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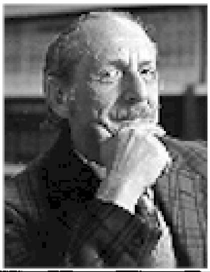

Current Comments®

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The Russians Are Coming! Part 2. The Top 50 Soviet Papers Most Cited in the 1973-1988 *Science Citation Index* and a Look at 1988 Research Fronts

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In Part 1 of this essay, we identified the most-cited authors from the USSR in the 1973-1988 ISI® *Science Indicators* database. Their institutional affiliations and membership in the USSR Academy of Sciences were discussed. In Part 2 we identify the 50 most-cited papers, high impact research centers, journals, and research fronts. As expected, physics dominates the list of most-cited papers. The highest impact Soviet papers were overwhelmingly published in Western journals, and in English. Research-front data indicate Soviet research specialization in crystal studies, applied chemistry, and heart research.

Fifty *Citation Classics* from the USSR: Physics Dominates

Table 1 lists the 50 papers by Soviet scientists that were most cited in the ISI® *Science Indicators* file. (Most of the papers identified may be regarded as classics, since most exceed a threshold of 200 citations.) This file, which covers 4.5 million cited papers published between 1973 and 1988, is a subset of ISI's entire *Science Citation Index*® (*SCI*®) database. The papers identified in the file were cited at least once. Nearly 3,830,000 papers of the 8,000,000 articles indexed in the *SCI* files during the same 15-year period were never cited.

Of these 50 papers, 28 concern physics-related topics. These include research on elementary particles, superconductivity, the electrical conductivity of solids, and low-temperature physics. Fifteen papers are in the life sciences and include studies of the structure, conformation, and activity of protein molecules, chromatin, bacteriorhodopsin, and aminoacyl-tRNA. Other life-sciences papers examine membrane transmission in red blood cells and electrical currents in mollusk neurons. Five chemistry papers are listed—on atomic absorption analysis and the use of nuclear magnetic resonance for the study of silicate structures and carbohydrate compounds. The remaining two papers are devoted to earth and space sciences.

In this small sample of high impact Soviet articles, not surprisingly physics predominates as it did in Part 1, where we examined the most-cited Soviet researchers in 1973-1988.[1] This is somewhat atypical because the life sciences tend to dominate undifferentiated lists of high impact publications and researchers ranked by total citations alone. The concentration in physics is borne out in larger samples of Soviet publications; for example, of the 892 Soviet papers cited 50 or more times in the 1973-1988 ISI *Science Indicators* database, 43 percent are in physics, 32 percent are in the biological sciences, and 19 percent are in chemistry. This is also shown in an even larger study of nearly 140,000 papers from ISI's databases from 1981 through 1985 in a world scientometric study by A. Schubert and W. Glänzel, Information Science and Scientometrics Research Unit, Library of the Hungarian Academy of Sciences, Budapest, and Tibor Braun, Institute of Inorganic and Analytical Chemistry, L. Eötvös University, Budapest.[2] Pie graphs of the subject distribution of Soviet papers in both studies are shown in Figure 1.

Table 1: The 50 most-cited Soviet papers from the 1973-1988 ISI® *Science Indicators* file. A = total citations. B = bibliographic data. *Academicians are indicated with an asterisk (*); corresponding members with a dagger (†).*

