In order to understand the role that the Internet plays in international collaborative research in molecular biology between scientists in Japan and those in other countries, an empirical study based on bibliometric study dealing with international co-authored articles and a survey for corresponding authors of the articles was conducted.

As a result of the international collaborative research, the international co-authored articles increased. The influence of the Internet to the outcome was not clear: factors (e.g., existing personal networks) which initiated international collaborative research were separate from the Internet; however, information technologies relying on the Internet were recognized as important communication tools in international collaborative research and database tools which were crucial for molecular biology research.

The finding indicates that the Internet as one kind of revolution of information technology is not a cause of international collaborative research; however, it is necessary technology to conduct international collaborative research.

Headings:

International Collaboration

Internet

Information Technology

Molecular Biology

Bibliometrics

Japan
THE ROLE OF THE INTERNET IN INTERNATIONAL COLLABORATIVE RESEARCH IN MOLECULAR BIOLOGY BETWEEN JAPANESE AND OTHER SCIENTISTS

by
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A Master’s paper submitted to the faculty of the School of Information and Library Science of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Science in Information Science

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April 2001

Approved by:

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Adviser
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INTRODUCTION

International collaboration in scientific research has been increasing, reflecting the growth of science and application of advanced computer technology and networks. In other words, it might be said that international collaboration plays an important role in facilitating the growth of science. Information technology, especially the Internet, has highly improved communication effectiveness beyond time and space in the scientific community, supporting international collaboration.

Then, has the Internet facilitated international collaborative research?

The purpose of this study is to examine the influence of the Internet on international collaborative research in aspects of productivity and diversity of the research related to the growth of science. Other factors which may affect international collaboration on initiating and conducting the research (e.g., policy and funding for research and development, personal or organizational network, research topics) will be also discussed.

This study focuses on molecular biology as a targeted area because it has expanded rapidly and is known for its successful international collaborative “Human Genome Project (HGP)” relying on shared database systems. The program announced the completion of initial sequencing of the human genome in June 2000, which was recognized as the landmark achievement of genome studies. The study will also focus on
Japan, which is a fairly independent country in terms of physical distance from most of other developed countries and cultural characteristics, but one of the countries in which science has grown rapidly and a country contributing greatly to molecular biology.

The results of this study should be useful for professionals supporting scientific research (e.g., policy makers, staff at higher research institutions, information specialists) as well as to the theory of collaborative communication.
BACKGROUND

International collaboration as a trend in world scientific research

The National Science Board of the U.S. (NSB, 2000) reports an increase in "international coauthorship" as evidence of international collaboration from 6% in 1986-88 to 15% in 1995-97, accompanied by a 12% increase of the number of science and engineering articles published in a set of about 5,000 of the world’s most influential science and technology journals in the Science Citation Index (SCI) journal and the Social Science Citation Index (SSCI) (2000). The growth of science has led to collaboration with 1) the desire to increase understanding of natural phenomena and 2) the need to provide practical benefits (Committee on Promoting Research Collaboration, 1990). In other words, the more science grows, the more it needs to share resources (e.g., knowledge, equipment, funds) from interdisciplinary fields and multiple institutions regardless of countries.

Scientific research in Japan from an international aspect

Japan contributes a large share of the scientific research articles in the world. It is ranked as one of the five nations which produce a large majority of articles (more than

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1 International coauthorship is a situation in which at least one author’s institutional affiliation is in a country different from that of the other(s). (NSB, 1998)
60 % in all) in 1995-97: US(34%), Japan(9%), UK(8%), Germany(7%), France(5%) (NSB, 2000).

The growth of scientific research in Japan has been rapid. From 1986-88 to 1995-97, the number of articles produced by researchers in Japan increased by 35 %, almost three times the world average of 12 % (NSB, 2000). Since this number is derived from SCI and SSCI, which mostly involves articles of U.S. origin journals, the increase is not only the consequence of research enhancement but also of the Japanese researchers’ increasing tendency to submit their articles to journals overseas (Yamazaki, 1996). This tendency might be connected to the increase of international collaborative research. In fact, articles involving international coauthorship with researchers in Japan also show an increase from 8.1% in 1986-88 to 15.2 % in 1995-97. (NSB, 2000).

**Expansion and globalization with information technology in molecular biology**

Molecular biology has been recognized as one of the most expanding areas in scientific research because of the development of recombinant-DNA technology and its application to a wide range of problems in medicine and biology (Hurd, Blecic, Vishwanathan, 1999). Molecular biology is also known for the success of international collaboration of genome research, which relies highly on databases such as sequence databases (e.g., GenBank, European Molecular Biology Laboratory, DNA Data Bank of Japan) and mapping databases (e.g., Genome Data Base, Online Mendelian Inheritance). The data sharing between the databases has been encouraged under the Human Genome Project, which officially started in 1991 (Weller, 1996). The application of information technology for biology is important for molecular biologists, since it has become
necessary to access those databases and submit, search, and analyze data (Sansom, 2000). The scholarly communication system called “electronic data publication” has also contributed to the use of databases. Submission of sequence data to the shared databases prior or simultaneously to publication has been required for the submission of articles for major journals since the late 1980s (Weller, 1996). A human communication tool over the Internet is also used among molecular biologists (Lei, 1996).

**Contribution of Japanese scientists to molecular biology**

In the share of articles in the world in the biochemistry/genetics area, representatives of molecular biology, Japan has ranked a distant second following the U.S. since the mid 1980s (approx. 10.5% and 37.5% respectively in 1994) (Yamazaki, 1996). In fact, molecular biology is one of the most active fields in life sciences in Japan; a share of articles in biochemistry is 8.7 %, ranked second following clinical medicine at 14.4% (Yamazaki, 1994). DNA Data Bank of Japan and Protein Data Bank of Japan exchange data with other databases in the world in a frame of Human Genome Project.
LITERATURE REVIEW

The Internet use in scientific research

Since the proliferation of the Internet in the early 1990s, studies of research activity on the Internet have been done for a variety of purposes (e.g., degree of Internet use, comparison among different academic fields, facilitating factors for Internet use, relationship with research productivity). The high use of email is commonly supported (Curtis, Weller, Hurd, 1996;1997, Liebscher, Abels, Denman, 1996; Budd, Connaway, 1997; Lazinger, Bar-Ilan, Peritz, 1997; Sakai, 1998). Databases are also actually used and the Internet as the network interface has facilitated the database use (Hurd, Weller, Curtis, 1997; Lazinger, et al., 1997; Sakai, 1998). Both (email and databases via the Internet) are considered useful tools for international collaboration.

There are several studies supporting the positive impact of the Internet on the collaboration. In a survey among faculty members in six disciplines in the U.S. (Budd, Connaway, 1997), over 50% of respondents in chemistry, physics, and psychology answered that collaborative efforts have changed as the availability of electronic networks, while the respondents in English, history, and sociology show a lower percentage. Another survey for all the faculty members at Hebrew University in Israel suggests collaboration among researchers as one of the effects of the Internet (Lazinger,1997).
Sakai (1998), focusing on medical researchers in Japan, shows a mixed result on collaborative research: 70% of email users in the survey respondents support “facilitating communication”, while few support “new collaborative research” (5%); the interviews involve positive impact (i.e., using email and database via the Internet increase the productivity) and negative feelings about computer-mediated communication. One physiologist mentions that database availability in the 1970s had more impact on him than Internet email recently introduced. Kurata et al. (1999) surveyed psychologists in Japan and reports that email is evaluated as an effective communication tool for collaborative research activity depending on the degree of the researchers’ usage of email.

Collaboration and collaboratories

Studies focusing on collaboration in scientific research have been mostly done from the view of computer-mediated communication (CMC). The interviews for researchers among four disciplines (experimental biology, physics, mathematics, and sociology) conducted by Walsh and Bayma (1996) found that CMC’s helped organizations that are geographically dispersed, but virtually networked; however, CMC has not caused these changes, only provided the infrastructure. The interviewee making the latter statement also mentions that CMC is not a substitute for discussion.

For the testing of relationships between research collaboration and interdisciplinary research, Quin (1997) conducted citation analysis (846 scientific articles published in 1992) and a small questionnaire survey (24 returned). The study concluded that collaboration is likely to occur in the same department or the same discipline.
Factors affecting collaboration are the subject of the research, personal networking with people, and funding.

Following the suggestion of Collaboratory (merger of collaboration and laboratory) (Committee on a National Collaboratory, 1993), Kouzes (1996) points out that scientific collaboration still heavily relies on traditional communication and describes technical and sociological challenges for implementation of collaboratories. Patel et al. (1999) explores how electronic communication can support multi-institutional collaboration from 18 months of observational data on the InterMed Collaboratory, an Internet-based medical modalities: email used for communicating specific technical details; conference calls for clarifying executive activities; face to face interaction as crucial for building trust and informatics project. They emphasize the importance of using different communication modalities: email used for communicating specific technical details; conference calls for clarifying executive activities; face to face interaction as crucial for building trust and shared understanding of the goals of the collaboratory.

