



GLOBALIZATION OF SCIENCE ROLLS ON

Growth of scientific literature remains strong, while the **WORLD OF SCIENCE** continues to flatten

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GLOBALIZATION of science is a hot topic. Yet, no single set of quantitative data gives a definitive fix on what is going on in science and where science is being done. There are data compilations—such as on R&D spending and investment, patent activity, and scientific manpower—that each give part of the evolving worldwide story.

Another such indicator is detailed year-by-year information on the number of articles published in peer-reviewed scientific and engineering journals. If analyzed with caution, such data can identify, if not always explain, broad trends in scientific activity.

The latest data on article publication from the National Science Foundation, Thomson Scientific (formerly the Institute for Scientific Information, or ISI), Chemical Abstracts Service (CAS), and the American Chemical Society's journals operation all indicate above-average worldwide growth recently and especially rapid and substantial gains for China and selected other Asian and Western European nations. The NSF/ISI data are through 2003; the CAS and ACS data are through 2005.

The new data also confirm the relatively slower growth for papers from the U.S., which, nevertheless, remains the largest

single national source of papers by a substantial margin.

From 2001 to 2003, the NSF count—which is derived from ISI data—of papers worldwide rose by 7.5%, or 3.5% per year. This growth is higher than the average 2.7% average annual growth for the previous 13 years. The 2003-to-2005 increase in the number of papers abstracted by CAS was 12.5%, or 6.1% per year, and well above the average of 3.5% per year for the 15 previous years. The 2003-to-2005 increase in papers published in ACS journals was 21.0%, or 10.0% per year, again, higher than the 1988-to-2003 average of 5.5%.

The U.S. accounted for only 14% of the 1988-to-2003 increase in the NSF/ISI count of papers published worldwide, 18% of the 1988-to-2005 increase in the papers abstracted by CAS, and 24% of the 1988-to-2005 gain in the number of papers published in ACS journals.

The U.S.'s share of all scientific papers published worldwide dropped, according to NSF/ISI, from 38% in 1988 to 30% in 2003. By the CAS count, the decline was from 27% in 1988 to 23% in 2005. The percentage of the papers published in ACS journals that are from U.S. sources fell the most, from 64% in 1988 to 39% in 2005.

For all these data sets, a paper is attributed to a nation by institutional affiliation of its author or authors at the time of publication, not by the nationality of the authors.

These major findings confirm and extend the three major trends in scientific publication described two years ago in C&EN: These trends are of solid growth almost worldwide, a huge surge in papers from rapidly developing nations, and erosion of the U.S.'s share (C&EN, June 14, 2004, page 38).

However, one possible inference from the two years of new data is that the prolonged decline in the U.S.'s share of papers and abstracts may be slowing. The percentage of CAS abstracts from U.S. sources held at just over 23% for 2003, 2004, and 2005. The U.S. share of the NSF count slipped slightly from 30.9% in 2001 to 30.2% in 2003. And the U.S. share of the papers published in ACS journals slipped from 40.2% in 2003 to 38.6% in 2005. This is a 1.6%

NSF'S COUNT OF SCIENTIFIC PAPERS

Number of U.S. papers grew by only 1% per year from 1988 to 2003

THOUSANDS OF PAPERS	WORLD	U.S.	NON-U.S.	U.S. %
1988	466.4	177.9	288.6	38.1%
1989	497.1	187.2	309.9	37.7
1990	508.8	191.6	317.2	37.6
1991	515.5	194.0	321.5	37.6
1992	547.6	198.9	348.7	36.3
1993	540.5	197.4	343.1	36.5
1994	567.2	199.8	367.4	35.2
1995	580.8	202.9	377.9	34.9
1996	593.6	201.8	391.8	34.0
1997	594.5	197.5	396.9	33.2
1998	617.8	197.9	419.9	32.0
1999	632.1	198.5	433.5	31.4
2000	632.8	196.2	436.6	31.0
2001	649.8	200.9	448.9	30.9
2002	641.4	195.8	445.6	30.5
2003	698.7	211.2	487.5	30.2

