical and life scientists are employed in branch scientific organizations (*46*).

Adjustment and Comparison of Data

In order to make meaningful quantitative comparisons between Soviet and U.S. data on R & D employment, the number of persons who conduct and support R & D in the U.S.S.R. must be adjusted to include R & D personnel not in the official series and to exclude person-

nel not engaged full-time in R & D. The adjusted data are presented here in variants that include and exclude the social sciences and humanities. The year 1970 is selected because the published information for that year is more comprehensive than that for most other years. Table 8 illustrates the results of the adjustment of the original Soviet R & D personnel data.

No comparison is made here of personnel who conduct and support R & D, because there are significant differences in the identification and utilization of support personnel in the United States and the U.S.S.R. which make it impossible to determine the relative size of R & D employment in the two countries. One Western authority estimated that in 1970 the ratio of scientists and engineers engaged in R & D to auxiliary employees was 1:5 in the U.S.S.R. and only 1:1.3 in the United States (*47*). The difference does not mean that there is a larger pool of effective scientific personnel in the U.S.S.R. but is instead a reflection of the inferior efficiency of Soviet R & D support (*48*). It also reflects statistical differences between the United States and the U.S.S.R. in recording persons who are engaged in R & D support.

Table 9 gives U.S. and Soviet statistics on personnel directly engaged in conducting R & D. The figures for the U.S.S.R. are our adjusted series for scientific workers. Two U.S. statistical series that closely approach the official Soviet scientific workers series are the Bureau of Labor Statistics (BLS) series on scientists and engineers engaged in R & D and the National Science Foundation (NSF) regular series on full-time equivalent scientists and engineers employed in R & D. However, there are significant differences in the methods by which the U.S. and Soviet series were compiled:

1) The BLS series records the number of scientists and engineers who spend the greater portion of their working time in R & D or in direct R & D management. The NSF series is based on the number of employees working principally or part-time in R & D and R & D management, but these numbers are reduced to full-time equivalents. The Soviet series includes all specialists defined as scientific workers, with no reduction to full-time equivalents.

2) The BLS series excludes all humanities specialists, psychologists, and social scientists. The NSF series excludes all humanities specialists and those social scientists and psychologists who are employed in industry. The Soviet data cover all specialists doing research; however, for comparison purposes, scientific workers in the social sciences and humanities can be disaggregated as required, except in geography, which combines physical and socioeconomic geographers.

3) The BLS series includes salaried graduate students and the NSF series incorporates graduate students who are engaged in R & D on a full-time equivalent basis. The Soviet series excludes graduate students, but estimated full-time equivalent graduate students have been included in the Soviet series (Table 9).

4) Inclusion in either U.S. series requires a bachelor's degree in science or engineering or the equivalent in training and experience. At first glance, the Soviet educational criterion appears to be more stringent because it calls for the possession of a VUZy diploma for all those lacking advanced degrees or titles. In practice, however, scientists and engineers without diplomas have been counted as scientific workers if they work in units that have an approved scientific research plan.

5) The BLS data refer to a date early in the year. The components of the NSF series apply to different times of the year, but in general the series approximates an annual average measure. The Soviet figures are end-of-year data.

The most serious problem in making comparisons between the U.S. and Soviet series is the difference in the scope of employee participation in R & D. The Soviet definition of this participation in-

Table 9. Scientists and engineers employed in R & D in the United States and the U.S.S.R., 1950 to 1979 (in thousands). The figures in column 3 were derived by multiplying the published total numbers of scientific workers by the estimated percentage of scientific workers outside the social sciences and humanities for 1970 (63.7 percent). Similarly, the figures in column 4 were derived by applying the estimated percentage outside the humanities as adjusted for 1970 (71.4 percent). The 1970 percentages are used for all years because the data needed to calculate percentages for most other years are insufficient or unavailable. For the years 1950 to 1961 inclusive, the official Soviet series was multiplied by a factor of 1.107942 to adjust for the change in the series in 1962. N.A., not available; X, not applicable.