**Study on international collaboration using bibliometrics**

In bibliometric studies, international co-authored articles are measured as an indicator of the outcome of international collaborative research and related factors affecting the international collaboration are described in the analysis of the data.

In addition to pointing out the growth of international co-authored articles from 6% to 15% over all or from 8% to 15% in Japan from 1986-88 to 1995-97, NSB (2000) shows the rapid increase in the number of papers with authors from many institutions.
(i.e., number of papers with authors from 15 or more countries and number of papers with 15 or more U.S. institutions 1986-1997); however, the association of collaboration and the Internet is not verified by either bringing the data of the Internet growth or comparing with other factors which may have facilitated international collaboration. Instead, developments in information technology are described as an affecting factor for international collaboration, which reduce some geographic barriers. Lukkonnen also suggests less expensive communication including email as an external positive factor in international scientific collaborative research.

Other positive factors discussed in bibliometrics studies are: 1) internal factors (e.g., needs of sharing knowledge, perspectives, resources, and economics) (Lukkonen, 1992; NSB, 2000); 2) external factors (e.g., governmental initiatives); 3) the nature of science fields (i.e., data oriented fields are likely to need collaboration). Negative factors are language and isolation due to cultural reasons (Lukkonen, 1992).

In partnership in international collaboration, the U.S. is the number one country; however, the U.S. share declined for most countries (e.g., from 54% to 46% for Japan from 1986-88 to 1995-97) (NSB, 2000; Basu, 2000). Luukkonen (1992), examining international coauthored articles from 1981 to 1986, showed that Japan’s major partner is also the U.S. (53%) and Federal Republic of Germany, Great Britain, Canada, and France follow; however, a relative indicator of collaboration (the ratio of observed number of coauthored articles to the expected number) changes the ranking: China exceeds the U.S. and India follows as the third in satisfying the expected number of coauthored articles.

\[ \frac{\left( C_{X,Y} \right)}{\left( C_x \right) \times \left( C_y \right)} \times \left( T \right) \]

where \( C_{X,Y} \) = number of collaborations between countries X and Y; \( C_x \) = total number of collaborations country X has with other countries in the matrix of thirty countries; \( C_y \) = total number of collaborations country Y has with other countries in the matrix of thirty countries; \( T \) = total number of collaborations in the matrix of thirty countries.
**Bioinformatics as a new study discipline**

Responding to an expansion of application of information technology to biology, “Bioinformatics” has become an established area in which people in a variety of fields (e.g., biology, computer science, medical informatics, information science, and library science) participate. In addition to practical issues such as data management and analysis, data standards and intellectual property rights (Gavaghan, 2000; Spengler, 2000; Wickware, 2000), business issues such as selling software and related services, hiring specialists (Howard, 2000) and political issues (Marshall, 2000; Danchin, 2000), there are some studies to explore further research interests. A use study on information needs among scientists in biotechnology (Grefshein et al, 1991) reveals the high reliance of molecular biologists on factual databases. Cole (1996) recognizes the need for more stable connectivity to sequences and mapping databases via the Internet through a survey for information specialists in pharmaceutical companies in U.K. Changes of scholarly communication in molecular biology related to information technology are discussed in terms of speed (Committee on a National Collaboratory, 1993) and electronic data publishing (Weller, 1996)
PILOT STUDY

In order to gain basic data to see the current status of international collaboration, international co-authored articles as evidence of international collaboration between researchers in Japan and other countries published in ten molecular biology journals (basically selected by the impact factor\(^3\) in 1993, 1995, 1997, and 1999 were analyzed as a pilot study. According to the analysis of data from Science Citation Index (SCI), the percentage of international co-authored articles to articles with at least one author with an institutional affiliation in Japan (1,459 articles in all) has slightly increased from 1993 to 1999 (from 39.5% to 40.2%) with reductions in 1995 and 1999. The reductions seem to be related to the decrease in U.S. participation, a major partnership due to the decrease of R & D funding and the increase of the number of participating institutions in Japan per article.

\(^3\) The impact factor is a measure of the frequency with which the "average article" in a journal has been cited in a particular year or period. (http://sunweb.isinet.com/isi/hot/essays/journalcitationreports/7.html#muscat_highlighter_first_match)
HYPOTHESIS

From the literature review and the result of the pilot study, which describes the Internet as one kind of revolution in information technology that provides useful human communication tools and database interface, the author hypothesizes that the Internet has facilitated international collaboration not as a cause but simply as a necessary utility as a part of information technology. Specific hypotheses on variables proposed for this study are:

1) The ratio of international co-authored articles has increased according to the growing number of articles as an outcome of international collaborative scientific research.

2) The increase in the ratio of international co-authored articles has followed the establishment of shared database interfaces using the Internet rather than the diffusion of Internet email as a human communication tool in Japan.

3) The variation of participant countries in the international co-authored articles has grown with the diffusion of the Internet both as a human communication tool and shared database interface.

4) The Internet has been recognized as a necessary utility as a part of information technology for international collaborative research acting as a human communication tool and database among the researchers.
RESEARCH DESIGN AND PROCEDURES

In order to grasp the roles that the Internet plays in international collaborative scientific research in molecular biology between Japan and other countries, two kinds of methods were applied in this study.

Bibliometrics

The first method was bibliometrics. The purpose of using this method to see the outcome of international collaborative research with the diffusion of the Internet and other possible factors which affect international collaboration. As a measurement of the outcomes of international collaborative research, bibliographic data of international co-authored articles with at least one author whose institutional affiliation was in Japan in 20 molecular biology journals published in 1989, 1991, 1993, 1995, 1997, and 1999 were analyzed in terms of productivity and diversity.

Journal titles were taken from a list of the Science Citation Index database (ISI) in two categories, “Genetics and Heredity” and “Biochemistry and Molecular biology” as representatives of molecular biology. Top 20 journals were further selected according to the Impact Factors in 1998 (Journal citation reports, 1999). Journals mostly consisting of review articles (e.g., Annual review of biochemistry, which has the second largest
impact factor in the category, 39.000) were eliminated, since the journals are likely to have a high impact factor due to the nature of article type.

The numbers of entire articles in sample journals were collected searching against Science Citation Index database with journal titles and a year: 1989, 1991, 1993, 1995, 1997, and 1999. Five journals established after 1989 and three journals whose titles were changed during the period were involved only when the title existed (the detail is included in Appendix 1). Article data were derived from the resulting set of queries adding “Japan” in Geographic Location in January 2001.

Data were processed using Microsoft Excel 2000 and SPSS for Windows 10.0 for statistical analysis. Indicators analyzed were: a) the number of articles; b) the number of international co-authored articles; c) the number of countries and institutions per article; d) the countries participating in international co-authored articles. The productivity is inferred from the percentage of international co-authored articles to all the sample articles (a divided by b); the diversity is inferred from the number of countries and institutions participating in international co-authored articles (c). The coupling is also analyzed to examine the detail of diversity in the country level (d).

The years of the diffusion of the Internet connectivity among scientists in Japan was estimated with host count of .ac domain that was assigned to higher education institutions based on data provided by Japan Network Information Center (JPNIC, 2001) and other supportive literature. Host count in partner countries based on data of Réssaux IP Européens (RIPE, 1992) and Internet Software Consortium (ISC, 2001) were also collected as a reference.
The establishment of database interfaces using the Internet was estimated with the availability of data search / analysis tools for GenBank developed at the National Center for Biotechnology Information (NCBI). GenBank was selected because it is one of the most widely used large-scale databases by molecular biologists and well known for its international collaborative sharing data with EMBL (European Molecular Biology Laboratory Data Library) and DDBJ (DNA Data Bank of Japan). In addition, since the NCBI assumed responsibility of GenBank in 1992, replacing LANL (Los Alamos National Laboratory), many kinds of advanced tools using the Internet have been developed and provided by NCBI.

The change of both indicators (i.e., productivity and diversity) is examined with the specific years of the diffusion and establishment of the Internet technology for international collaborative research in molecular biology (e.g., WWW interface for GenBank in 1994; email among Japanese researchers in 1996). Other related factors (e.g., the number of the entire articles in the selected journals as the indicator of growth of science; funding and policy for research and development in participant countries). Data indicating the diffusion and establishment of the related Internet technology and other factors derived from existing data sources are also discussed for comparison.

The time span was expanded from the pilot study in order to cover the years when the Internet email was diffused among large universities in the U.S. (around the late 1980s and early 1990s) as the major counterpart of international collaborative research and gradual establishment of interface for genetic databases from the early 1990s. The number of journals was also expanded, so that the journals to which Japanese researchers frequently contribute were included (Institute of Scientific Information, 1990).
Survey

The second method was a survey. The purpose of the survey was to figure out the mechanism of international collaboration and the degree of contribution of information technology, including the Internet, in actual international collaborative research in molecular biology between Japanese and other scientists. An evaluation of various information technologies relying on the Internet in scientific research was also asked for to see how researchers have recognized the importance of these information technologies for their research.