NOTE: These data include the social and behavioral sciences and are derived from Thomson's citation indexes. **SOURCE:** National Science Foundation, *Science and Engineering Indicators 2006*

TRENDS IN CAS ABSTRACTS

Foreign sources have long been dominant

THOUSANDS OF ABSTRACTS	WORLD	U.S.	NON-U.S.	U.S. %
1988	389.7	106.7	283.0	27.4%
1989	397.2	110.5	286.7	27.8
1990	394.9	110.0	284.9	27.8
1991	453.6	132.3	321.4	28.1
1992	430.3	117.8	312.4	27.4
1993	448.7	126.2	322.5	28.1
1994	542.5	158.2	384.3	29.2
1995	563.0	152.2	410.8	27.0
1996	579.1	160.3	418.9	27.7
1997	585.5	151.6	434.0	25.9
1998	559.0	136.6	422.4	24.4
1999	591.1	141.3	449.8	23.9
2000	573.5	136.3	422.4	23.8
2001	606.7	139.3	467.4	23.0
2002	630.5	150.5	479.9	23.9
2003	646.9	150.9	496.0	23.2
2004	685.8	158.8	527.0	23.2
2005	727.5	168.8	558.7	23.2

SOURCE: Chemical Abstracts Service

decline, but it is less than the 2.6% decline over the previous two years.

The NSF data in this report are from the 2006 edition of the foundation's biennial *Science and Engineering Indicators*. They are derived from the papers published in the expanding number of peer-reviewed journals—4,458 in 1988 and 5,315 in 2003—tracked by Thomson Scientific's Science Citation Index (SCI) and Social Science Citation Index (SSCI).

Journals are assigned to one of 134 fields, which are in turn grouped into chemistry and 11 other major fields. There are eight hard science fields and four social science fields; the latter group accounted for 13% of the 2003 total. Chemistry is defined along traditional lines as analytical, applied, general, inorganic, nuclear, organic, physical, and polymer chemistry.

CAS's data on the number of abstracted papers are based on its monitoring of a somewhat larger number of journals, about 9,000 in 2005. The data on the papers in ACS journals come from a program that has expanded from 19 journals in 1988 to 33 in 2005 and so have a substantially higher growth rate than for chemistry itself.

According to the NSF/ISI data, the number of scientific papers published worldwide rose from 466,000 in 1988 to 699,000 in 2003. This is a gain of a

little over 232,000, or 50%. Growth in non-U.S. papers was 199,000—from 289,000 to 488,000—or 69%.

Growth in the number of U.S. papers was a more modest 33,000, or 19%, from 178,000 in 1988 to 211,000 in 2003. From 1991 to 2002, there was no sustained growth. Annual totals held at between 194,000 and 203,000 and were at 196,000 for 2002. The 2003 total moved up to 211,000 for the biggest annual gain in many years.

NSF points out that there is no clear reason for the flattening of U.S. R&D publications in the 1990s and through 2002. The stagnation contrasts with continuing increases in both real R&D expenditure and the number of researchers.

The foundation

is undertaking a special study to find the reasons, such as changes in publication practices, behind this prolonged lack of growth.

The CAS data indicate a similar pattern but with a somewhat muted difference between U.S. and non-U.S. performance. Between 1988 and 2005, the worldwide total of abstracted papers rose from 390,000 to 728,000, or by 87%. Non-U.S. papers increased from 283,000 to 559,000, or by 97%. U.S. papers were up by a smaller 58%, from 107,000 to 169,000.

The large 169% increase in the number of papers published in ACS journals—from 10,900 in 1988 to 29,300 in 2005—is partly due to the aggressive expansion of the ACS journals operation over

the period. U.S. papers were up by 63%, from 6,900 to 11,300, and non-U.S. papers by 355%, from 3,900 to 18,000.

Of the 18,400 increase in the papers published between 1988 and 2005, 13,100 came in the 20 journals already established in 1988 and 5,300 were from the 13 journals established since 1988.