Year	U.S. series		U.S.S.R. adjusted scientific workers series (end of year)	
	BLS estimates* (beginning of year)	NSF estimates† (annual average)	Less specialists in social sciences and humanities	Less specialists in humanities
1950	157.9	158.7	111.7	125.2
1951	175.4	N.A.	117.0	131.2
1952	204.9	N.A.	123.1	138.0
1953	227.8	N.A.	131.9	147.9
1954	243.5	237.1	144.5	162.0
1955	248.8	254.3	153.9	172.6
1956	271.0	N.A.	164.9	184.9
1957	308.8	N.A.	179.9	201.6
1958	329.7	354.1	195.3	218.9
1959	362.1	N.A.	213.2	238.9
1960	386.1	380.9	243.5	273.0
1961	409.5	425.7	277.9	311.5
1962	441.9	N.A.	334.1	374.5
1963	475.7	N.A.	360.5	404.1
1964	497.9	N.A.	389.8	436.9
1965	513.2	494.5	423.3	474.5
1966	526.3	N.A.	453.8	508.7
1967	554.0	N.A.	490.5	549.8
1968	552.8	N.A.	524.2	587.6
1969	549.0	556.6	562.7	630.8
1970	535.4	546.5	590.9	661.9
1971	X	526.4	638.9	716.1
1972	X	518.5	672.7	754.0
1973	X	517.5	706.1	791.5
1974	X	525.4	745.1	835.2
1975	X	534.8	779.3	873.5
1976	X	549.9	798.5	895.0
1977	X	571.1	815.1	913.6
1978	X	595.0	828.1	928.2
1979	X	610.0	N.A.	N.A.

*Excludes social scientists, psychologists, and humanities specialists. †Excludes humanities specialists in all sectors and social scientists and psychologists in industry. [It is estimated that in the U.S., social scientists performing R & D in industry would add only about 5 percent or less to the industry figures (*51*).] It also excludes scientists and engineers in R & D employed in state and local governments. The proportion of the latter, however, is very small—only 0.8 percent of all R & D scientists and engineers in the BLS data for 1970.

Table 10. Scientists and engineers employed in R & D at higher educational institutions in the United States and the U.S.S.R. in full-time equivalents, 1950 to 1976 (in thousands). Both series exclude graduate students. The U.S. figures include university-associated federally funded R & D centers, which are equivalent to problem and branch laboratories in the U.S.S.R. The Soviet figures are derived from the reported number of scientific workers in VUZy, adjusted as follows: for each year, the number of research and teaching personnel and full-time R & D employees is multiplied by 79 percent, the reported proportion of VUZy scientific workers not in the humanities in 1970; the number of research and teaching personnel is reduced to full-time equivalents by multiplying by 25 percent, and full-time equivalents are added to full-time R & D employees.

Year	U.S. (NSF series)	U.S.S.R.
1950	18.3	18.3
1955	25.2*	25.1
1960	37.1†	32.4
1965	51.1	53.9
1970	61.3	95.9
1976	68.5	134.1

*1954. †1961.

cludes so many criteria that a precise comparison of Soviet and U.S. figures is out of the question. Nevertheless, it is assumed that the two sets of series, after adjustment of the Soviet series, fall within a range that offers a valid comparison of Soviet and U.S. R & D employment.

The U.S. data in Table 9 are given as they were published; the estimates for the U.S.S.R. are based on the official scientific worker series, but the estimates in columns 3 and 4 are adjusted to correspond to the BLS and NSF series, respectively. According to these estimates, the United States was well ahead of the U.S.S.R. during the early 1950's both in the number of scientists and engineers employed in R & D and in the rate of employment growth. By the end of the decade, however, the Soviet rate of employment growth rose above the U.S. rate and remained far ahead during the 1960's. The numerical crossover occurred toward the end of the 1960's. During the first half of the 1970's, the Soviet total continued to increase more rapidly than the U.S. total, although the rate of growth declined. The U.S. growth rate surpassed the Soviet rate by a small margin during the period from 1975 to 1978. The number of R & D scientists and engineers in the United States declined during the first half of the 1970's and regained the 1969 level only in 1977. As a result, the Soviet total in 1978 was nearly 60 percent greater than the U.S. total.