The study population was the corresponding authors of the international co-authored articles published in 1999, which was derived from the preceding analyzed article data after eliminating the cases of corresponding authors unspecified (154), authors duplicated (21), and email unavailable (5). 321 scientists out of 501 articles were chosen as candidate subjects.

An invitation letter and a questionnaire were prepared both in English and Japanese (Appendix 2-1, 2-2) for the convenience of the major population of expected respondents (138 or 42.3% in the U.S.; 116 or 35.6% in Japan). The letter was sent out by email and the survey was done on the Web, since the author assumed that scientists invited were familiar with online communication and the Web interface and preferred participating in an online survey rather than a paper based survey. Saving time (e.g., entering the response data; waiting for postal mailing) was also an important advantage of an online survey. Other features to encourage the response for the survey based on exchange theory (Dillman, 1978) were: 1) personalization (i.e., including information
about each article in the invitation letter); 2) establishment of trust (e.g., emphasizing anonymous procedures); and 3) reward (i.e., an emphasis on the study’s academic and practical value as a contribution to the growth of science; 5 US dollars or 500 Japanese Yen gift certificate for an online bookshop in the U.S. or Japan for respondents who wish to accept it)

The questionnaire consisted of four parts: 1) the facts about the international collaborative research which resulted in the article involved in the invitation letter; 2) the evaluation of information technologies in aspects of scientific research in molecular biology and international collaboration; 3) demographic information including experience of international collaboration research; 4) optional comments. Part 1 included questions about factors which necessitate international collaboration, a research topic initiator, a team organizer, financial source, communication tools and various information technologies (e.g., databases, data analysis tools) used in the research. The Internet was not emphasized or directly included in the specific questions, since the author assumed that the Internet was hardly isolated from application by the scientists due to the Internet’s contributions to the variety of components. Specific tools or databases were included in the questions instead of “the Internet”; the result was analyzed considering several components of information technology to which the Internet contributes.

The invitation email was sent out to the 321 corresponding authors on March 2, 2001 after the approval of the Academic Affairs Institutional Review Board of the University of North Carolina at Chapel Hill, which reviews studies including human subjects. Another email, which included a reminder note and copied email, was sent on
March 11 and 12, 2001 to all the scientists except to those who had given their name in order to receive a gift.

By the due date set on March 17, 2001, 84 responses (27.4%) out of 307 candidates (14 were unreachable because of invalid address) were delivered to the author’s email account. Inputs were analyzed using Microsoft Excel and SPSS for manipulation and statistical analysis.
SIGNIFICANCE OF THE STUDY

A quantitative study on international collaboration with affecting factors, especially the Internet, focusing on the particular field and the country based on the latest data is needed, because: 1) there is no quantitative study focusing on the relationship between international collaborative scientific research and the Internet; 2) there is no study working with the nature of a particular scientific field and the scientific research environment in the country.

Furthermore, a survey of the researchers participating in international collaborative research is important because the result provides previously unknown facts: how affecting factors, including the Internet, work in the actual research and how those factors are recognized among participating researchers.
LIMITATIONS OF THE STUDY

The study involves several limitations as follows.

International coauthorship as evidence of international collaboration has the limitation that the nationality of the author’s affiliation is not the same as “research nationality.” For instance, it is common that Japanese scientists study and do research at institutions overseas. Their articles with scientists in the institutions overseas were not counted as international co-authored articles.

By the same token, it is hard to determine the nationality of survey respondents. The nationality was asked as countries in which the respondents’ affiliated institutions were located at the time of the international collaborative research, applying the same definition of international coauthorship.

International collaboration is discussed on an individual research level in this study. International collaboration on a higher level, such as the Human Genome Project, working on shared databases is not directly considered. Thus, the contribution of the Internet used for the higher-level projects (i.e., exchange of a large set of data on a daily basis between shared databases) is not included.

The study dealt with molecular biology and Japan as a focused scientific field and a country. Therefore, the result will not apply to all other fields and countries.
**FINDINGS**

**Findings of the bibliometrics study**

Bibliographic data of 5623 articles including 1755 international co-authored articles published in 20 molecular biology journals in 1989, 1991, 1993, 1995, 1997 and 1999 with at least one author whose affiliated institution was located in Japan were derived from SCI database and were analyzed. The number of articles of each title is shown in Appendix 1.

Host count data of the Internet in Japan and partner countries and chronological data on the availability of GenBank database tools were collected from other sources and analyzed in comparison with bibliometrics results.

**The number of articles with a Japanese author**

The number of articles continuously increased in both categories (i.e., international co-authored articles; Japan only articles) during the period 1989-1999 (Figure 1), while the ratio of international co-authored articles to all Japanese articles increased from 22.3% to 33.7% except for one decrease between 1995 and 1997 (Figure 2)
Of overall growth rate during the period, the increase of international co-authored articles is much larger than Japan only articles (i.e., International co-authored articles + 503.6%; Japan only + 239.3%; all +298.1%)
The number of countries

The average number of countries per article slightly increased from 1.25 in 1989 to 1.43 in 1999. The majorities are one-country articles (= Japan only articles) and two-country articles as shown in Figure 3. Among international co-authored articles, the majority are two-country articles (80.7%).

![Figure 3. The number of articles by the number of countries per article](image)

The ratio of solo-country articles decreased from 77.7% in 1989 to 68.3% in 1999, while the ratio of duo-country articles increased from 19.8% to 27.2%. One exception of this tendency is shown between 1995 and 1997 (Figure 4). The ratio of solo and duo country articles is correlated with the ratio of international co-authored articles respectively (Pearson correlation is significant at the 0.01 level [2-tailed]).
Countries of corresponding authors

Corresponding author’s countries depending on the location of affiliated institutions increased from 8 in 1989 to 18 in 1999. The U.S. and Japan are the top two corresponding author's countries: 39.5% (US), 39.0%(Japan) through 1989/1999. The US has been the top since 1995 (Figure 5). The number of articles of which the corresponding author is affiliated a U.S. institution is correlated with the number of international co-authored articles (Pearson Correlation is significant at the 0.01 level [2-tailed]).
Participant countries

The participant countries in international co-authored articles including at least one Japanese institution increased from 12 in 1989 to 43 in 1999.

The U.S. is the top partner country, participating in 73.7% of international co-authored articles through 1989/1999. The number of the U.S. participation continuously increased (Figure 6); however, the ratio of the U.S. participation gradually decreased from 77.1% in 1989 to 73.3% in 1999 with a remarkable drop from 76.3% in 1995 to 67.9% in 1997. The number of U.S. participation is correlated with the number of co-authored articles (Pearson Correlation is significant at 0.01 level [2-tailed]).
The number of institutions per article

The number of institutions per article increased from 2.29 in 1989 to 3.28 in 1999 with one decrease between 1995 and 1997. In three categories of participant institutions (i.e., Japanese institutions in Japan-only articles; Japanese institutions in international co-authored articles; institutions of other countries in international co-authored articles), the number of Japanese institutions in Japan-only articles shows a similar change (Figure 7).

The number of institutions in each category (e.g., Japanese institutions in international co-authored articles) is correlated with the number of co-authored articles (Pearson Correlation is significant at 0.01 level [2-tailed]).
**Diffusion of the Internet in Japan and partner countries**

There is no consistent established measurement of the Internet diffusion in all the participant countries and Japan through the study period from 1989 to 1999; however, the number of hosts can supply one of the indicators that imply the diffusion.

Although JUNET (Japan Unix Network) was established using UUCP in 1984 and connected to the NSFNET in 1989 (Zakon, 2000), the number of hosts in Japan was relatively small until 1995 (3,343); a rapid increase has been seen after that especially in 1996 (10925, +226.8%) (Table.1). Meanwhile, a supplementary governmental budget in fiscal year 1993 (April 1993 – March 1994) for the establishment of LAN encouraged...
national research institutions to have Internet connectivity. This measure resulted in that all 99 of the national universities established LAN with Internet connectivity by March 1995 (Chiba University Library, 1994).

Table 1 also shows that the number of “ac.jp” domains assigned to the Internet hosts in higher educational institutions in Japan reached over 600. This fact implies that most universities in Japan (approximately 600) had an Internet host in 1996. Thus, the year when the Internet diffused in Japanese research institutions is recognized as 1996.

In the partner countries other than the U.S., the rapid increase of hosts around 1996 is seen also in Figure 8, which includes the top ten participant countries and Japan through out the study period (1989-1999). The data for Japan, USA, Australia, and Canada in 1993 and 1994 are missing because of no public availability of data. For the U.S. the figure includes only .edu domain which is assigned to an educational institution as a reference.