A	B
839	**Shifman M A, Vainshtein A I & Zakharov V I.** QCD and resonance physics: theoretical foundations. *Nucl. Phys. B* 147:385-447, 1979.
730	**Shakura N I & †Sunyaev R A.** Black holes in binary systems: observational appearance. *Astron. Astrophys.* 24:337-55, 1973.
682	**†Polyakov A M.** Particle spectrum in quantum field theory. *JETP Lett.—Engl. Tr.* 20:194-5, 1974.
677	**†Polyakov A M.** Quantum geometry of bosonic strings. *Phys. Lett. B* 103:207-10, 1981.
615	**Shifman M A, Vainshtein A I & Zakharov V I.** QCD and resonance physics: applications. *Nucl. Phys. B* 147:448-518, 1979.
533	**†Chirikov B V.** Universal instability of many-dimensional oscillator systems. *Phys. Rep.—Rev. Sect. Phys. Lett.* 52:263-379, 1979.
503	**Linde A D.** A new inflationary universe scenario: a possible solution of the horizon, flatness, homogeneity, isotropy and primordial monopole problems. *Phys. Lett. B* 108:389-93, 1982.
437	**†Polyakov A M.** Quark confinement and topology of gauge theories. *Nucl. Phys. B* 120:429-58, 1977.
417	**Belavin A A, †Polyakov A M & Zamolodchikov A B.** Infinite conformal symmetry in two-dimensional quantum field theory. *Nucl. Phys. B* 241:333-80, 1984.
399	**Altshuler B L, Aronov A G & Lee P A.** Interaction effects in disordered Fermi systems in two dimensions. *Phys. Rev. Lett.* 44:1288-91, 1980.
394	**Matveev V A, Muradyan R M & †Tavkhelidze A N.** Automodellism in the large-angle elastic scattering and structure of hadrons. *Lett. Nuovo Cimento* 7:719-23, 1973.
377	**†Polyakov A M.** Interaction of Goldstone particles in two dimensions: applications to ferromagnets and massive Yang-Mills fields. *Phys. Lett. B* 59:79-81, 1975.
369	**†Privalov P L.** Thermodynamic approach to problem of stabilization of globular protein structure: calorimetric study. *J. Mol. Biol.* 86:665-84, 1974.
366	**Gerr R G, Yanovsky A I & Struchkov Y T.** Perfection of the system of crystallographic programs in the laboratory of X-ray structure: analysis of the A.N. Nesmeyanov Institute of Organoelemental Compounds of the USSR Academy of Sciences. *Kristallografiya SSSR* 28:1029-30, 1983.
359	**Altshuler B L, Khmelnitzkii D, †Larkin A I & Lee P A.** Magneto-resistance and Hall effect in a disordered two-dimensional electron gas. *Phys. Rev. B—Condensed Matter* 22:5142-53, 1980.
337	**Varshavsky A J, Bakayev V V & †Georgiev G P.** Heterogeneity of chromatin subunits *in vitro* and location of histone H1. *Nucl. Acid. Res.* 3:477-92, 1976.
336	**†Polyakov A M.** Compact gauge fields and infrared catastrophe. *Phys. Lett. B* 59:82-4, 1975.
331	**Linde A D.** Phase transitions in gauge theories and cosmology. *Rep. Progr. Phys.* 42:389-437, 1979.
324	***Ovchinnikov Y A, Abdulaev N G, Feigina M Y, Kiselev A V & Lobanov N A.** Structural basis of the functioning of bacteriorhodopsin: overview. *FEBS Lett.* 100:219-24, 1979.
304	**Ivanov V I, Minchenkova L E, Schyolkina A K & Poletayev A I.** Different conformations of double-stranded nucleic acid in solution as revealed by circular dichroism. *Biopolymers* 12:89-110, 1973.
300	**†Polyakov A M.** Quantum geometry of fermionic strings. *Phys. Lett. B* 103:211-3, 1981.
296	**Novikov V A, †Okun L B, Shifman M A, Vainshtein A I, Voloshin M B & Zakharov V I.** Charmonium and gluons. *Phys. Rep.—Rev. Sect. Phys. Lett.* 41:1-133, 1978.
293	**Lvov B V.** Electrothermal atomization: way toward absolute methods of atomic-absorption analysis. *Spectrochim. Acta Pt. B—At. Spec.* 33:153-93, 1978.
292	***Kostyuk P G, †Krishtal O A & Shakhovalov Y A.** Separation of sodium and calcium currents in somatic membrane of mollusk neurons. *J. Physiol.—London* 270:545-68, 1977.
280	**Lippmaa E, Magi M, Samoson A, Engelhardt G & Grimmer A-R.** Structural studies of silicates by solid-state high-resolution SI^{29} NMR. *J. Amer. Chem. Soc.* 102:4889-93, 1980.
279	**Yagubskii E B, Shchegolev I F, Laukhin V N, Kononovich P A, Karatsovnik M V, Zvarykina A V & Buravov L I.** Normal-pressure superconductivity in an organic metal $(BEDT\text{-}TTF)_2I_3$ [bis(ethylene dithiolo) tetrathiofulvalene triiodide]. *JETP Lett.—Engl. Tr.* 39:12-6, 1984.
271	***Migdal A B.** Pion fields in nuclear matter. *Rev. Mod. Phys.* 50:107-72, 1978.
269	**Shifman M A, Vainshtein A I & Zakharov V I.** QCD and resonance physics: RHO-omega mixing. *Nucl. Phys. B* 147:519-34, 1979.
264	**Sun S S, Nesbitt R W & Sharaskin A Y.** Geochemical characteristics of mid-ocean ridge basalts. *Earth Planet. Sci. Lett.* 44:119-38, 1979.
256	**Serbinenko F A.** Balloon catheterization and occlusion of major cerebral vessels. *J. Neurosurg.* 41:125-45, 1974.
252	**Shuryak E V.** Quantum chromodynamics and the theory of superdense matter. *Phys. Rep.—Rev. Sect. Phys. Lett.* 61:71-158, 1980.