The 33,000 increase in the number of papers published by U.S. institutions between 1988 and 2003, according to the NSF/ISI data, falls well shy of the gains of 97,000 for Western Europe and 79,400 for Asian nations.

Western Europe has moved ahead of the U.S. In 2003, it had 241,000 articles, and the U.S. had 211,000. Compared with the 19% increase in U.S. papers, particularly large 1988-to-2003 gains were posted by Spain, 210%; Italy, 120%; the Netherlands, 57%; Germany, 51%; and France, 49%.

For Japan, the 1988-to-2003 increase in scientific articles was 74%, and for Australia, it was 60%.

The truly spectacular gain was posted by

PAPERS PUBLISHED IN ACS JOURNALS

U.S. share has dropped from 64% to 39%

NUMBER OF PAPERS	WORLD	U.S.	NON-U.S.	U.S. %
1988	10,875	6,926	3,949	63.7%
1989	11,473	7,308	4,165	63.7
1990	12,351	7,729	4,622	62.6
1991	13,670	8,326	5,344	60.9
1992	14,432	8,407	6,025	58.3
1993	15,067	8,710	6,357	57.8
1994	15,750	8,600	7,150	54.6
1995	16,541	8,555	7,986	51.7
1996	18,503	9,192	9,311	49.7
1997	18,691	8,497	10,194	45.5
1998	19,254	8,737	10,517	45.4
1999	19,730	8,809	10,921	44.7
2000	20,915	9,005	11,910	43.1
2001	21,138	9,051	12,087	42.8
2002	23,061	9,527	13,534	41.3
2003	24,222	9,738	14,484	40.2
2004	26,220	10,533	15,687	40.2
2005	29,302	11,318	17,984	38.6

SOURCE: ACS Journals Publishing Group

No single set of quantitative data gives a definitive fix on what is going on in science and where science is being done.

what NSF defines as the East Asia 4—China, Singapore, South Korea, and Taiwan—with a boost from a combined total of 7,200 papers in 1988 to 55,300 in 2003. This is a 667% gain in 15 years, or an average of 14.5%

per year. Much of this gain has been in China (from 4,600 papers in 1988 to 29,200 in 2003) and South Korea (from 800 in 1988 to 13,700 in 2003). China's total in 2003 placed it sixth on the world ranking.

The only region with a decline in papers is Eastern Europe and the nations of the former Soviet Union, with a dip of from 41,500 papers in 1988 to 35,100 in 2003. The CAS data show a similar national

ACS JOURNAL ARTICLES

Most growth has come in the long-established journals

NUMBER OF PAPERS	1988	2005
OLDER JOURNALS		
<i>Accounts of Chemical Research</i>	70	100
<i>Analytical Chemistry</i>	627	1,068
<i>Biochemistry</i>	1,322	1,666
<i>Chemical Research in Toxicology</i>	60	222
<i>Chemical Reviews</i>	64	134
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<i>Energy & Fuels</i>	139	337
<i>Environmental Science & Technology</i>	192	1,288
<i>Industrial & Engineering Chemistry Research</i>	406	1,120
<i>Inorganic Chemistry</i>	1,013	1,178
<i>J of Agricultural & Food Chemistry</i>	310	1,528
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<i>J of the American Chemical Society</i>	1,894	3,390
<i>J of Chemical & Engineering Data</i>	165	388
<i>J of Chemical Information & Modeling</i>	34	215
<i>J of Medicinal Chemistry</i>	385	876
<i>J of Organic Chemistry</i>	1,417	1,605
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<i>J of Physical Chemistry</i>	1,390	4,855
<i>Langmuir</i>	250	1,788
<i>Macromolecules</i>	653	1,419
<i>Organometallics</i>	484	849
TOTAL	10,875	24,026
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JOURNALS NEW SINCE 1988		
<i>Bioconjugate Chemistry</i>		206
<i>Biomacromolecules</i>		444
<i>Biotechnology Progress</i>		243
<i>Chemistry of Materials</i>		975
<i>Crystal Growth & Design</i>		333
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<i>J of Chemical Theory & Computation</i>		133
<i>J of Combinatorial Chemistry</i>		132
<i>J of Natural Products</i>		385
<i>J of Proteome Research</i>		269
<i>Molecular Pharmaceutics</i>		57
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<i>Nano Letters</i>		492
<i>Organic Letters</i>		1,471
<i>Organic Process Research & Development</i>		136
TOTAL		5,276
GRAND TOTAL	10,875	29,302

