

ORIGINAL ARTICLE

Japan's share of research output in basic medical science

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Abstract. **Objective:** To investigate the degree of Japan's contribution to the research in basic biomedical science in the last decade. **Methods:** Articles published during 1991–2000 in highly reputed basic biomedical science journals (10 journals from each of the 16 categories related to basic biomedical science) were accessed through Medline database. The number of articles having affiliation with a Japanese institution was then determined using appropriate search strategies. **Results:** In total 312,748 articles were published in the selected journals and Japan's share was 20,665 articles (6.6% of total) with an upward trend over time ($p = 0.01$). Japan's share was higher in the journals, which publish mostly original articles (6.9%) than that in the journals, which publish only review articles (2.6%). The former group showed an upward trend ($p = 0.01$) over time (1991–2000) while the latter did not ($p = 0.08$). Among the 16 categories, Japan had significantly positive trend in 7 categories while others remained unchanged. **Conclusions:** Japan's share of original articles for basic medical science has increased in the last decade. On the other hand, its share of review articles was low and has remained stagnant in the same period. (Keio J Med 53 (3): 172–177, September 2004)

Key words: Medline, basic science, biomedical research, research productivity

Introduction

In a study which included only journal articles published during 1990–2000 in Medline database, we demonstrated that Japan is the second highest research articles producer (9.4% of total) in biomedical field following the USA (40.8%).¹ However, based on highly reputed top 6 basic science journals, its position slipped to 4th (3.1% of total articles) and went down heavily to 14th place for both general medicine (0.7% of total articles),^{2,3} and epidemiology journals (1.1% of total),⁴ although remained 3–11% for other categories^{5–14}. But up to now, little is known about Japan's contributions to the specific basic science fields. We conducted this investigation to determine Japan's share of research articles for each of the categories related to basic medical science in the last decade and the time trend as well in this period of time.

Materials and Methods

Institute for Scientific Information¹⁵ listed most of the standard journals published in different countries

and grouped into some broad categories. Sorted by impact factor, ten journals from each of the categories related to basic medical science were selected based on the following criteria: (1) the journal is available in Medline database, (2) the journal's articles are available for at least 5 consecutive years in 1991–2000 period in the Medline database, (3) the journal published at least 100 articles in 1991–2000 period, and (4) the journals publish articles only in English. Maximum number of journals, which publish only review articles, included per category was 6. In case, if the number was more than that, it was omitted, and other journal, which publishes mostly original articles, was chosen. Only journal articles were included for the analysis, *i.e.*, letter, correspondence, and news were excluded. Medline database was searched in November 2002 to elicit the number of articles (journal-articles) originating from Japanese Institutions and published from 1991 through 2000. After that, the number of articles from Japan to each of the journals was generated and summed up to find the Japan's share in each category of journals. Again its contribution was divided into two subgroups: (1) for the journals, which publish only review articles,

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Table 1 Japan's Share of Articles in Each Category

Category**	Journal articles published in 1991–2000			Japan's share in 1991–2000		
	Total	Non-review Journals	Review Journals	Overall	Non-review Journals	Review Journals
Anatomy and Morphology	7,854	7,854	-#	11.9	11.9	-#
Biochemistry and Molecular Biology	14,582	11,655	2,927	3.8	4.3	1.8
Biotechnology and Applied Microbiology	12,383	10,818	1,565	6.0	6.5	2.1
Medicinal Chemistry	15,271	14,899	372	8.6	8.7	4.0
Genetics and Hereditary	21,212	17,307	3,905	5.6	6.3	2.5
Immunology	26,046	22,601	3,445	4.9	5.3	2.6
Medicine, Research and Experimental	19,476	19,082	394	6.4	6.5	1.5
Microbiology	33,277	30,332	2,945	5.6	6.0	1.5
Neuroscience	15,471	12,706	2,765	3.9	4.0	3.4
Oncology	36,764	36,192	572	10.7	10.8	2.6
Parasitology*	10,648	10,648	-#	4.5	4.5	-#
Pathology	15,159	14,883	276	7.4	7.5	0.4
Pharmacology	19,150	16,920	2,230	8.8	9.6	2.8
Physiology	40,680	40,014	666	5.8	5.9	2.3
Toxicology	14,686	14,309	377	6.8	6.9	2.4
Virology	29,768	28,755	1,013	5.5	5.4	8.0

* Only 8 eligible journals were found in this category. ** Some journals are listed in more than one category. Although we included them in the respective category, when net Japanese contribution was calculated, they were counted only once. # Journals publish only review articles are not available for these categories.