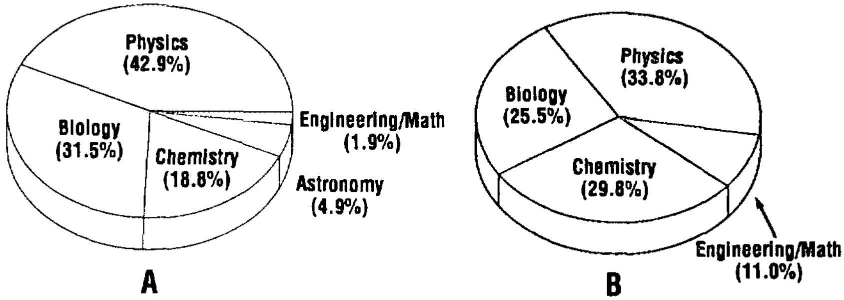
A	B
249	**Burstein E A, Vedenkina N S & Ivkova M N.** Fluorescence and the location of tryptophan residues in protein molecules. *Photochem. Photobiol.* 18:263-79, 1973.
247	**Vaskovsky V E, Kostetsky E Y & Vasendin I M.** Universal reagent for phospholipid analysis. *J. Chromatogr.* 114:129-41, 1975.
246	**Lubimov V A, Novikov E G, Nozik V Z, Tretyakov E F & Kosik V S.** An estimate of the upsilon-E mass from the beta-spectrum of tritium in the valine molecule. *Phys. Lett. B* 94:266-8, 1980.
246	**Rubakov V A.** Adler-Bell-Jackiw anomaly and fermion number breaking in the presence of a magnetic monopole. *Nucl. Phys. B* 203:311-48, 1982.
236	**Lim V I.** Algorithms for prediction of alpha-helical and beta-structural regions in globular proteins. *J. Mol. Biol.* 88:873-94, 1974.
235	**Shifman M A, Vainshtein A I & Zakharov V I.** Asymptotic freedom, light quarks and origin of $\delta t = \frac{1}{2}$ rule in non-leptonic decays of strange particles. *Nucl. Phys. B* 120:316-24, 1977.
228	**Starobinsky A A.** Dynamics of phase transition in the new inflationary universe scenario and generation of perturbations. *Phys. Lett. B* 117:175-8, 1982.
226	**Kukhtarev N V, Markov V B, Odulov S G, Soskin M S & Vinetskii V L.** Holographic storage in electrooptic crystals. 1. Steady-state. *Ferroelectrics* 22:949-60, 1979.
225	**Fesenko E E, Kolesnikov S S & Lyubarsky A L.** Induction by cyclic GMP of cationic conductance in plasma membrane of retinal rod outer segment. *Nature* 313:310-3, 1985.
221	**Friedenstein A J, Chailakhyan R K, Latsinik N V, Panasyuk A F & Keiliss-Borok I V.** Stromal cells responsible for transferring the microenvironment of hematopoietic tissue: cloning *in vitro* and retransplantation *in vivo*. *Transplantation* 17:331-40, 1974.
214	**Atiyah M F, Hitchin N J, Drinfeld V G & Manin Y I.** Construction of instantons. *Phys. Lett. A* 65:185-7, 1978.
211	**Abelev G I.** Alpha-fetoprotein as a marker of embryospecific differentiations in normal and tumor tissues. *Transplant. Rev.* 20:3-37, 1974.
205	**Postnov Y V, Orlov S N, Shevchenko A & Adler A M.** Altered sodium permeability, calcium-binding and Na-K-ATPase activity in red blood cell membrane in essential hypertension. *Pflügers Arch.—Eur. J. Physiol.* 371:263-9, 1977.
204	***Kostyuk P G & †Krishtal O A.** Effects of calcium and calcium-chelating agents on inward and outward current in membrane of mollusk neurons. *J. Physiol.—London* 270:569-80, 1977.
201	**Bogomolnyi E B.** Stability of classical solutions. *Sov. J. Nucl. Phys.—Engl. Tr.* 24:449-54, 1976.
201	**Efros A L & Shklovskii B I.** Coulomb gap and low-temperature conductivity of disordered systems. *J. Phys. C—Solid State Phys.* 8:L49-51, 1975.
201	**Kisselev L L.** Aminoacyl-tRNA synthetases: some recent results and achievements. *Advan. Enzymol. Relat. Areas Mol.* 40:141-238, 1974.
198	**†Polyakov A M.** String representations and hidden symmetries for gauge fields. *Phys. Lett. B* 82:247-50,1979.
193	**Shashkov A S & Chizhov O S.** C^{13} NMR spectroscopy in chemistry of carbohydrates and related compounds. *Bioorg. Khim.* 2:437-97, 1976.

Besides a breakdown by subject area of papers from various countries, the Schubert *et al.* study also examined their impact, or the average number of citations per paper in specific fields. In terms of publication output, the USSR ranks second to the US in both the physical sciences and chemistry. But the USSR ranks sixth in terms of impact of its physical-sciences publications after the US, the Federal Republic of Germany (FRG), the UK, Japan, and France. In chemistry, the USSR ranks seventh in impact after the US, Japan, the FRG, the UK, France, and Canada. The USSR also ranks 7th in the world in terms of life-sciences publications, and their impact puts the USSR in 16th position—trailing the US, the UK, the FRG, Japan, Canada, France, Australia, Sweden, Italy, The Netherlands, Switzerland, Denmark, Belgium, Finland, and Norway.[2]

Top 10 Papers: Particle Physics, Astronomy/Astrophysics

All of the 10 most-cited papers are in physics or astrophysics. Six deal with particle physics and, in particular, the topic of quantum chromodynamics (QCD). This field of research seeks to explain why quarks (regarded as the fundamental constituents of matter) combine to form the observed patterns of elementary particles, such as the proton and meson. The strong interactions between quarks are fundamental as to how atomic nuclei bind together. The QCD

Figure 1: Distribution of main areas of Soviet research. Data in graph A are derived from 892 highly cited Soviet papers from ISI®'s *Science Indicators* file, 1973-1988. Data in graph B are from **Schubert A, Glänzel W & Braun T.** Scientometric datafiles. A comprehensive set of indicators on 2649 journals and 96 countries in all major science fields and subfields 1981-1985. *Scientometrics* 16:3-478, 1989.



theory is particularly attractive to researchers because the mathematics involved is nearly identical to that employed in quantum electrodynamics (QED) and to the unifed theory of weak and electromagnetic interactions. Particle physicists hope that the mathematical similarities between these theories may be an indication that a "unified field theory" may be close to being realized. Subfields of interest in QCD include gauge theories, Yang-Mills fields, "color," and asymptotic freedom.[3]

Three of the QCD papers in Table 1—the most-cited "QCD and resonance physics: theoretical foundations," the fifth most-cited "QCD and resonance physics: applications," and "QCD and resonance physics: RHO-omega mixing"—are authored by a trio of scientists from the Theoretical and Experimental Physics Institute, Moscow: M.A. Shifman, A.I. Vainshtein, and V.I. Zakharov. All three physicists rank in the four most-cited Soviet scientists for the 1973-1988 period.