Both the BLS and the NSF series also include distributions of R & D scientists and engineers by economic sector. However, due to the great institutional differences between the U.S. and Soviet systems, the only reasonable comparison that can be made is between U.S. universities and colleges and Soviet VUZy. Table 10 gives the numbers of R & D scientists and engineers in this sector in the two countries. As the table indicates, U.S. and Soviet R & D employment figures in higher education were remarkably similar in the 1950's and fairly similar from 1960 to 1965. After 1965, however, the Soviet numbers moved considerably ahead, rising to nearly twice the U.S. figure by 1976. The Soviet increase obviously reflects the rapid growth in full-time R & D employees in VUZy during this period. Since these employees are not reduced to full-time equivalents in the table, the differences after 1965 are somewhat overstated.

Table 11 gives the distribution of scientists and engineers in R & D in the United States and the U.S.S.R. in 1974 by branch of science and engineering (*49*). The U.S. proportions are based on a national sample survey of scientists and engineers conducted by the Bureau of the Census for the NSF. To make the Soviet and U.S. distributions more comparable, only U.S. scientists and engineers in R & D, R & D management, and college teaching are included in the table. As of 1974, the distribution of personnel in the physical and life sciences was nearly the same in the two countries, although the relative distribution among subgroups of the physical and life sciences differed. For example, the U.S.S.R. had somewhat larger percentages in physics/astronomy/mathematics, in agriculture, and in medicine, even after national differences in the classification of fields are accounted for. The U.S. percentage of scientists and engineers in chemistry was more than double the Soviet figure. The proportions in biology were approximately the same, with the U.S. share slightly higher when differences in classification are considered. The U.S. proportion in engineering was higher and is judged to remain so even if differences in the classification of engineering fields are taken into account. The Soviet percentage of social scientists was higher than the U.S. percentage, despite the fact that some Soviet psychology specialists were included under medicine and some anthropologists under biology. The Soviet proportion in economics was much greater than the U.S. figure, but was somewhat exaggerated by the inclusion in Soviet data of fields that are classified under other branches of the social sciences or humanities in the United States, such as demography and economic history (which are included with sociology and history, respectively) (*39*, pp. 7–17; *50*).

Table 11. Distribution of R & D scientists and engineers by branch in the United States and the U.S.S.R., 1974. N.A., not available; X, not applicable.

Branch	U.S. (%)	U.S.S.R. (%)
Physical and life sciences	32.4	32.9
Physics/astronomy/mathematics	7.4	11.0
Computer sciences*	1.3	N.A.
Environmental sciences†	2.7	3.1
Chemistry	11.5	5.1
Biology‡	5.1	4.3
Medicine	1.5	5.4
Pharmaceutics§	N.A.	0.1
Veterinary sciences‖	N.A.	0.5
Agriculture	1.9	3.4
Other	1.0	X
Technical (engineering) sciences¶	60.2	51.7
Social sciences	7.4	11.3
Economics	1.9	7.6
Law (political science)	N.A.	0.6
Education	N.A.	2.9
Psychology**	2.6	0.2
Sociology/anthropology	1.5	N.A.
Other	1.4	X
Architecture††	N.A.	0.3
Other sciences (military and military-related)††	N.A.	3.8

*Computer sciences in the U.S.S.R. is divided between mathematics and engineering. †Geology/mineralogy/geography. The Soviet data include socioeconomic geography. ‡In the U.S. classification, includes anatomy, immunology, nutrition, pathology, and pharmacology (these appear under medicine in the Soviet data). §In the U.S. classification, divided between chemistry and medicine. ‖In the U.S. classification, under medicine. ¶Several fields of science included under the technical sciences in the Soviet classification, such as geodesy, cartography, control systems and information processing, and food technology, are placed under the physical and life sciences in the U.S. classification. **Some psychologists in the Soviet Union are probably classified under medicine (along with psychiatrists) and under education, accounting for part of the disparity between the U.S. and Soviet proportions. Psychology became a separate branch of science in the U.S.S.R. only recently. ††Partly under engineering in the U.S. classification.