Anatomy and Morphology: Journal of Pineal research, Developmental Dynamics, Microscopy Research and Technique, Anatomy and Embryology, Anatomical Record, Journal of anatomy, Journal of Morphology, Tissue & Cell, European Journal of Morphology, and Clinical Anatomy.

Biochemistry & Molecular Biology: Annual Review of Biochemistry, Cell, Nature Medicine, Annual Review of and Developmental Biology, Annual review of Biophysics and Biomolecular Structures, Trends in Biochemical Sciences, Current Opinion in Genetics & Development, Embo Journal, Current Opinion in Structural Biology, and Nature Structural Biology.

Biotechnology and Applied Microbiology: Current Opinion in Genetics & Development, Nature Biotechnology, Genome Research, Current Opinion in Biotechnology, Gene Therapy, Human Gene Therapy, Trends in Biotechnology, Pharmacogenetics, Critical Reviews in Eukaryotic Gene Expression, Gene Expression, and Genomics.

Genetics and Hereditary: Nature Genetics, Gene Development, Annual review of Genetics, Trends in Genetics, American Journal of Human Genetics, Human Molecular Genetics, Genome Research, Oncogene, Human Mutations, and Gene Therapy.

Immunology: Annual review of Immunology, Advances in Immunology, Immunity, Journal of Experimental Medicine, Current Opinions in Immunology, Immunology Today, Journal of Immunology, Immunological Reviews, AIDS, and Critical Reviews in Immunology.

Medicinal Chemistry: Natural Product Reports, Medicinal Research Reviews, Journal of Medical Chemistry, Chemical Research in Toxicology, Anti-Cancer Drug Design, Journal of Pharmaceutical Sciences, Bioorganic and Medicinal Chemistry, Journal of Natural Products, Chemo-Biological Interactions, and Chirality.

Medicine, Experimental: Nature Medicine, Journal of Experimental Medicine, Journal of Clinical Investigation, Molecular Medicine Today, Gene Therapy, Human Gene Therapy, Molecular Therapy, Laboratory Investigation, Journal of Molecular Medicine-JMM, and Experimental Hematology.

Microbiology: Annual Reviews of Microbiology, Clinical Microbiology Reviews, FEMS Microbiology Reviews, Trends in Microbiology, Molecular Microbiology, Journal of Bacteriology, Journal of Clinical Microbiology, Applied and Environmental Microbiology, and Current Topics in Microbiology and Immunology.

Neuroscience: Annual Reviews of Neurosciences, Trend in Neurosciences, Frontiers in Neuroendocrinology, Neuron, Current Opinion in Neurobiology, Progress in Neurobiology, Brain Pathology, Annals of Neurology, Journal of Neurosciences, and Brain.

Oncology: Journal of National Cancer Institute, Advances in Cancer Research, Cancer Research, Oncogene, Experimental Cell Research, Seminar in Cancer Biology, Carcinogenesis, Genes Chromosomes & Cancer, Leukemia, and International Journal of Cancer.

Parasitology: International Journal of Parasitology, Molecular and Biochemical Parasitology, Parasitology and Immunology, Journal of Parasitology, Experimental Parasitology, Annals of Tropical Medicine and Parasitology, Parasitology Research, and Journal of Helminthology.

Pathology: Brain Pathology, American Journal of Pathology, Journal of Neuropathology and Experimental Neurology, Journal of Pathology, American Journal of Surgical Pathology, Modern Pathology, American Journal of Clinical Pathology, Human Pathology, Neuropathology and Applied Neurobiology, and Seminar in Diagnostic Pathology.

Pharmacology: Pharmacological Reviews, Annual Reviews of Pharmacology, Trends in Pharmacological Science, Antiviral Therapy, Pharmacology and Therapeutics, Neuropsychopharmacology, Pharmacogenetics, Neuropharmacology, Journal of Pharmacology and Experimental Therapeutics, and British Journal of Pharmacology.

Physiology: Physiology Reviews, Annual Reviews of Physiology, Journal of General Physiology, American Journal of Physiology, Journal of Physiology-London, Journal of Cell Physiology, Journal of Pineal Research, Journal of Mammary Gland Biology and Neoplasia, Journal of Neurophysiology, and Psychophysiology.