Four QCD papers are authored by academy corresponding member Aleksander M. Polyakov, then at the Chemical Physics Institute, Moscow, and now at the L.D. Landau Theoretical Physics Institute, Moscow. In all, Polyakov has 8 papers among the 50 most-cited papers in Table 1. Polyakov is followed in productivity by Shifman, Vainshtein, and Zakharov, with five; and by mathematician B.L. Altshuler, B.P. Konstantinov Nuclear Physics Institute, Leningrad; physicist A.D. Linde, P.N. Lebedev Physics Institute, Moscow; and P.G. Kostyuk and O.A. Krishtal, A.A Bogomolets Physiology Institute, Kiev, each with two.

The second-ranked paper, "Black holes in binary systems: observational appearance," is by N.I. Shakura, Shternberg Astronomy Institute, Moscow, and corresponding member Rashid A. Sunyaev, then at the Institute of Applied Mathematics, Moscow, and now at the Space Research Institute, Moscow. Black holes are believed to be the aftermath of collapsed stars, where the gravitational forces are so great that even light itself cannot escape. The paper draws attention to the notion that, in binary star systems, the outflow of matter from a visible star to its collapsed companion should lead to an appreciable observational effect and would aid in identifying a black hole.

Another astrophysics paper, ranked seventh in Table 1, authored by Linde, is entitled "A new inflationary universe scenario: a possible solution of the horizon, flatness, homogeneity, isotropy and primordial monopole problems." Cosmologists debate whether the universe periodically expands and contracts, or expands on forever. Linde's paper puts forward a new scenario for a continually expanding universe, which is free of the shortcomings of the previous version of the theory and provides possible solutions to some of the inherent problems the theory previously had. The paper also provides a possible answer to the magnetic monopole problem in the early universe, which is a central aspect to grand unified theories. By the way, Linde, Shakura, and

Table 2: Soviet institutions associated with the authors of the 50 most-cited papers published from 1973 to 1988 from ISI®'s *Science Indicators* file.

Institution	Number of Papers
ACADEMY OF SCIENCES OF THE USSR	
Leningrad	
B.P. Konstantinov Nuclear Physics Institute	2
A.F. Ioffe Physical Technical Institute	1
M.I. Kalinin Polytechnic Institute	1
Moscow	
L.D. Landau Theoretical Physics Institute	11
Molecular Biology Institute	3
P.N. Lebedev Physics Institute	2
Nuclear Research Institute	2
Institute of Chemical Physics	1
A.N. Nesmeyanov Institute of Organoelemental Compounds	1
M.M. Shemyakin Bioorganic Chemistry Institute	1
Shternberg Astronomy Institute	1
N.D. Zelinskii Organic Chemistry Institute	1
V.A. Steklov Mathematics Institute	1
V.I. Vernadskii Geochemistry and Analytical Chemistry Institute	1
Novosibirsk	
Nuclear Physics Institute	2
Pushchino-on-Oka	
Biological Physics Institute	2
Protein Research Institute	2
Vladivostok	
Marine Biology Institute	1
ACADEMY OF SCIENCES EsSSR	
Tallin	
Cybernetics Institute	1
ACADEMY OF SCIENCES UkSSR	
Kiev	
A.A. Bogomolets Physiology Institute	2
Physics Institute	1
ACADEMY OF MEDICAL SCIENCES USSR	
Moscow	
Central Research Laboratory, Ministry of Public Health	1
N.N. Burdenko Neurosurgery Institute	1
N.F. Gamaleya Epidemiological and Microbiological Institute	2
AFFILIATED RESEARCH ORGANIZATIONS, COUNCIL OF MINISTERS ORGANIZATIONS	
Moscow	
Theoretical and Experimental Physics Institute	6

Sunyaev all appeared in Part 1's listing of most-cited Soviet scientists.

The sixth most-cited paper, "Universal instability of many-dimensional oscillator systems," is by B.V. Chirikov, Novosibirsk Nuclear Physics Institute. The article examines the mechanism for a common instability in oscillating systems—the Arnold diffusion—via an experiment with a swinging pendulum that undergoes periodic perturbations. The instability results in a random motion of the system as if the system itself were influenced by a random perturbation, even though the pendulum's motion is governed by purely dynamic equations.

The 10th most-cited paper, "Interaction effects in disordered Fermi systems in two dimensions," is by Altshuler and A.G. Aronov, also of the B.P. Konstantinov Nuclear Physics Institute, and the American P.A. Lee, Bell Laboratories, Murray Hill, New Jersey. The article discusses interaction effects in disordered Fermi systems. Of interest to physicists is the behavior and voltage strength of electrical currents that are generated when metal foil and semiconductor surfaces are influenced by magnetic fields. The paper quantizes the characteristics of a Fermi system—electronic density of states, specific heat, and electrical conductivity.