The distribution by scientific field of specialists with advanced degrees (that is, doctorates in the United States and candidates or doctors of sciences in the U.S.S.R.) diverged from the distribution of total scientists and engineers in R & D. Table 12 gives the comparative distribution of these specialists in 1977 for the United States and 1974 for the U.S.S.R., the only years for which available data permit an intercountry comparison in all fields of science and the humanities. The proportion of advanced degree holders in the physical and life sciences was roughly 45 percent for both countries, whereas only 32 percent of the total number of R & D scientists and en-

gineers in the U.S.S.R. were in these sciences in 1974. Employment in chemistry and the environmental sciences had almost the same relative distribution in the two countries (see Table 11). The United States share in biology, however, was much higher than the Soviet share, probably reflecting the years in which biology was a controversial field in the U.S.S.R. In engineering, the Soviet percentage with advanced degrees was more than twice that of the United States. Except in economics, the Soviet proportion in the social sciences and humanities was lower than the U.S. proportion. With respect to the overall figure of specialists with advanced degrees, if one discounts the number of U.S. doctorates not included in Table 12 (those not in the labor force, not employed, or not reporting) the Soviet and U.S. totals for the mid-1970's were remarkably similar.

Table 12. U.S. and Soviet specialists with advanced degrees, by branch (U.S. figures are actual; Soviet figures are rounded to nearest hundred). The original U.S. data were adjusted as follows to conform to the Soviet categorization of branches of science: (i) mathematics: computer theory and software systems were added; (ii) chemistry: biochemistry was moved to biology and pharmaceutical chemistry to pharmaceutics; (iii) environmental sciences: fuel technology and petroleum engineering were moved to engineering, and socioeconomic geography was added; (iv) biology: anatomy, immunology, and nutrition and dietetics were moved to medicine; food science and technology was moved to engineering; anthropology was added from the social sciences; and behavior/ethology was moved to psychology; (v) agriculture: agricultural economics was moved to economics and food science and technology to engineering; (vi) medicine: veterinary medicine was separated and hospital administration was moved to economics; (vii) engineering: communications, computer hardware, and library and archival sciences were added; (viii) economics: social statistics, business administration, and home economics were added; (ix) law: political science, public administration, international relations, and jurisprudence were combined; (x) psychology: education was moved to general education; (xi) language and literature: linguistics and journalism were included; and (xii) history: archeology was added. N.A., not available; X, not applicable.

Branch	U.S., beginning of 1977*		U.S.S.R., end of 1974	
	Number	Percent of total	Number	Percent of total
Physical and life sciences	147,607	43.6	160,000	47.2
Physics/astronomy/ mathematics	34,778	10.3	36,500	10.7
Physics and astronomy†	17,911	5.3	N.A.	N.A.
Mathematics	16,867	5.0	N.A.	N.A.
Chemistry	29,640	8.7	19,500	5.7
Environmental sciences	14,170	4.2	15,200	4.5
Geology/mineralogy	4,081	1.2	11,600	3.4
Geography‡	7,103	2.1	3,600	1.1
Other earth sciences§	2,986	0.9	N.A.	N.A.
Biology	39,324	11.6	25,300	7.4
Agriculture	10,641	3.1	17,100	5.0
Medicine/pharmaceutics	18,164	5.4	43,000	12.6
Veterinary sciences	890	0.3	3,400	1.1
Engineering (technical sciences)	49,481	14.6	102,900	30.1
Social sciences	72,526	21.4	34,400	10.1
Economics	16,376	4.8	23,300	6.8
Law (political science)	17,735	5.2	3,600	1.1
Education	10,467	3.1	6,200	1.8
Psychology‖	27,948	8.3	1,300	0.4
Humanities	55,355	16.3	35,700	10.4
Philosophy/sociology	10,070	2.9	8,000	2.3
Language and literature	26,040	7.7	12,600	3.7
History	14,237	4.2	13,400	3.9
Art	5,008	1.5	1,700	0.5
Architecture¶	923	0.3	1,100	0.3
Other (U.S.S.R.)**	X	X	7,100	2.1
Other (United States)††	13,275	3.9	X	X
Total	339,167‡‡	100.0	341,200	100.0