Table 1 Continued

Toxicology: Annual Reviews of Pharmacology, Critical Reviews in Toxicology, Drugs, Drug Safety, Chemical Research in Toxicology, Toxicology and Industrial Health, Toxicology and Applied Pharmacology, Mutation Research-Fundamental and Molecular Mechanisms of Mutagenesis, Neurotoxicology and Teratology, and Environmental and Molecular Mutagenesis.

Virology: Antiviral Therapy, AIDS, Journal of Virology, Advances in Virus Research, Virology, Journal of General Virology, Journal of Medical Virology, Journal of Neurovirology, AIDS Research and Human Retroviruses, and Antiviral Research.

and (2) for the journals, which publish mostly original articles. Finally net Japan's share for basic science research output was determined. Japan's share was also generated for each year (1991–2000) for each category of journals to examine the time trend.

Statistical Analyses

Nonparametric tests for trend were performed using STATA 7.0 (STATA Corporation, College Road, Texas, USA) to determine any significant change in Japan's share in different categories and also as a whole over the period of time. Besides, relationship between contribution to each journal, and journal impact factor was fitted into generalized estimating equation (GEE) regression model. In this model, percentage of contribution of Japan to each journal in a year was considered as dependent variable and impact factor of individual journal in a particular year was considered as independent variable. Five years data (1996–2000)¹⁵ were fitted into the model, as data on impact factor before that period were not available from the known sources. Besides, Japan's total contribution to each of the journal during 1991–2000 was also regressed by journal impact factor during 2001 by simple linear regression. Relative contribution of Japan regarding articles in review jour-

nals and journals with original articles was examined by chi-square test. Tests of significance were two-tailed and value of $p < 0.05$ was considered significant.

Results

In total, 312,748 articles in the 16 categories journals related to basic medical science were published from 1991 through 2000. Among these, Japan's contributions were 20,655 articles (6.6%). Japan's share was higher in the journals, which publish mostly original articles (6.9%) than that in the journals, which publish only review articles (2.6%). Contributions ranged from 3.8% to 11.9% (Table 1) in different categories. When the journals were divided into "journals mostly publish original articles" and "journals publish only review articles", the ranges were 4.0% to 11.9% and 0.4% to 8.0%, respectively in different categories (Table 1). Japan's contribution was significantly higher in each of the categories (except virology where the reverse is true; and anatomy and parasitology where journals for review articles were not available) for journals, which publish mostly original articles than that for journals, which publish only review articles.

Year-wise, as a whole, Japan's contribution has increased from 6.2% in 1991 to 7.2% in 2000 (Fig. 1). This upward trend was statistically significant ($p = 0.01$) over the period of time. However, for journals, which publish only review articles, the trend was not significantly upward ($p = 0.08$), although it went up from 1.9% in 1991 to 3.2% in 2000. On the other hand, journals, which publish mostly original articles showed strongly significant upward trend ($p = 0.01$) (Fig. 1).

Figure 2 shows the trend of Japan's share in each of the 16 categories of journals. Among the 16 categories, Japan had significantly positive trend over the last decade in Biotechnology & Molecular Biology ($p = 0.05$), Genetics & Hereditary ($p = 0.01$), Immunology ($p = 0.01$), Microbiology ($p = 0.03$), Pathology ($p = 0.01$), Physiology ($p = 0.01$) and Pharmacology ($p = 0.05$) while contribution to the remaining 9 categories were stagnant in the last decade.

Japan's contribution was lower in the journals with higher impact factor as derived from GEE regression model (coefficient = 0.13, $p = 0.01$) which means that its contribution decreases 0.13% [95% confidence interval (CI): 0.06%–0.2%] if impact factor of a journal increases by one point. Same relationship was also

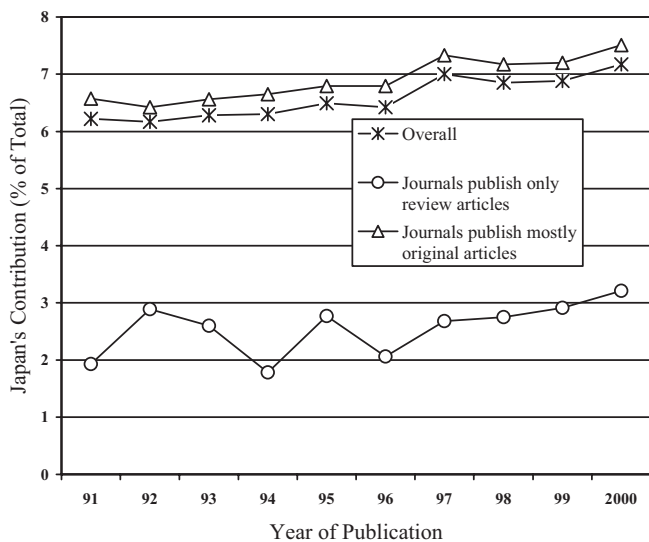


Fig. 1 Trend of Japan's share of articles in basic medical science journals during 1991–2000.