High Impact Research Centers

Table 2 identifies 25 institutions that are among those listed for the 50 most-cited papers from the USSR. The USSR Academy of Sciences is represented by 18 institutes and accounts for 36 papers (72 percent of the total). A nonacademy research institution, the Theoretical and Experimental Physics Institute, appears with six papers. Three papers listed authors from two institutes of the Ukranian Union Republic Academy, while the Estonian Union Republic Academy contributed one paper. Three institutes of the Academy of Medical Sciences account for 4 papers. Nearly all of the institutions in Table 2 are in the Moscow-Leningrad area.

A study of the 10 highest impact Russian research centers appeared recently in *The Scientist*®,[4] and the data are reprinted here in Table 3. The list is based on institutional affiliations from all 180,000 cited Soviet publications in the 1973-1988 ISI *Science Indicators* file. Given the data presented in this essay, it is not surprising that institutes

Table 3: High impact Soviet institutions. Data are from ISI®'s *Science Indicators* file, 1973-1988. Institution citation impact is calculated by dividing number of citations to the institute's papers, *SCI*® 1973-1988, by the total number of the institute's cited papers. All institutes are in Moscow unless otherwise noted.

Rank	Institute	Number of Papers	Number of Citations	Citation Impact
1.	L.D. Landau Theoretical Physics Institute	1,254	19,896	15.86
2.	Theoretical and Experimental Physics Institute	1,001	13,324	13.31
3.	M.M. Shemyakin Bioorganic Chemistry Institute	1,203	10,490	8.71
4.	P.N. Lebedev Physics Institute	4,615	32,742	7.09
5.	I.V. Kurchatov Institute of Atomic Energy	1,812	11,246	6.20
6.	N.D. Zelinskii Organic Chemistry Institute	1,408	8,647	6.14
7.	Joint Institute for Nuclear Research (Dubna)	2,729	16,702	6.12
8.	A.F. Ioffe Physical Technical Institute (Leningrad)	5,539	28,153	5.08
9.	M.V. Lomonosov State University	16,952	82,080	4.84
10.	L.Y. Karpov Physicochemical Research Institute	2,165	9,964	4.60

for physics and nuclear research dominate. The highest impact Soviet research institute on *The Scientist* list—the L.D. Landau Theoretical Physics Institute (15.86)—is also first in terms of the number of articles in this study. Five other institutes appear on both lists: the M.M. Shemyakin Bioorganic Chemistry Institute, Moscow; the P.N. Lebedev Physics Institute; the N.D. Zelinskii Organic Chemistry Institute, Moscow; the Theoretical and Experimental Physics Institute; and the A.F. Ioffe Physical Technical Institute, Leningrad.

Soviet Scientific Publications: Coming out of the Russian-Language Cold

Table 4 lists 32 journals that published the 50 most-cited USSR papers. Only two are Soviet journals. Twelve are from the US, eight each are from the UK and The Netherlands, and one each from Italy and Denmark. Forty-eight of the 50 most-cited USSR articles are in English.

In fact, of the 239 journals that published Soviet research in the 1973-1988 ISI *Science Indicators* database, Russian-language journals account for only 18 percent of the papers. The remaining 82 percent appear in Western publications and/or in English translation. During her stay at ISI, visiting information scientist Valentina A. Markusova, chief, Information Department, Far-East Branch of the USSR Academy of Sciences All-Union Institute for Scientific and Technical Information, Moscow, posited two explanations for this. First, publishing one's paper in English immediately brings the work a broad international audience. Also, the time lag between submitting and publishing a paper in the West is much shorter than in the USSR, where it could typically take up to two-and-a-half years for a paper to appear after submission. In the US the lag generally was from 8 to 18 months 10 years ago.[5] Presumably this is shorter today due to technological improvements in publishing.

Fourteen physics journals in Table 4 account for 30 of the papers. Twelve life-sciences journals are listed, including such diverse areas as molecular biology, biopolymers, physiology, neurosurgery, and immunology. But only one is a Soviet life-sciences journal, *Bioorganicheskaya Khimiya*.

Perhaps in recognition of the USSR's lag in domestic publication of high impact life-sciences research, a new monthly, English-language journal of Soviet research, entitled *Biomedical Science*, was launched. It is a joint venture between the USSR Academy of Sciences, the British Royal Society of Chemistry, and the UK scientific publisher Pion.[6]

Soviet Research-Front Data—Emphasis on Crystal Studies, Applied Chemistry, and Heart Research

In contrast to the 15 years of data used above, Table 5 lists 59 1988 *SCI* and *Social Sciences Citation Index*® research fronts in which Soviet research represents at least 55 percent of all current citing papers. These

Table 4: Journals publishing most-cited papers by the Soviet researchers from Table 1. A = title of journal. B = number of highly cited papers from Table 1 published in the journal. C = 1988 impact factor.