*Based on those receiving their doctorates between 1934 and 1976. †Scientific workers in physics and astronomy comprised about two thirds of those in physics/mathematics in 1971. ‡Includes socioeconomic geography, in which there were 1807 persons in the U.S. in 1977. §Includes branches of geology, physical geography, and geodesy. The latter, however, is classified as an engineering field in the U.S.S.R. classification. ‖Psychology totals may be misleading, since the U.S. figures include clinical psychology (12,397 persons in 1977). Some of the Soviet equivalents may be classified under psychiatry, which is in medicine. ¶The U.S. figure is incomplete, and includes only urban and regional planning, which is classified under architecture in the U.S.S.R. **Believed to be primarily military or military-related sciences. ††Includes area studies, social work, speech and hearing, religion and theology, general social sciences, general humanities, and unspecified fields. ‡‡Excludes 35,834 doctorates who were outside the labor force or unemployed (27,154) or who did not report their fields of employment (8680).

In summary, the estimated number of scientists and engineers engaged in R & D in the U.S.S.R. today substantially exceeds the number in the United States. The estimated numbers of R & D scientists and engineers with advanced degrees more nearly correspond in the two countries. The distribution of Soviet personnel by branch of science and engineering, though differing from the U.S. distribution, reflects a commitment to scientific endeavor generally as broad as in the United States. Although no qualitative comparison is made here between Soviet and U.S. scientific personnel, it is apparent that, in terms of number of personnel and scope of R & D, the U.S.S.R. has reached or surpassed the U.S. level during the past decade in a number of branches of science and engineering.