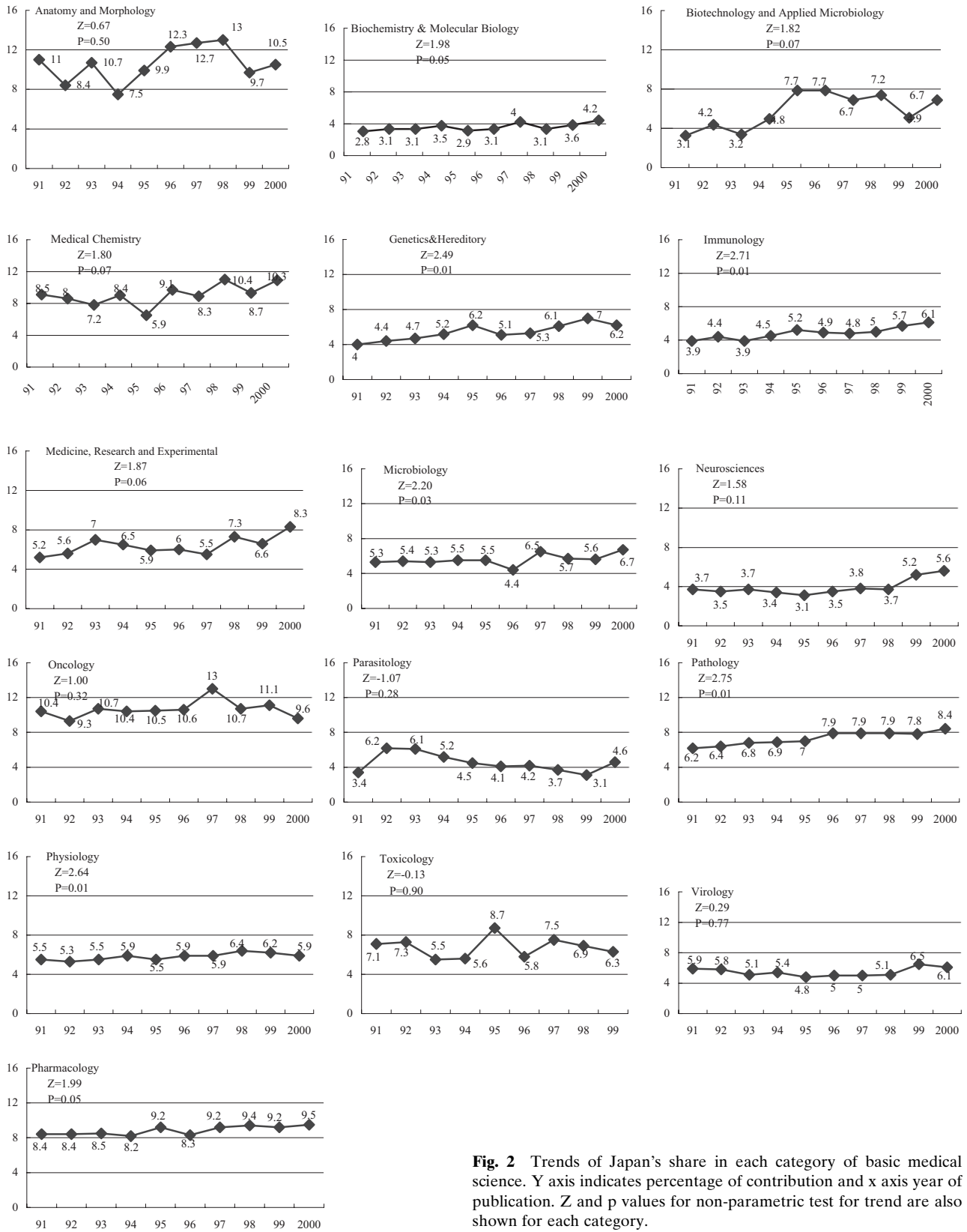


Fig. 2 Trends of Japan's share in each category of basic medical science. Y axis indicates percentage of contribution and x axis year of publication. Z and p values for non-parametric test for trend are also shown for each category.