A	B	C
Phys. Lett. B	8	3.51
Nucl. Phys. B	7	6.11
Phys. Rep.—Rev. Sect. Phys. Lett.	3	8.23
JETP Lett.—Engl. Tr.	2	1.50
J. Mol. Biol.	2	6.55
J. Physiol.—London	2	3.90
Advan. Enzymol. Relat. Areas Mol.	1	8.77
Astron. Astrophys.	1	1.96
Bioorg. Khim.	1	1.05
Biopolymers	1	2.11
Earth Planet. Sci. Lett.	1	2.78
FEBS Lett.	1	3.56
Ferroelectrics	1	1.62
J. Amer. Chem. Soc.	1	4.56
J. Chromatogr.	1	1.41
J. Neurosurg.	1	2.16
J. Phys. C—Solid State Phys.	1	1.97
Kristallografiya SSSR	1	0.46
Lett. Nuovo Cimento	1	—
Nature	1	15.75
Nucl. Acid. Res.	1	—
Pflügers Arch.—Eur. J. Physiol.	1	3.15
Photochem. Photobiol.	1	2.13
Phys. Lett. A	1	1.36
Phys. Rev. B—Condensed Matter	1	1.36
Phys. Rev. Lett.	1	8.21
Rep. Progr. Phys.	1	3.66
Rev. Mod. Phys.	1	15.12
Sov. J. Nucl. Phys.—Engl. Tr.	1	0.59
Spectrochim. Acta Pt. B—At. Spec.	1	3.46
Transplantation	1	2.98
Transplant. Rev. (now Immunol. Rev.)	1	9.67

fronts are only a fraction of the 8,177 in ISI's 1988 research-front database. A research front (specialty) is formed by the connections made by scientists in their referencing patterns. When this method, called co-citation clustering, is applied, the scientific literature orders itself into bibliographically distinct and intellectually coherent units. Articles that are frequently cited together by current papers constitute the "core" of the specialty. The citing articles comprise the research front, which is named from phrases co-occurring in these citing titles.

Soviet papers make up 4 percent of all the papers in ISI's research-front database for 1988. In the specialties in Table 5, at least 55 percent of all citing papers are from the USSR and can therefore be considered areas in which Soviet scientists are particularly *active*.

Topics in physics (20 research fronts) and materials science (13) dominate Table 5. The major subjects relating to these research specialties are 11 research fronts on the magnetic, electric, and optical properties of different classes of crystals (#88-0316, #88-5765, #88-7022, #88-7724, #88-7973, #88-0576, #88-7011, #88-2777, #88-1011, #88-0021, and #88-4324).

There are 11 research fronts associated with applied chemistry, where in 7 fronts the major activity appears to be on molecular structures and the function of various materials in solution, with special emphasis on cadmium complexes (#88-2955, #88-3877, #88-5102, #88-7030, #88-7971, #88-2871, and #88-5783).

The life-sciences and medical specialties are represented in 11 research fronts, in 4 of which the emphasis is on cardiovascular disease (#88-6021, #88-7441, #88-1140, and #88-5275).

Other scientific fields represented are geology (#88-6985, "Geochemical features and rare metal granites of Ukraine shield"); psychology (#88-7142, "Thinking motivation and psychological help"); and genetics research on fruit flies (#88-6977, "*Drosophila melanogaster* population and level of genetic variability") and trout (#88-0739, "Genetic differentiation, salmonid fish and stabilized selection").

A research front that is identified here as largely Soviet may well be represented in another and separate specialty that amounts to the Western version of research on the same topic. It should be noted that, in 45 of the fronts, all of the core papers are by USSR authors. Only three research fronts have a 50 percent or less Soviet representation in the core—#88-7425, "Superoxide dismutase activity, rat myocardium, and antioxidant system" (50 percent); #88-1579, "Multiphoton excitation of SF_6 molecules and CO_2 laser radiation" (50 percent); and #88-1008, "Vertical Bloch line, domain wall dynamics, and uniaxially anisotropic rare earth ferrite garnet films" (46 percent). Only one research front—#88-6871, "Low flying quadrupole vibrations of superfluid nuclei and cross section for inverse beta decay"—has no Soviet-authored core papers.

Personal Commentaries on Soviet *Citation Classics*

To date 18 Soviet scientists have provided us with personal commentaries on their highly cited works. The publications discussed in the *Citation Classic*® commentaries are, for the most part, of an older vintage than those identified in this study, so most of the *Citation Classic* authors do not appear in the top Soviet authors listing discussed in Part 1. The exceptions are the following academicians: physicist Vitalii I. Goldanskii, Chemical Physics Institute,[7,8] and molecular biologist Aleksander S. Spirin, Institute of Protein Research, Pushchino-on-Oka.[9]

We do not have the space here to highlight specific commentaries, but one can say that of the 18 Soviets who have written *Citation Classic* commentaries, 8 are academy members. Besides the aforementioned Goldanskii and Spirin, these include the following academicians: theoretical physicist Alexei A. Abrikosov, L.D. Landau Theoretical Physics Institute;[10] oceanographer Leonid M. Brekhovskikh, Institute of Oceanology, Moscow;[11] and molecular biologist Georgi P. Georgiev, V.A. Engelhardt Molecular Biology Institute, Moscow.[12] Corresponding members include immunobiologist Gary I. Abelev, Laboratory of Immunochemistry, Cancer Research Center, Moscow,[13] and physical chemist Boris V. Derjaguin, Department of Surface Phenomena, Physical Chemistry Institute, Moscow.[14] Speaking of Abelev, his most-cited paper in Table 1 is on the same topic as his *Citation Classic*—alpha-fetoprotein and its relationship to tumors.