NOTES: Data for 2005 for the *Journal of Physical Chemistry* includes both A and B editions. The *Journal of Chemical Information & Modeling* was formerly the *Journal of Chemical Information & Computer Sciences*. *Biotechnology Progress* is co-published with the American Institute of Chemical Engineers. **SOURCE:** ACS Journals Publishing Group

SCIENTIFIC PAPERS BY SOURCE

European Union contributed most to growth between 1988 and 2003

THOUSANDS OF PAPERS	1988	% OF TOTAL	2003	% OF TOTAL	1988-2003	
					CHANGE	% CHANGE
WORLD TOTAL	466.4	100.0%	698.7	100.0%	232.3	50%
U.S.	177.7	38.1	211.2	30.2	33.5	19
Non-U.S.	288.7	61.9	487.5	69.8	198.8	69
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EUROPEAN UNION	134.6	28.9	220.0	31.5	85.4	64
France	21.4	4.6	32.0	4.6	10.6	49
Germany	29.3	6.3	44.3	6.3	15.0	51
Italy	11.2	2.4	24.7	3.5	13.5	120
Netherlands	8.6	1.8	13.5	1.9	4.9	57
Spain	5.4	1.2	16.8	2.4	11.4	210
Sweden	7.6	1.6	10.2	1.5	2.6	34
U.K.	36.5	7.8	48.3	6.9	11.8	32
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OTHER WESTERN EUROPE	9.3	2.0	20.9	3.0	11.6	125
Switzerland	5.3	1.1	8.5	1.2	3.2	61
Turkey	0.5	0.1	6.2	0.9	5.7	1,127
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EASTERN EUROPE/FORMER U.S.S.R. BLOC	41.5	8.9	35.1	5.0	-6.4	-16
Poland	4.0	0.9	6.8	1.0	2.8	68
U.S.S.R./Russia	31.6	6.8	15.8	2.3	nm	nm
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EAST ASIA 4	7.2	1.5	55.3	7.9	48.1	667
China	4.6	1.0	29.2	4.2	24.6	532
Singapore	0.4	0.1	3.1	0.4	2.7	661
South Korea	0.8	0.2	13.7	2.0	13.0	1,682
Taiwan	1.4	0.3	9.3	1.3	7.9	556
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JAPAN	34.4	7.4	60.1	8.6	25.6	74
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OTHER ASIA	10.1	2.2	15.8	2.3	5.7	56
India	8.9	1.9	12.8	1.8	3.9	44
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MIDDLE EAST/NORTH AFRICA	7.9	1.7	13.5	1.9	5.6	71
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SUB-SAHARAN AFRICA	4.5	1.0	4.2	0.6	-0.3	-7
South Africa	2.5	0.5	2.4	0.3	-0.2	-4
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CENTRAL/SOUTH AMERICA	5.6	1.2	18.9	2.7	13.1	233
Argentina	1.4	0.3	3.1	0.4	1.7	116
Brazil	1.8	0.4	8.7	1.2	6.9	392
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AUSTRALIA	9.9	2.1	15.8	2.3	5.9	60
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CANADA	21.4	4.6	24.8	3.1	3.4	16

nm = not meaningful. **SOURCE:** National Science Foundation, *Science and Engineering Indicators 2006*

profile of growth rates. Increases in the number of abstracted papers between 1988 and 2005 were 668% for South Korea, 647% for China, 179% for Spain, 71% for Germany, 65% for the Netherlands, 58% for the U.S., and 46% for France. China's 102,000 abstracts in 2005 placed it second on the world list behind the U.S. at 169,000.