In the U.S., the birthplace of the Internet, National Science Foundation (NSF)’s establishing five supercomputing centers to provide high-computing power in 1986 led to the explosion of connections, especially from universities (Zakon, 2000). And now, even though other countries have increased their Internet connectivity, the U.S. still keeps an overwhelming majority of hosts. The total number of hosts in the U.S. in 1999 is estimated at 40,364,185 which represents 55.8% of world’s hosts, based on the

<table>
<thead>
<tr>
<th>Year</th>
<th>.ac.jp</th>
<th>Growth</th>
<th>Total</th>
<th>Growth</th>
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<td></td>
<td>770</td>
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<td>359</td>
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<td>1995</td>
<td>533</td>
<td>48.5%</td>
<td>3343</td>
<td>105.3%</td>
</tr>
<tr>
<td>1996</td>
<td>791</td>
<td>48.4%</td>
<td>10925</td>
<td>226.8%</td>
</tr>
<tr>
<td>1997</td>
<td>1099</td>
<td>38.9%</td>
<td>27262</td>
<td>149.5%</td>
</tr>
<tr>
<td>1998</td>
<td>1427</td>
<td>29.8%</td>
<td>51927</td>
<td>90.5%</td>
</tr>
<tr>
<td>1999</td>
<td>1808</td>
<td>26.7%</td>
<td>107181</td>
<td>106.4%</td>
</tr>
<tr>
<td>2000</td>
<td>2266</td>
<td>25.3%</td>
<td>214148</td>
<td>99.8%</td>
</tr>
</tbody>
</table>

* Source: JPNIC http://www.nic.ad.jp
assumption that 70% of three domains internationally used (i.e., com, net, org) are located in the U.S. (Internet hakusho, 2000).

![Figure 8. The number of hosts in partner countries and Japan](http://www.ripe.net; ISC http://www.isc.org)

**Establishment of molecular biology database interface using the Internet**

To establish the timeline for molecular biology database interfaces using the Internet, historical facts on data access and handling tools for using GenBank developed by the NCBI were collected. Table 2 shows the tools with the interface and years in which the tool became available after the responsibility for GenBank moved from LANL to NCBI in 1992
Most services using the Internet began in 1992 when the center started the service and the Web interface have been applied since 1994 when the center launched the Web services. NCBI has encouraged scientists to use online tools over the Internet especially the Web interface and discontinued the “standalone” type of software and data distribution; however, a conventional tool (i.e., Sequin software for preparation of much sequence data for email submission) remains due to the size of the file. Standalone and network client software are available online for download as well as data itself.

**Verification of operational hypothesis for bibliometrics study**

From the findings of the bibliometrics study, operational hypotheses 1-3 were verified with existing data on the growth of the Internet. Hypothesis 4 is verified in the findings of the survey.

*Hypothesis 1:* The ratio of international co-authored articles has increased according to the growing number of articles as an outcome of international collaborative scientific research.

Partly accepted. Although the “number” of international co-authored articles has continuously increased beyond the growth of total number of articles (503.6% and
298.1% respectively), the ratio shows one decrease between 1995 and 1997. It seems that other factors affect the ratio of international co-authored articles, since the decrease corresponds to the decrease in two-country articles while there is an increase in one-country (=Japan-only) articles and to the decrease in U.S. participation and the decrease of the average number of participant institutions in Japan-only articles. Moreover, the decrease of the major partner U.S. participation could be considered a result of the continuous decline in expenditures on research and development through 1991-1994 (Payson, 1999), while there was a consecutive four-year increase of Japan’s research and development expenditure (Statistics Bureau & Statistics Center, 1999) endorsed by the Japan’s new Science and Technology Basic Plan (Science and Technology Agency, 1996).

The timing of the decrease is different from the pilot study, perhaps because of the much smaller size of the sample in the pilot study (5,263 articles from 20 journals vs. 1,459 articles from ten journals).

**Hypothesis 2:** The increase of the ratio of international co-authored articles has followed the establishment of shared database interface using the Internet rather than the diffusion of Internet email as a human communication tool in Japan.

It is unclear what factors are related to these effects. First of all, it is difficult to distinguish the timing of diffusion of Internet email and the establishment of shared database Internet interface for Japanese scientists, since both of them seem to have been brought into Japan almost at once around 1996. Shared database Internet interface had already been available, for instance GenBank could be searched by email or a network...
client, and accept sequence data submission by email since 1992; however, those tools were meaningless if there was no Internet connectivity.

Other than international co-authored articles, the rapid increase of Japan-only articles between 1995 and 1997 can be considered as the influence of the availability of Internet interface for using molecular biology databases; however, this is also difficult to isolate from other affecting factors.

**Hypothesis 3:** The variation of participant countries in the international co-authored articles has grown with the diffusion of the Internet both as a human communication tool and as a shared database interface.

This is also unclear. As described in the finding on participant countries, partner countries have increased from 12 to 43 and many countries increased their participation in the international co-authored articles with Japanese scientists; however, it is hard to say that it has been associated with the diffusion of the Internet communication tool and/or shared database Internet interface. There is no one single point of sudden increase in the number of countries or the number of participation for each country. In addition, the U.S still mostly occupies the highest share of participant countries in the international co-authored articles. For instance, England has increased participant articles with Japanese authors from 4 in 1989 to 48 in 1999 in number and 4.8% to 9.6% in share; however, the U.S. also increased participation and keeps the highest share (77.1% in 1989 and 73.3% in 1999)
Findings of the survey

84 responses (27.4%) out of 307 were analyzed on: demographic characteristics; necessities of international collaboration; research topic initiation and team organization; funding; communication tools; use of databases and other information technologies; evaluation of databases and information technologies. Comments from 28 respondents including three email communications and excluding logistical information were also analyzed within each topic and with an additional part on “comments on international collaboration and information technology in molecular biology.” Hypothesis 4 was verified mostly based on the findings of the evaluation of information technology.

Demographic characteristic

The mean age of 84 respondents is 43. The nationality of respondents was asked as countries in which the respondents, affiliated institution was located at the time of the international collaborative research in the survey. As shown in Table 3, the majority were in Japan 40 (47.6%) followed by the U.S. 21(25.0%). It should be noted that the distribution of countries is different between the respondents and the study population (i.e., corresponding authors of 501 international co-authored articles published in 1999 including at least one institution located in Japan).

For instance, in the study population authors who are affiliated with a Japanese
institution or a U.S. institution are 187 (36.3%) and 212 (42.3%) respectively. Some findings are analyzed with an adjustment index to correct this discrepancy.

Table 4 shows the variation of respondents’ titles. Major titles fall into the “faculty” category (41.7%); most of the rest are titles indicating an administrative status (e.g., director, head, chief, leader) (22.6%) or a research position (21.4%). For visiting status, 13 (15.5%) respondents were in a visiting position (i.e., seven in Japan; six in other countries). It is notable that ten research fellows (11.9%) are corresponding authors, although the position is considered temporary for training in general and that only six of them answered the position as visiting.

Experience in international collaborative research was asked as number of publications other than the article included in the invitation letter.

Table 5 shows that most respondents (81, 96.3%) have been involved in international collaborative research publications. Over one third of respondents have been involved in “10 or more” (36.6%) beyond the author’s expectation, while another one third (30.5%) marked “1-3.”
Experience of visiting Japan was asked only of respondents whose residency was not Japan at the time of the research. Almost half (19 out of 41, 46.3%) have visited Japan most for attending a conference (19 out of 19, 100.0%) or visiting research (nine of 19, 47.4%)(Table 6).

### Factors which necessitated the international collaboration

Figure 9 shows the degree of factors which necessitated the collaborative research in two levels (i.e., multiple institutions and multiple countries) to distinguish collaboration within a country and international collaboration. Scores are the average of responses with 5 as the most likely. In multiple institutions, “to share research techniques and skills”, “to share human ideas and thoughts”, “existing personal network” are the top three factors followed by “the research topics” and “to share research data.” The rest of the factors (e.g., to share workforce, to share financial support) didn’t gain more than “3“ which was considered neutral. On the multiple countries level, the ranking is almost the same except “existing personal network” replaces the top, while the scores for all the factors are relatively lower. As an example of the personal network, a comment from one Japanese respondent mentioned that his previous faculty positions in the U.S. resulted in the international collaborative research.