References and Notes

1. N. K. Serov, in *Nauchno-tekhnicheskaya revolyutsiya i izmeneniye struktury nauchnykh kadrov SSSR*, D. M. Gvishiani, S. R. Mikulinskiy, S. A. Kugel', Eds. (Nauka, Moscow, 1973), p. 132.
2. G. Glagoleva, *Vopr. Ekon.* **3**, 120 (1975).
3. A. M. Omarov *et al.*, Eds., *Nauchno-tekhnicheskiy progress i khozyaystvennaya reforma* (Nauka, Moscow, 1969), p. 165. Some sources report that there are about 5,000 scientific institutions and over 40,000 project-design organizations in the country. However, the latter figure evidently includes design organizations that are subordinate to other organizations, such as the nearly 25,000 design departments in industrial enterprises [G. Glagoleva (*2*), p. 117; G. I. Marchuk, *Vestn. Akad. Nauk SSSR* **10**, 114 (1972).
4. S. A. Kugel', in *Nauchno-tekhnicheskaya revolyutsiya i izmenenive struktury nauchnykh kadrov SSSR*, D. M. Gvishiani *et al.*, Eds. (Nauka, Moscow, 1973), p. 32.
5. Yu. V. Poshekhonov, in *Problemy deyatel'nosti uchenogo i nauchnykh kollektivov*, G. P. Dzhelomanova, Ed. (Leningradskoye otdeleniye, Institut istorii yestestvoznaniya i tekhniki Akademii nauk SSSR, Leningrad, 1970), issue 3, pp. 95-96.
6. This proportion was calculated by deducting from total scientific workers in 1970 (927,700) those in the VUZy (348,800), industrial enterprises (30,300), and central administrative staffs and other organizations (14,300) and then dividing the remainder (534,300) by total employment (new series) in science and science services for 1970 (2,999,000).
7. P. N. Zavlin *et al.*, *Trud v sfere nauki* (Nauka, Novosibirsk, 1971), p. 230.
8. A. M. Zhdanov, *Neft. Khoz.* **10**, 33 (1977).
9. However, total employment in these sectors cannot simply be combined with employment in science and science services to arrive at total R & D employment, because much of the activity of these sectors is not R & D.
10. L. E. Nolting, *The Financing of Research, Development, and Innovation in the U.S.S.R. by Type of Performer* (Foreign Economic Rep. 9, U.S. Department of Commerce, Washington, D.C., 1976), pp. 13-14 and 44.
11. S. R. Mikulinskiy, in *Problemy deyatel'nosti uchenogo i nauchnykh kollektivov*, S. A. Kugel', I. V. Blauberg, O. M. Volosevich, A. V. Kol'tsov, V. N. Makeyeva, Yu. S. Meleshchenko, N. K. Serov, M. G. Yaroshevsky, Eds. (Leningradskoye otdeleniye, Institut istorii yestestvoznaniya i tekhniki Akademii nauk SSSR, Leningrad, 1973), issue 5, p. 159.
12. L. A. Kostin, *Proizvoditel'nost' truda i tekhnicheskiy progress* (Ekonomika, Moscow, 1974), p. 83.
13. Tsentral'noye statisticheskoye upravleniye pri Sovete Ministrov SSSR, *Narodnoye khozyaystvo SSSR v 1975 godu; statisticheskiy yezhegodnik* (Statistika, Moscow, 1976), p. 780.
14. M. Feshbach, "Notes on R & D manpower," unpublished manuscript based on discussions in