While we are on the subject of *Citation Classics*, I encourage Soviet scientists to write us to nominate authors of highly cited papers (please include up-to-date addresses). If appropriate, we will contact authors directly and invite their commentaries.

Will *Perestroika* and *Glasnost* Improve Soviet Science?

This survey of Soviet science has identified the highest impact people, institutes, publications, and research specialties in the USSR. A consistent finding is that physics is "king" of Soviet science. In comparison,

Table 5: The 1988 *SCI*® /*SSCI*® research fronts in which Soviet scientists predominate. A = research-front number. B = research-front name. C = percent of 1988 citing papers published by Soviet researchers. D = number of citing papers. E = number of core papers.

A	B	C	D	E
88-0316	Polarization of waves and gyrotropic cubic photorefractive crystals	100.0	31	3
88-1517	Quasi-classical trajectory coherent states of relativistic spinless particle and periodic magnetic field	100.0	33	4
88-2208	Low-frequency waves, magnetized plasma, and coherent anomalous parametric reflection	100.0	28	3
88-2249	Rare earth ortho ferrites, spin reorientation, and metamagnetic phase transitions	100.0	30	2
88-2360	Electron paramagnetic-res spectra, copper porphyrins, and kinetic stability of tetraphenyl porphine complexes	100.0	30	3
88-2570	Interhemispheric asymmetry and visual recognition in rats	100.0	22	3
88-2643	Magnetically mixed semiconductors, exchange interaction, and band states	100.0	27	2
88-2851	Navier-Stokes equations and nonlinear Schrödinger model	100.0	22	3
88-2955	Cadmium acetate complexes in aqueous solutions and Ni trilotrimethylenephosphonic acid	100.0	30	4
88-3877	Molecular structure of para-tolyldimethylphosphine sulfide $P\text{-}CH_3C_6H_4P(S)\ (CH_3)_2$	100.0	15	2
88-4985	Water transport, electrolyte aqueous solutions, and acetyl cellulose membranes	100.0	26	3
88-5102	Pyridine salts, chemi-luminescent oxidation, and extraction system tin (II)-aqueous solution	100.0	26	3
88-5765	Magnetic semiconductors and crystal structure of germanide $Sc_3Ni_{11}Ge_4$	100.0	19	2
88-6021	Malignant arterial hypertension	100.0	33	3
88-6726	Fine grain magnesium alloy during hot deformation and low-temperature superplasticity of metallic materials	100.0	19	2

A	B	C	D	E
88-6865	Disordered alloys, short range order, and indirect interaction	100.0	31	3
88-6936	Intensity fluctuations, wave scattering, turbulent atmosphere, and deep-sea drilling data	100.0	49	3
88-6977	*Drosophila melanogaster* population and level of genetic variability	100.0	15	2
88-6985	Geochemical features and rare metal granites of Ukraine shield	100.0	28	4
88-7022	Orbital ordering crystals and transitional metals pressure	100.0	17	2
88-7030	Polyethylene glycol glycerol water system and copolymers of acrylamide	100.0	26	4
88-7179	Stochastic dynamics, quantum chaos, and nonlinear charge density waves	100.0	29	2
88-7441	Chronic heart failure and postinfarction cardiosclerosis	100.0	26	3
88-7724	Photorefractive crystals, light modulators, and dynamic self-diffraction	100.0	36	2
88-7772	Pharmacological activity and anti-inflammatory action of Voltaren	100.0	16	2
88-7971	Zinc extraction, thiourea cadmium complexes in aqueous solutions, and $La_2Ti_2O_7$ (perovskitelike structure)	100.0	18	2
88-7973	Acoustically gyrotropic crystals and anisotropic collinear diffraction	100.0	31	3
88-7528	Amorphous films, electron transitions, negative magnetoresistance, and Hopping conduction	98.3	57	2
88-6568	Inverse problem for a parabolic equation and optimization of regularization methods	98.2	67	7
88-1337	Relaxational transitions and filled poly-flow birefringence	97.8	196	26
88-6580	Dipole interaction, easy plane anisotropy antiferromagnets, and paired spin green function for cubic ferromagnets	97.0	34	3
88-0576	Ferroelectric phase transitions in crystals, soft mode and heat capacity oscillations	96.8	27	5
88-7011	Crystal structure of $CaNiAl_9$ and copper(I) complexes in the butine-2-diol-1,4-CuX-KbR system	96.6	37	2
88-2368	Lipid bilayer, source of phospholipids, and endoplasmic reticulum membranes	96.5	23	2
88-2510	Anisotropic weight spaces and operator approximation of Fourier functions	96.0	37	4
88-0739	Genetic differentiation, salmonid fish, and stabilized selection	95.8	21	3
88-2777	Nematic liquid crystals, flexoelectric polarization, and dielectric mode of electrodynamic instability	95.8	22	2
88-2871	Molecular structure of calcium borohydride complex	95.6	19	2
88-1646	Bound surface waves, acoustic beams, and two-dimensional defect	95.4	21	3
88-8006	Fractal cluster light-scattering properties and percolation transitions in WO_3 electrochromium films	95.0	19	3
88-0418	Optical solitons, nonlinear Schrödinger equation, and fiber light guides	93.7	36	4
88-7142	Thinking motivation and psychological help	90.9	27	2
88-5707	Tautomerism of azine derivatives and P-III-N bond spallation	90.6	30	5
88-1140	Free-radical lipid peroxidation of the ischemic myocardium and microsomal oxidation	90.0	62	4
88-7425	Superoxide dismutase activity, rat myocardium, and antioxidant system	89.6	26	2
88-6871	Low flying quadrupole vibrations of superfluid nuclei and cross section for inverse beta decay	89.2	26	4
88-0266	Optical transitions in noncollinear antiferrodielectrics and dipole interaction	76.0	22	3
88-6960	Kolmogorov turbulence, local wind velocity spectra, and spatial variability	75.8	29	3
88-1008	Vertical Bloch line, domain wall dynamics, and uniaxially anisotropic rare earth ferrite garnet films	68.9	98	13
88-1011	Optical bistable ring cavity, instabilities in liquid crystals, heat bi-stability, and stationary spatial structures	68.0	220	29
88-5783	Thermodynamic systems, silicon dioxide, and methane oxidation	67.6	32	2
88-1579	Multiphoton excitation of SF_6 molecules and CO_2 laser radiation	64.5	21	2
88-5132	Monomolecular heterolysis, aromatic solvents, industrial organohalide compounds, and dehydrobromation of 7-alpha-bromocholesterol benzoate	64.1	92	11
88-5275	Heart rhythm disorders in acute myocardial infarction	62.1	41	4
88-0021	Multiphonon recombination via deep impurity centers and electron hole liquid in germanium	61.3	41	4
88-0417	Surface acoustic waves, laser irradiation, and growth dynamics of periodic structures	57.1	31	3
88-0819	Semilinear parabolic equations and viscous barotropic gas one-dimensional motion	56.8	35	4
88-4324	Plastic flow at high pressure, charged dislocations, and KCl crystals	55.2	31	5
88-6868	Interaction of influenza virus proteins and artificial phospholipid membranes	55.0	23	3