<table>
<thead>
<tr>
<th>Purpose of visiting Japan</th>
<th>% (N=41)</th>
<th>% (N=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visiting research</td>
<td>9</td>
<td>22.0%</td>
</tr>
<tr>
<td>Conference</td>
<td>19</td>
<td>46.3%</td>
</tr>
<tr>
<td>Pleasure</td>
<td>4</td>
<td>9.8%</td>
</tr>
<tr>
<td>Other*</td>
<td>3</td>
<td>7.3%</td>
</tr>
</tbody>
</table>

*1 Visit former fellows  
*2 Discussing experimental plans and exchanging ideas  
*3 Post Doc position
Other factors added by respondents with high scores are shown in Table 7; the top two rows are related to sharing research materials (4 respondents); in logistical factors

Table 7. Other factors which necessitated the international collaboration

<table>
<thead>
<tr>
<th>Factor</th>
<th>Institutional</th>
<th></th>
<th>International</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needs for specific specimens, reagent, or tools</td>
<td>3</td>
<td>5.0</td>
<td>2</td>
<td>5.0</td>
<td>5</td>
</tr>
<tr>
<td>Pooling experimental resources and samples</td>
<td>1</td>
<td>4.0</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>To facilitate further cooperation</td>
<td>1</td>
<td>5.0</td>
<td>1</td>
<td>5.0</td>
<td>2</td>
</tr>
<tr>
<td>An existing training program for scientists</td>
<td>4</td>
<td>4.0</td>
<td>3</td>
<td>4.3</td>
<td>7</td>
</tr>
<tr>
<td>Funding</td>
<td>2</td>
<td>4.0</td>
<td>1</td>
<td>5.0</td>
<td>3</td>
</tr>
<tr>
<td>Needs for native English speakers</td>
<td>1</td>
<td>5.0</td>
<td>1</td>
<td>5.0</td>
<td>2</td>
</tr>
<tr>
<td>By chance</td>
<td>1</td>
<td>5.0</td>
<td>1</td>
<td>5.0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12</strong></td>
<td><strong>4.4</strong></td>
<td><strong>9</strong></td>
<td><strong>4.8</strong></td>
<td><strong>21</strong></td>
</tr>
</tbody>
</table>

“Training program” (4 respondents) seems to correspond to the fact that the respondents include ten research fellows.

Research topic initiator and team organizer

About in two thirds of the research, the topic was initiated by an individual researcher (69.0%) and the team was organized also by an individual researcher (66.3%).
Although not all the research initiated by an individual was organized by an individual, the majority is still a research with an individual initiator and organizer (54.2%). (Figure 10)

![Figure 10. Research topic initiator and team organizer](image)

Most initiators and organizers are affiliated to institutions in Japan or in the U.S. (Table 8). The percentage has been adjusted by the adjustment index calculated based on the discrepancy between the study population and respondents. In comparison with corresponding authors’ countries, the ranking is similar, while the percentage of all the countries are relatively large. The reason may be considered that countries, which have

<table>
<thead>
<tr>
<th>Country</th>
<th>N</th>
<th>%</th>
<th>% (Adj)</th>
<th>N</th>
<th>%</th>
<th>% (Adj)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>48</td>
<td>64.0%</td>
<td>53.7%</td>
<td>39</td>
<td>59.1%</td>
<td>48.8%</td>
</tr>
<tr>
<td>USA</td>
<td>23</td>
<td>30.7%</td>
<td>48.0%</td>
<td>21</td>
<td>31.8%</td>
<td>49.1%</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
<td>8.0%</td>
<td>7.6%</td>
<td>5</td>
<td>7.6%</td>
<td>7.8%</td>
</tr>
<tr>
<td>England</td>
<td>10</td>
<td>13.3%</td>
<td>7.4%</td>
<td>5</td>
<td>7.6%</td>
<td>7.2%</td>
</tr>
<tr>
<td>Germany</td>
<td>4</td>
<td>5.3%</td>
<td>5.6%</td>
<td>7</td>
<td>10.6%</td>
<td>4.7%</td>
</tr>
</tbody>
</table>
much smaller share are excluded in the survey due to the lack of respondents.
Interestingly, at least 5.9% (53.7-48.8%) of the research was initiated by Japanese
scientists and scientists in another country organized the team.

**Funding**

Funding source was asked as six categories as shown in Table 9. The major type is
governmental sources (Japan 57.2%; other countries 48.8% in adjusted percentage). The
majority of other countries’ governmental funding (32 studies, 48.8%) is the U.S.
governmental funding (20 studies, 41.4%).

<table>
<thead>
<tr>
<th>Table 9. Funding source</th>
<th>N</th>
<th>%</th>
<th>(N=83) Adj %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japanese government</td>
<td>56</td>
<td>67.5%</td>
<td>57.2%</td>
</tr>
<tr>
<td>Other government</td>
<td>32</td>
<td>38.6%</td>
<td>48.8%</td>
</tr>
<tr>
<td>Other public funding in Japan</td>
<td>3</td>
<td>3.6%</td>
<td>-6.7%</td>
</tr>
<tr>
<td>Other public funding in other countries</td>
<td>19</td>
<td>22.9%</td>
<td>33.2%</td>
</tr>
<tr>
<td>Private funding in Japan</td>
<td>11</td>
<td>13.3%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Private funding in other countries</td>
<td>11</td>
<td>13.3%</td>
<td>23.5%</td>
</tr>
</tbody>
</table>

**Communication tools**

Figure 11 shows the average score for each communication tool used for the
research based on the frequency in three situations (i.e., within the institution, between
multiple institutions, and multiple countries). Email is most frequently used in
international communication, marking the highest score of 4.8, and also highly used
even within the institution (3.8). The scores of face-to-face meetings make a contrast
with the scores of email from 3.7 for intra-institutional communication to 1.8 for
international communication. Interestingly, fax is still used for international
communication and the telephone is used for communication between multiple institutions relatively higher than 3.0, the neutral score.

![Figure 11. Communication tools](image)

Other communication tools added by respondents are shown in Table 10. Virtual meeting includes net meeting and videoconference within an institution. Meetings and conferences might fall into face-to-face meetings; however, as one respondent said in a comment, organized meetings or conferences should be distinguished from talking with each other in general. This may imply that organized meetings are opportunities to create personal networks for collaboration. The need for couriers is corresponds to the

<table>
<thead>
<tr>
<th>Table 10. Additional communication tools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Single institution</strong></td>
</tr>
<tr>
<td><strong>Multiple institution</strong></td>
</tr>
<tr>
<td><strong>Inter-national</strong></td>
</tr>
<tr>
<td><strong>N</strong></td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>virtual meeting</td>
</tr>
<tr>
<td>meetings; conferences</td>
</tr>
</tbody>
</table>

Courier | 1 | 5.0 | 3 | 3 | 2.7
needs for experimental materials mentioned as factors which necessitate the collaborative research in the previous part.

**Use of databases and other information technologies**

Figure 12 shows databases and other information technology tools used for the research. Literature databases are used for most research (85.7%) as well as biological databases (78.6%). The category “biological databases” is a combination of “genome databases” and “other databases” in original categories in the questionnaire (see the note of the end of this part). Attachment email is also used at a high rate (77.4%). From the fact of high use of biological databases, it is easily imagined that attachment email is used mostly for exchanging data, not only for actually editing the draft of the paper. Use of data search/analysis tools (61.9%) supports this assumption for “data-oriented” fields of science. Other logistical use of tools based on information technology are relatively low (e.g., submission to a conference or a journal).
The specific databases are listed in Table 11 and 12. In literature databases, MEDLINE is the top (58.3% of all the respondents; 68.1% of literature database users).

Based on the fact that only 52 respondents out of 72 who used literature databases didn’t mention the specific databases, the percentage could be adjusted that 80.7% of all the respondents used MEDLINE.

In biological databases, GenBank and NCBI databases including GenBank are the ones used in many cases.

Those percentages can be adjusted into 68.0% and 61.6% respectively in the same manner as MEDLINE. The minority of EMBL (Europe) (only one respondent) is understandable from the demographic characteristics of respondents (i.e., Japan or U.S.);

<table>
<thead>
<tr>
<th>Table 11. Literature databases</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>MEDLINE</td>
</tr>
<tr>
<td>BIDS*</td>
</tr>
<tr>
<td>BIOSIS</td>
</tr>
<tr>
<td>CAS</td>
</tr>
<tr>
<td>Web of Science</td>
</tr>
</tbody>
</table>

* Bath Information and Data Services, UK

<table>
<thead>
<tr>
<th>Table 12. Biological databases</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>DNA and RNA sequence databases</td>
</tr>
<tr>
<td>GenBank</td>
</tr>
<tr>
<td>DDBJ (DNA Database of Japan)</td>
</tr>
<tr>
<td>EMBL</td>
</tr>
<tr>
<td>EST database (a division of GenBank)</td>
</tr>
<tr>
<td>Protein structure database</td>
</tr>
<tr>
<td>PDB (Protein Data Base)</td>
</tr>
<tr>
<td>Human gene databases</td>
</tr>
<tr>
<td>GDB</td>
</tr>
<tr>
<td>OMIM</td>
</tr>
<tr>
<td>Integrated database site</td>
</tr>
<tr>
<td>NCBI</td>
</tr>
<tr>
<td>Organism specific databases</td>
</tr>
<tr>
<td>Arabidopsis thaliana database (plant genome sequence)</td>
</tr>
<tr>
<td>C. elegans database (Web)</td>
</tr>
<tr>
<td>RGP (Rice Genome Project) database</td>
</tr>
<tr>
<td>Saccharomyces Genome Database</td>
</tr>
<tr>
<td>Wormbase (Web)</td>
</tr>
</tbody>
</table>

4 Since 94.2% of 52 respondents mentioned MEDLINE, the same percentage of all literature database users (72) are considered MEDLINE users. 94.2% of 72 equals to 80.7% of 84 respondents.
however, DDBJ in Japan is somehow less used (21.2% in adjusted percentage) in spite of the fact that the majority of respondents are Japanese and three sequence databases (i.e., GenBank, EMBL, DDBJ) exchange their data on a daily basis. Perhaps the slight difference of those databases, accessibility to NCBI from anywhere via the Internet and “Entrez,” a search and retrieval system for integrated NCBI databases, encourages scientists to use GenBank instead of other databases.