Moscow and Leningrad, 26-30 June 1978, p. 1.
15. S. R. Mikulinskiy, S. A. Kugel', V. I. Maslennikov, Z. M. Mirskiy, P. B. Shelishch, *Podgotovka i ispol'zovaniye nauchnykh i inzhenerno-tekhnicheskikh kadrov v SSSR* (Soviet Side of the Joint Soviet-American Working Subgroup on Training and Utilization of Scientific and Engineering-Technical Manpower, Moscow, December 1976), part 2, p. 9; N. K. Serov (*1*), p. 131.
16. Stanford Research Institute, *Report on the Conference of the U.S.-U.S.S.R. Joint Subgroup on the Training and Utilization of Scientific, Engineering, and Technical Personnel*, 8-10 March 1978 (Arlington, Va., 1978), p. 28.
17. Some Soviet scholars have projected an annual growth rate of 2 to 3 percent at least until 1980, with a probable slowdown during the 1980's (*14*, p. 8).
18. As noted in Table 5, some overlap occurs between the number of advanced degree holders and the number of title holders. For example, professors hold doctor of science degrees.
19. R. Campbell, "Notes on conversations in Moscow," unpublished manuscript based on discussions with Soviet Working Group on Manpower, 26-30 June 1978, p. 1; M. Feshbach (*14*), p. 10; unpublished memorandum.
20. K. M. Varshavskiy and S. A. Kugel', in *Nauchno-tekhnicheskaya revolyutsiya i izmeneniye struktury nauchnykh kadrov SSSR*, D. M. Gvishiani, S. R. Mikulinskiy, S. A. Kugel', Eds. (Nauka, Moscow, 1973), p. 88.
21. V. N. Klimenyuk, *Upravleniye razvitiyem i ispol'zovaniyem nauchnogo potentsiala* (Naukova Dumka, Kiev, 1974), p. 44.
22. B. P. Vladimirov, in *Nauchno-tekhnicheskaya revolyutsiya i stroitel'stvo kommunizma*, V. G. Lebedev, V. I. Kushlin, A. B. Nikolayev, V. M. Grigorov, K. Ye. Tarasov, N. N. Kiselev, Eds. (Mysl', Moscow, 1976), p. 168. The percentage given is for 1970.
23. V. G. Lebedev *et al.*, *Ekonomicheskiye problemy effektivnosti nauki* (Mysl', Moscow, 1971), pp. 77 and 79.
24. E. M. Siderova, in *Nauchno-tekhnicheskaya revolyutsiya i izmeneniye struktury nauchnykh kadrov SSSR*, D. M. Gvishiani, S. R. Mikulinskiy, S. A. Kugel', Eds. (Nauka, Moscow, 1973), pp. 122-123.
25. Ye. Ya. Udovenko *et al.*, *Vnedreniye nauchnykh dostizheniy v sel'skoye khozyaystvo* (Ekonomika, Moscow, 1975), p. 4; G. V. Grigor'yev, *Povysheniye proizvoditel'nosti truda v stroitel'stve* (Stroizdat, Moscow, 1974), p. 12; B. V. Petrovskiy, *Sovetskoye zdravookhraneniye za 50 let SSSR* (Meditsina, Moscow, 1973), p. 95.
26. The highest proportional rise was in material-technical supply.
27. V. A. Pokrovskiy, *Nauk. Inf. (Kiev)* **18**, 49 (1977). The scientific production associations recently organized under branch ministries in the U.S.S.R. are mergers of both branch scientific organizations and experimental and series production plants. The number of scientific workers employed in scientific production associations is not reported separately in Soviet statistics but is included in the total number of branch scientific workers. [For a more detailed discussion of the organization of branch scientific organizations and scientific production associations, see L. E. Nolting (*10*), pp. 7-12; *The Structure and Functions of the State Committee for Science and Technology*, in press.]
28. Tsentral'noye statisticheskoye upravleniye pri Sovete Ministrov SSSR, *Narodnoye khozyaystvo SSSR v 1977 godu; statisticheskiy yezhegodnik* (Statistika, Moscow, 1978), p. 95.
29. V. P. Yelyutin, *Vestn. Vyssh. Shk.* **11**, 13 (1977); Tsentral'noye statisticheskoye upravleniye pri Sovete Ministrov SSSR, *Vyssheye obrazovaniye v SSSR* (Statistika, Moscow, 1961), pp. 208-209.
30. For example, B. Palkin, "A scientist's time," *Izvestiya*, 7 August 1975, p. 2.
31. M. A. Yudelevich, in *Puti povysheniya effektivnosti nauchnogo truda; materialy k nauchno-prakticheskoy konferentsii*, N. A. Chinakal *et al.*, Eds. (Institut gornogo dela Sibirskogo otdeleniya AN SSSR, Novosibirsk, 1966), part I, p. 81.
32. "Improving the organization of labor of the professorial and instructor staff of VUZy," Decree No. 805, U.S.S.R. Ministry of Higher and Specialized Secondary Education U.S.S.R., 1 August 1977; *Byulleten' Ministerstva vysshego i srednego spetsial'nogo obrazovaniya SSSR No. 9* (September 1977), pp. 4-5.