The data for ACS's journals program indicate a 1983-to-2005 increase in papers published of 228%, from 8,900 to 29,300, with U.S. papers up by 88%, from 6,000 to 11,300, and non-U.S. papers up by 517%, from 2,900 to 18,000.

PAPERS ABSTRACTED BY CAS, BY SOURCE

Since 1988, China's share has quadrupled

THOUSANDS OF PAPERS	1988	% OF TOTAL	2005	% OF TOTAL
WORLD TOTAL	389.7	100.0%	727.5	100.0%
U.S.	106.7	27.4	168.8	23.2
Non-U.S.	283.0	72.6	558.7	76.8
EUROPEAN UNION				
France	16.8	4.3	24.6	3.4
Germany	29.2	7.5	49.9	6.9
Italy	9.3	2.4	21.3	2.9
Netherlands	5.7	1.5	9.4	1.3
Spain	5.4	1.4	15.1	2.1
Sweden	4.7	1.2	8.2	1.1
U.K.	21.8	5.6	30.2	4.2
OTHER WESTERN EUROPE				
Switzerland	4.1	1.1	7.8	1.1
Turkey	0.6	0.2	6.0	0.8
EASTERN EUROPE/FORMER U.S.S.R. BLOC				
Bulgaria	1.7	0.4	1.5	0.2
Czechoslovakia	4.4	1.1	3.4	0.5
Poland	6.8	1.7	11.4	1.6
Russia	—	—	22.4	3.1
U.S.S.R.	50.6	13.0	—	—
EAST ASIA 4				
China	13.7	3.5	102.3	14.1
Singapore	0.2	0.1	2.8	0.4
South Korea	2.2	0.6	16.9	2.3
Taiwan	1.4	0.4	7.4	1.0
JAPAN	44.6	11.5	81.4	11.2
OTHER ASIA				
India	12.0	3.1	19.6	2.7
MIDDLE EAST/NORTH AFRICA				
Egypt	0.7	0.2	2.6	0.4
Israel	2.4	0.6	4.3	0.6
Turkey	0.6	0.2	6.0	0.8
SUB-SAHARAN AFRICA				
South Africa	1.3	0.3	1.6	0.2
CENTRAL/SOUTH AMERICA				
Argentina	1.1	0.3	2.5	0.4
Brazil	1.5	0.4	9.3	1.3
Mexico	0.7	0.2	3.5	0.5
AUSTRALIA	5.0	1.3	9.6	1.3
CANADA	12.1	3.1	18.1	2.5

NOTES: East Asia 4 consists of China, Singapore, South Korea, and Taiwan. — = data not available. **SOURCE:** Chemical Abstracts Service

Data on Asian nations are scanty for 1983, when they produced relatively few papers. But the 1,776 papers from China published in 2005 were enough to place China third, behind Japan at 2,510, and the U.S. at 11,318.

An analysis by NSF gives a guide to the scientific productivity of nations. Based on the most recent data available (from within the 2000-to-2003 range) for each country, it is expressed as the number of science and engineering articles published per year per million inhabitants.

Of 157 nations ranked, the U.S. ranks 12th at 707 papers per million. The top six are

smaller nations, with Sweden at 1,137; Switzerland, 1,120; Israel, 1,018; Finland, 974; Denmark, 933; and the Netherlands at 800. The U.K., at 796, ranks the highest among larger nations at seventh. The worldwide average is 108 papers per million.

The NSF/ISI data indicate that 11.9% of the scientific papers published worldwide in 2003 were in chemistry. This is little changed from 12.1% in 1996. The biggest field in 2003 was clinical medicine, with 27.9% of the papers; followed by physics, with 13.9%; biomedical research, with 13.7%; and then chemistry.

Chemistry's share of scientific papers varies widely by nation. In 2003, chemistry claimed 26.6% of the papers from India, 25.5% of those from Eastern Europe and the nations of the former Soviet Union, and 20.2% of papers from the East Asia 4. The U.S. was at the other end of this spectrum, with 7.5% of its papers in chemistry. Canada came in at 7.3% and Australia at 8.0%.