The magnitude of database use for each research cannot be estimated from the number of users. For instance, protein structure databases and human genetic databases have relatively small users, maybe because of the width and popularity of the research area compared to sequence databases at this point. Organism specific databases have only one user for each due to the specificity of the database.

The most frequently used interface for both kinds of databases is the Web, although many respondents did not specify the interface. For instance, 31 use the Web, 2 use telnet, and 16 use unknown interface for MEDLINE; 16 use the Web, 1 use telnet, and 15 use unknown interface for GenBank.

Data search / analysis tools are listed in Table 13. Most tools are used for sequence analysis. BLAST is the most frequently used. The popularity of sequence analysis tools corresponds to the popularity of those databases.

* Note: Original responses on databases and tools looked confused because of the difficulty of districting the four categories (i.e., literature databases, genome databases, other databases, and data analysis/search tools). For instance, “PubMed” can be considered a literature database as an interface to MEDLINE; meanwhile, it has a link to other NCBI databases consisting of DNA/RNA sequences (e.g., GenBank), protein sequence and structures and other data through the integrated system Entrez. It is natural that some respondents listed PubMed as a literature database and some as a genome database. Confusion between
databases and data analysis / search tools was also seen (e.g., Entrez as a genome database). Therefore, the author reorganized databases based on the major characteristic in order to allow one database to be categorized in either of three categories (i.e., literature databases, biological databases, and analysis/search tools). The detail of reorganization is attached in Appendix 3 as a list of databases and tools used in molecular biology with an annotation.

**Evaluation of databases and information technologies**

Table 13. Data analysis / search tools

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>%  (N=84)</th>
<th>%  (N=52)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sequence analysis (DNA, Protein)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLAST (Basic Local Alignment Search Tool)</td>
<td>26</td>
<td>31.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>GeneWorks (Web)</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>GCG (Genetics Computing Group) Package</td>
<td>3</td>
<td>3.6%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Husar (Heidelberg Unix Sequence Analysis Resources)</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>FASTA</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>DNA Strider (local)</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>TFSEARCH (Searching Transcription Factor Binding Sites)</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td><strong>Protein analysis (sequence, structure)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSORT (Prediction of Protein Sorting Signals and Localization Sites in Amino Acid Sequences)</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Dali structure search</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Expasy (Expert Protein Analysis System)</td>
<td>2</td>
<td>2.4%</td>
<td>3.8%</td>
</tr>
<tr>
<td>PHYLIP (the PHYlogeny Inference Package) (Web)</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td><strong>Statistical genetics software</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARLEQUIN</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>MEGA</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>GENETIX</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAAP</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>TIGR (Web)</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Original software</td>
<td>1</td>
<td>1.2%</td>
<td>1.9%</td>
</tr>
</tbody>
</table>

Table 14 is an evaluation of respondents for six kinds of information technologies (two kinds of databases, data handling tool, and three kinds of applications mostly relying on the Internet) in five aspects of research with 1 as the least and 5 as the most important.

In aspects directly related to research effectiveness (i.e., progress and productivity), most information technologies mark high scores (the average scores of all information technologies of both aspects are 4.3 for progress and 4.0 for productivity). It should be
noted that two respondents pointed out the heavy reliance on protein structural databases, which was not categorized in “genome databases.” Web browser also earned a relatively high score (4.2), more than file transfer (3.8), which is also only the application.

For two levels of collaboration (collaboration in general and international collaboration), email and file transfer show high scores corresponding to the actual use seen in the previous part. Seven respondents emphasized the importance of email both as a communication tool and data transfer interface in international collaboration in their comments.

In aspect of diversity, which may contribute to the progress or growth of science, literature database has the highest score (4.0). For overall aspects, email marks the highest point (4.3).

<table>
<thead>
<tr>
<th>Table 14. Evaluation of information technologies</th>
<th>Progress</th>
<th>Productivity</th>
<th>Collaboration</th>
<th>“International”</th>
<th>Diversity</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genome databases</td>
<td>4.3</td>
<td>4.0</td>
<td>3.1</td>
<td>3.2</td>
<td>3.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Literature databases</td>
<td>4.5</td>
<td>4.2</td>
<td>3.3</td>
<td>3.4</td>
<td>4.0</td>
<td>3.9</td>
</tr>
<tr>
<td>Data search / analysis software</td>
<td>4.3</td>
<td>4.2</td>
<td>3.1</td>
<td>3.1</td>
<td>3.6</td>
<td>3.7</td>
</tr>
<tr>
<td>email</td>
<td>4.5</td>
<td>4.1</td>
<td>4.7</td>
<td>4.7</td>
<td>3.5</td>
<td>4.3</td>
</tr>
<tr>
<td>file transfer</td>
<td>3.8</td>
<td>3.6</td>
<td>4.0</td>
<td>4.0</td>
<td>3.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Web browser</td>
<td>4.2</td>
<td>3.8</td>
<td>3.4</td>
<td>3.4</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td><strong>Avg</strong></td>
<td><strong>4.3</strong></td>
<td><strong>4.0</strong></td>
<td><strong>3.6</strong></td>
<td><strong>3.6</strong></td>
<td><strong>3.6</strong></td>
<td><strong>3.8</strong></td>
</tr>
</tbody>
</table>

Since it is common that actual users are likely to evaluate the devices highly, three information technologies (two kinds of databases and a data handling tool) were examined from the cross calculation with the previous results on the use of the technologies. Figures 13-1, 13-2, 13-3 show that the average scores for each technology and each aspect is mostly higher among actual users. One exception is “Genome
databases” for collaboration. The reason may be that “genome databases as successful international collaboration” have been commonly accepted among scientists.

Figure 13-1. Evaluation for Genome databases by users/non-users

Figure 13-2. Evaluation of literature databases by users/non-users
Comments on information technology, international collaboration, and research

Comments from the respondents, which were not mentioned in the previous parts, are: the importance of information technology in general; the advantage of international collaboration for research; and other miscellaneous comments on international collaboration for research.

Seven respondents described the importance of information technologies in terms of both research and international collaboration, emphasizing email as a communication tool (7) and the attachment for data transfer (5). For instance, one respondent described him/herself as an outreach scientist: “I couldn’t publish the article without email and the Web, since I was working in a small hospital which didn’t have a research department or a library” (Japan). Two others also pointed out that the information technologies solved the problem of time difference and cost in collaboration with scientists at a distance (e.g., USA and Europe countries and/or Japan and/or Australia). One respondent mentioned
that “the Internet has made international collaboration as easy as national collaboration” (Japan).

Eight respondents in their comments described the advantage of international collaboration: progress of research (2); productivity of research (2); diversity of research (3); useful to sustain research activity in the international arena (1). One respondent suggested another study on the roles of information technology in the process of creating ideas for scientific research. S/he emphasized that the progress of science depended on scientists’ originality.

One respondent and three non-respondents posted comments on post-doctorate training programs as related to international collaboration. They were wondering if their articles should be considered international collaborative research because they coincidentally involved “international members” related to post-doctorate training programs. In the author’s definition, they are international collaborative research, even though patterns are various (e.g., Japanese post-doctorate research fellow used Japanese affiliation to publish an article with U.S. researchers; Japanese post-doctorate research fellow published an article with U.S. researchers after s/he returned to Japan). In addition, a post-doctorate program seems a good opportunity to form a personal network which is a trigger to further international collaborative research.

**Verification of operational hypothesis**

*Hypothesis 4:* The Internet has been recognized as a necessary utility as a part of information technology for international collaborative research to use a human communication tool and databases among researchers.
From the findings about information technologies relying on the Internet connectivity actually used (e.g., email, databases which need the internet connectivity) and highly evaluated, it is safe to say that the Internet has been recognized as a necessary utility consciously or subconsciously.
DISCUSSION

Why didn’t the outcomes of international collaboration show a sharp increase affected by the Internet, while the results of the survey revealed that information technologies relying on the Internet have been appreciated by molecular biologists? One reason may be a difference of methodology. The outcomes may take much longer to show the influence of the Internet compared to the survey in which scientists tell about the latest research activity highly relying on the Internet. Another reason may be the anonymity of the Internet rather than the applications and complicated aspects in “international collaborative research in molecular biology between Japanese and other scientists.”