life-sciences research occupies a secondary position in terms of the number of publications and impact. A probable reason for this is the negative influence of academician Trofim D. Lysenko (1898-1976), who was supported by Stalin and Krushchev (Lysenko's pseudoscience held sway from the late 1930s until as late as the 1960s). As a result the agricultural and life sciences in the USSR suffered.

According to Soviet science historian Zhores A. Medvedev, National Institute for Medical Research, Mill Hill, London, UK, even though the influence of "Lysenkoism" has dissipated, the long-term effects of politicization are still with Soviet science:

> The improper teaching of biology in universities and in high schools had been standard for nearly 30 years. Today, this has changed. However, it is less Lysenkoism and more the political system under which Soviet science operates which is now the major factor in the lagging of their life-science research behind the West. For example, Soviet microbiology and genetics research has conducted world-quality work, but bureaucratic structures that are in place for acquiring experimental equipment, money, and capable university graduates trained in modern techniques are the hindrances.[15]

Secrecy is another problem that has plagued Soviet science and prevents Soviet scientists from reaping the benefits of scientific and technological advances. In a recent interview, academician Vsevolod Avduyevskiy, chairman, Soviet National Commission for the Promotion of Conversation, stated that pervasive secrecy has prevented people working in one section of industry from learning about the results of the research in another, thus slowing the incorporation of innovative technologies. Military-derived technology that could benefit the civilian production sector is not transferred because of security concerns. These technologies include the finishing of parts, welding, reinforcement of surfaces, the growing of crystals, as well as the use of flexible, automated production lines.[16]

This situation has lowered morale among Soviet scientists. Academician Roald Z. Sagdeev, former director, Space Research Institute, points out that, before *perestroika*, researchers in the military sector were pampered while scientists in civil research were ill-equipped and badly paid, with few chances for promotion or international recognition. But restructuring is making things worse, according to Sagdeev. Instead of bringing all scientists up to the military standard, Sagdeev asserts, all scientists are instead being lowered to the civilian standard.[17]

In an effort to capture the societal and economic benefits of scientific research, Soviet research institutes are now being encouraged to build bridges to industry. One example is the setting up of a joint company by the American think tank/consulting firm Arthur D. Little, Cambridge, Massachusetts, and the USSR Academy of Sciences. The joint company will scout out basic Soviet technologies, have Western companies develop them, and grant product licenses to companies that will produce the end products. The most promising areas are in materials science and lasers.[18]

Another new step in Soviet science reform involves funding allocations. Instead of being channeled through the academy institutes, much of the funding is now awarded directly to projects by committees representing science and industry. Last year 6,200 projects competed for funding, and some 3,800 succeeded. According to Sagdeev, however, a large part of the money is still spent on unprofitable ventures.[17]

This two-part essay provides a citationist overview of Soviet science and has commented only on the highest impact Soviet researchers and their papers. We have also briefly noted certain factors that may have had a hand in deterring Soviet science from reaching its fullest potential. It's true that Soviet science is beset with many problems, but Gorbachev's reform efforts give both Soviet and Western scientists hope. Perhaps the most positive hope for the immediate future is the increased number of travel exchanges between Soviet and other scientists and the proliferation of electronic media such as the fax machine and personal computers.

We are fully aware that a large volume of Soviet journals and other low-impact foreign journals are not included in the ISI databases. But our coverage of these countries gives us a reasonable perspective on their best unclassified research. As the language barrier goes down, there will be better representation in the future.

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