NSF'S TOP 10 PRODUCERS

France replaced the Soviet Union in the top five

RANK	NATION	THOUSANDS OF PAPERS
1988		
1	U.S.	177.7
2	U.K.	36.5
3	Japan	34.4
4	Soviet Union	31.6
5	Germany	29.3
6	France	21.4
6	Canada	21.4
8	Australia	9.9
9	India	8.9
10	Netherlands	8.6
2003		
1	U.S.	211.2
2	Japan	60.1
3	U.K.	48.3
4	Germany	44.3
5	France	32.0
6	China	29.2
7	Canada	24.8
8	India	24.7
9	Spain	16.8
10	Russia	15.8
10	Australia	15.8

SOURCE: National Science Foundation, *Science and Engineering Indicators 2006*

TOP 10 SOURCES OF CAS ABSTRACTS

China moves to second, behind U.S.; Japan is third

RANK	NATION	THOUSANDS OF PAPERS
1988		
1	U.S.	106.7
2	U.S.S.R.	50.6
3	Japan	44.6
4	Germany	29.2
5	U.K.	21.8
6	France	16.8
7	China	13.7
8	Canada	12.1
9	India	12.0
10	Italy	9.3
2005		
1	U.S.	168.8
2	China	102.3
3	Japan	81.4
4	Germany	49.9
5	U.K.	30.2
6	France	24.6
7	Russia	22.4
8	Italy	21.3
9	India	19.6
10	Canada	18.1

SOURCE: Chemical Abstracts Service

ACS JOURNAL PAPERS BY SOURCE

Non-U.S. papers made up 74% of growth from 1983 to 2005

NUMBER OF PAPERS	1983	2005	1983-2005	
			CHANGE	% CHANGE
TOTAL	8,946	29,302	20,356	228%
U.S.	6,033	11,318	5,285	88
Non-U.S.	2,913	17,984	15,071	517
WESTERN EUROPE				
Belgium	45	263	218	484
Denmark	24	215	191	795
France	264	1,124	860	326
Germany	231	1,561	1,330	576
Italy	175	964	789	451
Netherlands	107	481	374	350
Spain	39	1,136	1,097	2,813
Sweden	68	412	344	506
Switzerland	88	412	324	368
U.K.	200	1,224	1,024	512
EASTERN EUROPE				
Czechoslovakia	8	72	64	800
Poland	14	208	194	1,386
Russia	—	118	—	—
ASIA				
China	—	1,776	—	—
Hong Kong	—	102	—	—
India	77	587	510	662
Japan	666	2,510	1,844	277
Singapore	—	204	—	—
South Korea	—	568	—	—
Taiwan	—	369	—	—
MIDDLE EAST				
Israel	89	286	197	221
Turkey	—	58	—	—
LATIN/CENTRAL AMERICA				
Argentina	16	93	77	481
Brazil	11	154	143	1,300
Mexico	—	120	—	—
OTHER				
Australia	117	406	289	247
Canada	498	1,230	732	147
New Zealand	—	69	—	—

— = data not available. SOURCE: ACS Journals Publishing Group

CITATIONS IN HIGH-IMPACT JOURNALS

U.S. dominance is still strong but declining

PERCENTAGE OF CITATIONS	U.S. dominance is still strong but declining				
	U.S.	WESTERN EUROPE	JAPAN	EAST ASIA 4	OTHER
Top 1% cited journals					
1992	68.5%	19.9%	3.0%	0.1%	8.5%
2003	59.3	25.7	4.6	0.8	9.6
Top 5% cited journals					
1992	61.9	22.4	4.8	0.4	10.5
2003	49.1	30.8	6.7	1.8	11.7
Top 10% cited journals					
1992	55.9	25.4	6.0	0.7	12.0
2003	43.7	32.6	7.7	2.8	13.2
All cited journals					
1992	37.8	29.1	7.4	1.8	23.9
2003	31.1	32.8	8.8	5.9	21.4