This section is a discussion of the relationship between information technology, the Internet and international collaboration in scientific research, responding to the findings from two kinds of data collection (i.e., bibliometrics study on the outcomes of international collaboration and the survey on the use and evaluation of information technologies) in order to reorganize the factors affecting international collaborative research in molecular biology between Japanese and other scientists.
The Internet and information technology

On one hand, the Internet and information technology have some things in common, since a lot of information technologies now relying heavily on the Internet connectivity. This is why it is hard to distinguish the impact of the Internet and information technology committed to the Internet connectivity. On the other hand, the Internet cannot always cover all the components of information technologies. In addition, it seems that other factors aside from information technologies affect international collaboration. This is why the evaluation of information technologies does not always reflect the impact of the Internet on international collaboration.

According to the categories suggested in Science & engineering indicators (NSB, 2000), information technologies can be grouped into four components: 1) human interface devices; 2) communication links (including networks); 3) information processing hardware and software; and 4) storage media. The Internet originally indicated only a standard for data transmission consisting of TCP (Transmission Control Protocol) that ensures complete data transfer and IP (Internet Protocol) that handles data transmission using a particular unit of data called a packet. Thus, the Internet only supports communication links; however, the definition of the Internet has been expanded according to the proliferation of applications using the Internet and accepted in many dimensions. For instance, the Web relying on the Internet is frequently considered as the Internet per se; it can be categorized in not only communication links but also human interface devices and information processing software. Some may believe that the Web is also a storage device, since data can be submitted through the Web interface to the file server or database server. By the same token, as another representative of the Internet
application, email can cover all the components; email is a human interface device to communicate someone or “something” (e.g., databases or machines) through the network to process information and/or store data or information.

The Internet and International collaboration in molecular biology between Japanese and other scientists in four layers

It is also true that international collaborative research in molecular biology between Japanese and other scientists should be considered in different levels of layers: a) research in molecular biology; b) collaboration; c) international collaboration; d) scientific research in Japan.

The following part discusses the Internet supporting the four components of information technology in each of four layers of targeted international collaboration in order to distinguish the factors affecting international collaboration.

The Internet and research in molecular biology

As shown in the results of the survey on the evaluation of information technology in terms of contribution to the progress, productivity and diversity of research, information technology especially related to the “data” (e.g., databases, handling tools, interface for data transfer) is recognized as an important tool in research in molecular biology. In this layer, even email is more likely to be used as a data transfer tool rather than a communication tool, because data is critical in research in this field.

This finding is matched to the description of molecular biology as “data oriented field of science” (Lukkonen, 2000). The NSB (2000) further states that data dependent
research method in molecular biology is one of the major effects of information technology. New scholarly communication model involving “electronic data publishing” begun by the *Journal of the Biological Chemistry* in 1983 must have led further data dependency in the research in molecular biology contributing to the progress and productivity of research with shared databases themselves. Although the relationship such as cause and result may not be determined, it is safe to say that information technology has supported the data oriented science.

It is less easy to understand that information technology contributes to the diversity of research. From the result of higher scores of literature database (4.0) and Web browser (3.7), it is assumed that literature databases and the Web contents make it possible to find research topics underway easily in this context. The diversity is related to the creativity or originality that one respondent suggested as important factors for the progress of science.

In this layer, the Internet is important for researchers to ensure handy and speedy access or data transfer through the network in order to use data stored in shared databases on distant servers. Thus, the Internet works mainly as a communication link component, while processing and storage components are covered by other technologies. In this aspect, the rapid increase of Japan-only articles between 1995 and 1997 can be interpreted as the impact of the Internet diffused around 1996, which made it possible for Japanese scientists to access shared databases and contribute to the productivity of research.
For the component of human interface, the Web as an Internet could have contributed to the research in this layer; however the result of the survey shows relatively lower attention to the Web interface itself.

The Internet and collaboration

The second layer is “collaboration.” In this layer, information technology supports collaborative research mainly as communication and data transfer tools, as email earns the highest scores for collaboration (4.7). File transfer also earns a relatively high score (4.0) in the evaluation in the survey because researchers need to transmit data among collaborators in the “data-oriented” research field. The Internet is necessary as a communication link, which is the “original” component assigned to the Internet particularly in this layer.

While the Internet can be described as a necessary network to conduct collaborative research, it is hard to say whether the Internet “causes” the collaboration in research. The factors which necessitate the collaboration shown in the results of the survey (i.e., “to share skills and techniques “ [4.2]; “ existing personal network” [3.8], and “to share human ideas/ thoughts”[3.7]) are not necessarily related to either the Internet or information technology. A part of the factors may be supported by information technology with the Internet. For instance, to share the skills and techniques, some sort of tools over the Internet can be applied. The other two factors (i.e., personal networks, sharing human ideas and thoughts) can be supported by communication tools over the Internet. However, email may not be perfect. While email works well to keep
human communication, it may be less easy to “create” personal networks with email only. Moreover, face-to-face meetings should be also considered as an important communication tool, as the high usage (3.7) of the direct meeting in a single institution implies the need for this communication mode. Email is highly used just because it is impossible to meet frequently among collaborators at a distance. The point is that different communication modalities are needed in the process of collaboration as Patel concludes his study on computer-mediated collaborative design in medical informatics (1999).

**The Internet and international collaboration**

There are a few comments that indicate that the boundary of international collaboration and collaboration within a country is becoming blurred: ”it was by chance that the groups worked in these particular countries” (Germany); “according to the development of information technology, the distinction between collaboration in general and international collaboration, has been fading out” (USA). In fact, factors which necessitated “international” collaborative research were weaker overall than collaboration in general. If there is still a difference between collaboration in general and the third layer, “international collaboration”, it must be the degree of distance between collaborators and differences of culture (e.g., language, customs) and research environments (e.g., financial support).

In this layer, information technology contributes to shrinking some of the obstacles caused by those distance and differences. Email and data transfer earn the high score in the evaluation of information technologies (4.7 and 4.0 respectively) as they earn
for collaboration in general. In addition to the evaluation, some comments show great appreciation for email in international collaboration contributing to easing difficulties caused by the fairly larger distance and differences (seven as communication tools; five as data transfer tool.

The Internet is crucial particularly as a worldwide standard network which makes communication links much easier in this layer; however, as well as collaboration in general, other modes of communication seem to be important also. Among factors which necessitate the international collaboration, “existing personal network” marks the highest point (3.7) beyond others (e.g., to share research techniques and skills 3.6; to share human ideas and thoughts 3.5). This means that more communication modes should be necessary to create and maintain the personal links which resulted in international collaboration. For instance, one respondent in Canada emphasizes that his/her visit to Japan made him/her have more links with collaborators and more collaborative research. Other than visits to collaborators, organized conferences may be a good opportunity to make personal networks especially between scientists in other countries.

**Scientific research in Japan**

In addition to the distance from the most developed countries, scientific research in Japan in terms of differences of culture and research environments should be considered in international collaboration in this study as the last layer.

The distance, which causes difficulty in conducting international collaborative research, can be solved by information technology supported by the Internet as communication and data transfer tools; however, other factors which affect initiating
international collaborative research seem be separate from information technology and from the Internet.

To make “personal networks” to initiate international collaborative research, multiple modes for communication are needed for scientists in Japan as well as international collaboration layers. Sato (1998), focusing on Japanese aerospace engineers’ information-seeking processes compared to those of the U.S. engineers, reveals the fact that Japanese engineers are likely to make human links attending official opportunities such as conferences and study, research, and collaboration abroad to expand information resources.

Corresponding to Sato’s investigation on Japanese scientists’ activities overseas, a post-doctorate training program seems related to the high scored factor “to share research skills and techniques” which results in international collaborative research. One respondent in Japan recollects, “Research skills have been improved thanks to the training program.” As described in the findings of the survey, some scientists did not think training itself is international collaboration, although collaborative research is likely to occur during or after the program as other scientists describe in their comments. It seems that personal networks created during the training program lead to future collaborative research.

One of the additional factors particularly for Japanese scientists suggested by a respondent was the language barrier. He showed needs of native English speakers to describe the interpretation of experimental data for acceptance by journals. Coleman (1999) also describes the problem of English language as a common obstacle for Japanese scientists at the acceptance for publication.
Another remarkable fact related particularly to Japanese scientists was funding by HSFP (Human Frontier Science Program) as which six respondents suggested as their research funding source. In fact, HSFP is a multinational initiative funding for international collaborative research in basic science in molecular biology and brain sciences mostly supported by the Japanese government, which started accepting the suggestion at the program in G7 summit in 1987. Although the funding was not recognized as a major prior factor for international collaboration, HSFP should be recognized as a positive supportive factor, which encouraged international collaboration in this field for Japanese scientists. The relatively small share of funding other than governmental support in Japan seems not enough to support international collaborative research by Japanese scientists.

**Modeling of the Internet and international collaboration in scientific research in molecular biology**

Figure 14 is a model, which shows the ternary relationship of the Internet, information technology and international collaboration in molecular biology with other factors.

As described in an earlier part of the discussion, the Internet supports information technology basically for the component of “communication links”; however, it is recognized interchangeably as other components such as “human interface”; “information processing hardware and software,” and “data storage.”
The contribution of six information technologies to the progress, productivity, and diversity was recognized in the survey and given an average score “4.3,” while the contribution of information technologies to international collaboration was scored “3.6.”