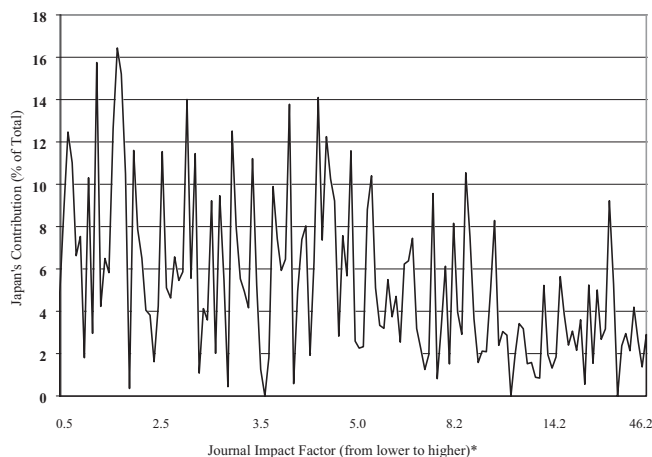


Fig. 3 Japan's contribution (1991–2000) to individual journal versus the impact factor of journals in 2001. *In total, 144 journals' impact factors were placed on the x-axis. Journal impact factors labeled outside x-axis are for 1st, 25th, 50th, 75th, 100th, 125th, 144th journal from lower to higher impact factors.

found [0.18% decrease (CI: 0.11–0.26%) for one point increase of impact factor] in a linear regression between Japan's contribution to different journals during 1991–2000 and impact factor of journals for the year 2001 (Fig. 3).

Discussion

The number of publications elicited from these selected journals is only a gross estimate of the proportion of Japan's contribution to the high quality basic medical science journals. We included journals from 16 categories only, although there are many more journals in the selected categories with lower impact factor. Moreover, a good number of clinical journals also publish few articles on basic science. On the flip side, journals selected for this study could also include some articles not related to basic science, rather to clinical, behavioral or social sciences. Actually there is no automatic search strategy to elicit all the basic science articles included in Medline database. And therefore, we used search command for journal articles only. Thus the absolute number of high quality journal articles originating from Japan is certainly different from our findings. However, the proportion of contribution obtained here is likely to reflect the real situation.

Although Japan's ranking was 2nd in the world,¹ in terms of overall number of articles based on journal articles included in Medline database, its contributions and rankings in different categories had wide range of variation: high quality basic medical science (3.1%, 4th),^{2,3} general and general internal medicine (0.7%,

14th)^{2,3} epidemiology (1.1%, 14th),⁴ nuclear medicine (11.4%, 2nd),⁵ orthopedics (8.3%, 3rd),⁶ ophthalmology (6.5%, 3rd),⁷ urology and nephrology (6.0%, 2nd),⁸ anesthesia (7.3%, 4th),⁹ dermatology (9.5%, 3rd),¹⁰ infectious diseases (3.4%, 6th),¹¹ rheumatology (5.7%, 4th),¹² hematology (7.9%, 4th)¹³ and cardiovascular diseases (8.3%, 2nd)¹⁴. These figures are comparable with the results we obtained from this study, except general medicine and epidemiology, in which Japan's contribution was terribly meager. Remedial measures are necessary for the categories of basic science in which Japan's contribution is comparatively lower. Grants and the number of scientist, which are essential to increase research productivity,¹⁶ should be directed to those fields.

In our previous study, which dealt with only 6 basic science journals with the highest impact factor, Japan's share was much lower (3.1%)³ than the overall share of basic science articles elicited in this study (6.6%). Average impact factor for the 6 basic science journals (26.0) selected in the previous study was much higher than that in this study (7.7). GEE regression model also revealed that Japan's contribution significantly decreases with the increase of journal impact factor. This features reveals that Japan's contribution was comparatively lower to the high impact factor journals. On the plus side, since many of the review journals have higher impact factor and Japan's contribution to those journals is lower, it might contribute, to some extent, to this negative relationship.

In conclusion, Japan's overall share of original articles has increased in the last decade while its share of review articles was lower and has remained stagnant in the last decade.

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