NOTE: Western Europe is defined as the 15 nations that made up the European Union until 2000. East Asia 4 consists of China, Singapore, South Korea, and Taiwan. SOURCE: National Science Foundation, *Science and Engineering Indicators 2006*

SCIENTIFIC PAPERS BY FIELD, 1988 TO 2003

By NSF's count, U.S. share declined in all fields except mathematics

THOUSANDS OF PAPERS	1988	2003	1988-2003	
			CHANGE	% CHANGE
BIOLOGY				
World	35.0	49.6	14.6	42%
U.S.	12.9	13.9	1.0	8
Non-U.S.	22.1	35.7	13.6	62
% U.S.	37%	28%		
BIOMEDICAL RESEARCH				
World	70.9	95.7	24.8	35
U.S.	27.5	34.4	6.9	25
Non-U.S.	43.4	61.3	17.9	41
% U.S.	39%	36%		
CHEMISTRY				
World	57.4	83.1	25.7	45
U.S.	13.2	15.8	2.6	20
Non-U.S.	44.2	67.3	23.1	52
% U.S.	23%	19%		
CLINICAL MEDICINE				
World	136.7	194.9	58.2	43
U.S.	55.0	65.9	10.9	20
Non-U.S.	81.7	129	47.3	58
% U.S.	41%	34%		
EARTH/SPACE SCIENCES				
World	19.1	38.4	19.3	101
U.S.	8.1	12.5	4.4	54
Non-U.S.	11.0	25.9	14.9	135
% U.S.	42%	33%		
ENGINEERING/TECHNOLOGY				
World	31.3	62.9	31.6	101
U.S.	11.8	14.8	3.0	25
Non-U.S.	19.5	48.1	28.6	145
% U.S.	42%	24%		
MATHEMATICS				
World	9.8	15.4	5.6	57
U.S.	3.9	7.8	3.9	100
Non-U.S.	5.9	7.6	1.7	29
% U.S.	40%	51%		
PHYSICS				
World	62.0	97.2	35.2	57
U.S.	18.0	18.6	0.6	3
Non-U.S.	44.0	78.6	34.6	79
% U.S.	29%	19%		
TOTAL				
World	422.2	637.2	215.0	51
U.S.	150.4	183.7	33.3	17
Non-U.S.	271.8	453.5	181.7	67
% U.S.	36%	28%		

HOW TO READ THE TABLE: In 1988, 35,000 biology articles were published worldwide. Of these, 12,900, or 37%, were from U.S. institutions. SOURCE: National Science Foundation, *Science and Engineering Indicators 2006*

Between 1988 and 2003, the number of U.S. chemical papers rose by 2,600, from 13,200 to 15,800, while the number of non-U.S. chemistry papers grew by 23,100, from 44,200 to 67,300. This means that the U.S. contributed only 11% of the overall 15-year gain.

From 1988 to 2003, the U.S.'s share of papers fell in seven of the eight hard sciences. The exception was mathematics.

The bare-bone statistics on the number of articles published or abstracted do not address the issue of the caliber of the

2003 SCIENTIFIC ARTICLES BY FIELD

One out of 13 U.S. scientific papers is in chemistry

THOUSANDS OF PAPERS	WORLDWIDE	% OF TOTAL	U.S.	% OF TOTAL
HARD SCIENCES				
Clinical medicine	194.9	27.9%	65.9	31.2%
Physics	97.1	13.9	18.6	8.8
Biomedical research	95.7	13.7	34.4	16.3
Chemistry	83.2	11.9	15.9	7.5
Engineering/technology	62.9	9.0	14.8	7.0
Biology	49.6	7.1	14.0	6.6
Earth/space sciences	38.4	5.5	12.5	5.9
Mathematics	15.4	2.2	7.8	3.7
OTHER SCIENCES				
Social sciences	21.7	3.1	9.7	4.6
Psychology	15.4	2.2	3.8	1.8
Professional fields	14.7	2.1	8.7	4.1
Health sciences	9.8	1.4	5.1	2.4
TOTAL	698.7	100.0%	211.2	100.0%

SOURCE: National Science Foundation, *Science and Engineering Indicators 2006*

papers. However, an NSF/ISI analysis indicates that the U.S. holds a strong, if gradually declining, advantage.