33. R. Campbell, *Reference Source on U.S.S.R. R & D Statistics* (National Science Foundation, Washington, D.C., 1976), p. 46. Campbell has since adopted a proportion of 15.2 percent, based on the NSF estimates of the full-time R & D equivalents of U.S. college teachers [R. W. Campbell, *Reference Source on Soviet R & D Statistics 1950-1978* (National Science Foundation, Washington, D.C., in press)]. The proportion of 25 percent is retained here as a compromise between Campbell's new estimate and the somewhat higher Soviet estimates.
34. This lower proportion is also more in accord with the estimate that the VUZy account for only about 5 to 6 percent of total R & D expenditure in the Soviet Union [L. E. Nolting (*10*), p. 44].
35. See V. N. Shostakovskiy, in *Nauchno-tekhnicheskaya revolyutsiya i stroitel'stvo kommunizma*, N. P. Federenko *et al.*, Eds. (Mysl', Moscow, 1976), p. 335; V. M. Petrov, in *Voprosy teorii i praktiki upravleniya i organizatsii nauki*, D. M. Gvishiani, S. R. Mikulinskiy, S. A. Kugel', Eds. (Nauka, Moscow, 1975), p. 266.
36. Tsentral'noye statisticheskoye upravleniye pri Sovete Ministrov SSSR, *Nar. Khoz.* 77, 495 (1978); Heads of Departments of Social Sciences, *Vestn. Vyssh. Shk.* **12**, 18 (1976); V. Ye. Mikhaylichenko, in *Voprosy teorii i praktiki upravleniya i organizatsii nauki*, D. M. Gvishiani, S. R. Mikulinskiy, S. A. Kugel', Eds. (Nauka, Moscow, 1975), p. 277; V. I. Krutov, *Vestn. Vyssh. Shk.* **4**, 37 (1974); V. M. Petrov, *VUZy i nauchno-tekhnicheskiy progress* (Vysshaya shkola, Moscow, 1973), p. 48.
37. L. A. Kostin, *Plan. Khoz.* **11**, 8 (1974).
38. There may be other reasons for the spurt in the number of scientific workers in this subcategory, inasmuch as the "other institutions and organizations" included with administrative staffs have not been identified.
39. "Nomenclature of specialties of scientific workers," decree No. 801, Ministry of Higher and Specialized Secondary Education, U.S.S.R., 27 July 1977.
40. *Byulleten' Ministerstva vysshego i srednego spetsial'nogo obrazovaniya SSSR No. 9* (September 1977).
41. The U.S.S.R. has not published these distributions by field of science since 1974.
42. More detailed breakdowns of scientific workers by branch of science are rarely published. In 1971, workers in mathematics comprised 3.5 percent of all scientific workers and about 30 percent in physics and mathematics combined [S. R. Mikulinskiy, *Kommunist* **5**, 80 (1973)].
43. See L. S. Glyazer, *Izv. AN SSSR, Ser. ekon.* **4**, 68 (1974).
44. B. M. Remennikov, *Vysshaya shkola v sisteme vosproizvodstva rabochey sily v SSSR* (Vysshaya shkola, Moscow, 1973), p. 155. Although the assumption in this article is that the "other branches" of science are entirely or primarily military in nature, additional possibilities cannot be ruled out. The residual may also include scientific workers whose work or specialties span more than one branch of science. One Soviet commentator refers to the absence of "rigid boundaries" and mentions a "broad spectrum of interdisciplinary research" [S. R. Mikulinskiy *et al.*, *Podgotovka*, p. 34 (1976)].
45. The concentration of physical and life scientists is presumably even higher in the entire academy system than in the U.S.S.R. Academy alone, inasmuch as a large number of scientists in medicine and agriculture are employed in the specialized branch academies and few in the U.S.S.R. Academy.
46. Calculated by the authors.
47. D. W. Bronson, in *Soviet Economic Prospects for the Seventies*, U.S. Congress, Joint Economic Committee (Government Printing Office, Washington, D.C., 1973), p. 577. The ratio for the U.S.S.R. is derived from the adjusted number of scientific workers to the adjusted number of persons employed in science and science services given in this source.
48. The ratio of technicians to scientific workers, however, has generally been lower in the U.S.S.R. than in the West [P. N. Zavlin, A. I. Shcherbakov, M. A. Yudelevich, *Trud v sfere nauki* (Nauka, Novosibirsk, 1971), pp. 303-304], attesting to a relatively excessive use of other type of support personnel, unskilled labor and management in scientific organizations.
49. As noted earlier, 1974 is the last year for which the Soviets have published an employment distribution by branch of science.
50. See National Science Foundation, *Manpower Resources for Scientific Activities at Universities and Colleges, January 1977: Detailed Statistical Tables, Appendix B*, NSF 77-321 (Government Printing Office, Washington, D.C., 1977), pp. 57-58.
51. This estimate is based on information supplied by J. R. Chinichiello of NSF.