The analysis is based on a ranking of the journals covered by the two citation

TOP 10 SOURCES OF PAPERS IN ACS JOURNALS

U.S. leads, Japan retains second, and China climbs to third place

RANK	NATION	NUMBER OF PAPERS
1983		
1	U.S.	6,033
2	Japan	666
3	Canada	498
4	France	264
5	Germany	231
6	U.K.	200
7	Italy	175
8	Australia	117
9	Netherlands	107
10	Israel	89
2005		
1	U.S.	11,318
2	Japan	2,510
3	China	1,776
4	Germany	1,561
5	Canada	1,230
6	U.K.	1,224
7	Spain	1,136
8	France	1,124
9	Italy	964
10	India	587

SOURCE: ACS Journals Publishing Group

indexes (SCI and SSCI) according to the average number of citations to the articles published in them.

In 2003, 59.3% of the papers in the top 1% of journals ranked this way were from the U.S. Second were the 15 nations that made up the European Union in 1999 (referred to as EU-15) with a total of 25.7%. Japan had 4.6%, and East Asia 4 had 0.8%. In 1992, these shares had been 68.5%, 19.9%, 3.0%, and 0.1%, respectively.

The pattern is similar for the top 10% of journals. The U.S.'s share dropped from 55.9% in 1992 to 43.7% in 2003, while the EU-15's rose from 25.4% to 32.6%. Japan also advanced, from 6.0% to 7.7%, as did East Asia 4, from 0.7% to 2.8%.

Some journal editors have expressed concern about the uneven quality of the rising tide of articles submitted to their publications from China and other Asian sources (C&EN, Sept. 18, page 35). The fact remains, however,

PROPORTION OF CHEMISTRY ARTICLES

Chemistry is a smaller part of science in U.S., Canada, than it is elsewhere

REGION	CHEMISTRY PAPERS AS % OF ALL S&E PAPERS	
	1996	2003
Worldwide	12.1%	11.9%
U.S.	7.5	7.5
European Union	12.4	11.1
Japan	15.6	14.7
East Asia 4	19.8	20.2
Eastern Europe/former U.S.S.R.	26.3	25.5
Near East/North Africa	13.7	16.3
Central/South America	12.7	12.5
Australia	8.7	8.0
Canada	8.0	7.3
India	26.8	26.6

NOTE: East Asia 4 consists of China, Singapore, South Korea, and Taiwan. S&E = science and engineering. SOURCE: National Science Foundation, *Science and Engineering Indicators 2006*

SCIENTIFIC PAPERS PER CAPITA

European nations dominate the top 25 list

RANK	NATION	ARTICLES PER MILLION INHABITANTS PER YEAR
TOP 25		
1	Sweden	1,137
2	Switzerland	1,120
3	Israel	1,018
4	Finland	974
5	Denmark	933
6	Netherlands	800
7	U.K.	796
8	Australia	773
9	Canada	748
10	New Zealand	745
11	Norway	715
12	U.S.	707
13	Singapore	676
14	Iceland	672
15	Belgium	599
16	Austria	574
17	Germany	525
18	France	524
19	Taiwan	502
20	Slovenia	456
21	Japan	453
22	Ireland	435
23	Italy	401
24	Spain	394
25	Greece	329
WORLDWIDE		108
SELECTED OTHERS		
35	Russia	110
36	Kuwait	107
39	Chile	85
40	Argentina	83
48	Jordan	48
49	United Arab Emirates	48
50	Brazil	45
59	Egypt	24
67	China	19
79	India	11

NOTE: Number of science and engineering papers in the most recent year between 2000 and 2003 for which data are available. SOURCE: National Science Foundation, *Science and Engineering Indicators 2006*

that the rapidly growing number of articles from Asia and other nontraditional sources that are counted, abstracted, or published by ISI, CAS, or the ACS journals meet the criteria established by these entities. ■