The contribution of international collaboration to the progress and productivity of science was an assumption from the literature review and not included in the questionnaire in the survey; however, some respondents emphasized this point of view in addition to information technology’s contribution to the progress and productivity of the research: “International collaboration has a great advantage for our science in terms of research effort, speed and information “(Japan); “Both international collaboration and information technology are of paramount importance to my work and also important to sustain current academic activity in the international arena.” (Germany) One respondent pointed out the reverse factor, “Due to the rapid growth of knowledge in molecular biology in these two decades, scientists need more experts to deal with it (Japan).”

**FIGURE 14. The Internet and international collaboration in scientific research in molecular biology**
The model on the ternary relationship shows that the Internet contributes to international collaboration indirectly. It also shows that information technology contributes directly to the factors of the growth of science (i.e., progress, productivity, and diversity of scientific research), while it supports international collaboration and further contributes to the growth of science.
CONCLUSIONS

An empirical study based on bibliometrics and the survey was conducted to examine the roles of the Internet in international collaborative research in molecular biology between Japanese and other scientists.

In the bibliometric study, international co-authored articles with at least one author whose affiliated institution was located in Japan published in 1989, 1991, 1993, 1995, 1997, and 1999 in 20 major journals in the field of molecular biology as the outcomes of international collaboration and Japan-only articles in the same frame were collected. Existing host count data of the Internet by domain names as the diffusion of the Internet and the timeline of GenBank tools as the establishment of the interface for molecular biology databases using the Internet were also collected for the comparison. The outcomes (i.e., 5623 articles including 1755 international co-authored articles) were measured in terms of: 1) the number of international co-authored articles and the ratio to entire articles with a Japanese author in the journals; 2) the number of countries participating in the international co-authored articles; 3) participating countries; 4) the number of institutions per article. The results were further examined with the timing of the diffusion of the Internet and database interface relying on the Internet based on host count and the history of GenBank tools interface.
The findings of the bibliometrics study were: 1) the number of international co-authored articles continuously increased according to the total number of articles; however, the ratio to the total number of articles increases with one decrease between 1995 and 1997. The decrease seems to be related to the rapid increase of Japan-only articles compared to the increase of international co-authored articles during the period and relatively less participation of the U.S. as the major partner country in 1997; 2) a remarkable increase of number or ratio of international co-authored articles was not observed in any year; however, around 1996 when the Internet was introduced into almost all research institutions in Japan, the number of Japan-only articles did increase during the period. This increase may have been related to the spread of the Internet in Japan and database ability using the Internet; 3) participant countries in international co-authored articles with Japanese scientists have increased; however, the synchronization of the introduction of the Internet as a communication tool and database interface was not clear.

The survey was conducted during March 2 – March 17, 2001 by distributing an invitation letter to the Web survey by email to corresponding authors of international co-authored articles published in 1999 in the 20 journals previously selected in the bibliometrics study. 84 inputs were analyzed according to the questions about: 1) the fact of the international collaborative research which resulted in the article involved in the invitation letter (e.g., factors which necessitated the international collaboration, a research topic initiator and a team organizer, financial source, communication tools, various information technologies used for the research); 2) the evaluation of specific information technologies in aspects of scientific research and international collaboration; 3)
demographic information including experience in international collaboration; and 4) optional comments. The Internet was not directly included in the specific questions, since the author assumed that the concept varies from network to applications depending on the respondents.

The findings reveals the following facts: 1) factors strongly affecting the international collaboration were “existing personal network”, “to share research skills and techniques”, and “to share human ideas and thoughts”; 2) international collaborative research was mostly initiated by a single researcher and the team was also organized by a single researcher; 3) major funding resources were the Japanese government, U.S. government, and public sources in other countries; 4) email is the major tool for communication between multiple countries in contrast with face-to-face meeting frequently used in a single institution in the international collaborative research; 5) biological databases, literature databases, attachment email and data analysis/search tools are heavily used information technologies; 6) in the evaluation, most information technologies (i.e., databases, data search/analysis tools, internet applications including email) were recognized for their contribution to the progress, productivity for the scientific research in molecular biology; meanwhile, email and file transfer were recognized for their contribution to collaboration in general and international collaboration in molecular biology research.

From the findings of the two kinds of data collection, the reason that outcomes of international collaboration haven’t shown the clear increase affected by the Internet, despite high degree of use and evaluation of information technologies relying on the Internet in international collaborative research was further examined. One reason may be
that the outcome takes more time to show the influence of the Internet compared to the survey input which reflects the latest research activity relying on the Internet.

Another reason may be the anonymity of the Internet compared to the applications and complicated aspects in “international collaborative research in molecular biology between Japanese and other scientists.” Thus, the relationship between the Internet, information technology and scientific research in molecular biology was further analyzed. First, the Internet was recognized a part of information technology, contributing mostly “communication links” and partly to other three components of information technology: “human interface”, “information processing hardware and software”, and “data storage.” Second, the topic “international collaboration in molecular biology between Japanese and other scientists” was divided into four layers: research in molecular biology; collaboration; international collaboration; and scientific research in Japan.

The further analysis described the roles of the Internet as a part of information technology in each layer compared with other factors besides information technology or the Internet as follows: 1) Research in molecular biology is a data oriented field of science which leads to the dependency on information technology (e.g., databases, interfaces using database, data transfer technologies) partly supported by the Internet; 2) Collaborative research is initiated by factors other than information technology or the Internet. Information technologies may support some factors (e.g., email is useful to keep personal networks, which are likely to be necessary for collaboration); information technologies relying on the Internet are necessary to conduct collaborative research as communication tools and data transfer tools; 3) International collaborative research is initiated by other factors besides information technologies. Information technologies
relying on the Internet are necessary and more appreciated to shrink obstacles due to the larger distance and differences between collaborators; 4) Specific factors related to scientific research environment in Japan and international collaboration were also other than information technologies were post-doctorate programs overseas and funding for international collaborative research in basic research in molecular biology.

The suggested ternary model shows: that the Internet supports a part of information technology components; information technology strongly contributes to the progress, productivity, and diversity of scientific research in molecular biology; information technology also supports international collaboration and further contributes to the growth of science.
REFERENCES


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Liebscher, P., Abels, EG., Denman, DW. (1996). Factors that influence the use of electronic networks and network services by science and engineering faculty in small


### Appendix 1. A list of journals with number of articles

| Title # | Title | 1998 Impact Factor | Location | Publication Indexed in SCI from | Title # | Title | 1998 Impact Factor | Location | Publication Indexed in SCI from | Title # | Title | 1998 Impact Factor | Location | Publication Indexed in SCI from | Title # | Title | 1998 Impact Factor | Location | Publication Indexed in SCI from | Title # | Title | 1998 Impact Factor | Location | Publication Indexed in SCI from | Title # | Title | 1998 Impact Factor | Location | Publication Indexed in SCI from | Title # | Title | 1998 Impact Factor | Location | Publication Indexed in SCI from |
|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|-------------------|---------|---------------------------------|---------|-------|
| 12      | CELL          | 38.668 USA | i-1 (1992-94) | 513 9 1.8% 507 | 1998 All Japan Japan% 1992 |
| 13      | NATURE MEDICINE | 27.057 USA | i-1 (1995-97) | 399- | na na na na na na | 1998 All Japan Japan% 1992 |
| 14      | GENES & DEVELOPMENT | 19.675 USA | i-1 (1997) | 201 2 1.0% 226 | 1998 All Japan Japan% 1992 |
| 15      | NATURE JOURNAL | 13.512 USA | i-1 (1997) | 165 2 1.2% 8491 | 1998 All Japan Japan% 1992 |
| 16      | NATURAL HISTORY | 13.511 USA | i-1 (1996-94) | 399- | na na na na na | 1998 All Japan Japan% 1992 |
| 17      | EMBO JOURNAL | 13.102 USA | i-1 (1992) | 537 24 4.5% 496 | 1998 All Japan Japan% 1992 |
| 18      | MOLECULAR GENETICS | 12.804 USA | i-1 (1995) | 131 3 2.3% 137 | 1998 All Japan Japan% 1992 |
| 19      | AMERICAN JOURNAL OF HUMAN GENETICS | 10.856 USA | i-1 (1992) | 265 5 1.9% 3232 | 1998 All Japan Japan% 1992 |
| 20      | MOLECULAR AND CELLULAR BIOLOGY | 9.503 USA | i-1 (1992) | 712 24 3.4% 724 | 1998 All Japan Japan% 1992 |
| 21      | HUMAN MOLECULAR GENETICS | 9.100 USA | i-1 (1992) | 591 28 4.7% 388 | 1998 All Japan Japan% 1992 |
| 22      | CELL REGULATION | 8.256 USA | i-1 (1992-91) | 399- | 14 1 7.1% 95 | 1998 All Japan Japan% 1992 |
| 23      | MOLECULAR BIOSCIENCE | 8.303 USA | i-1 (1992) | 399- | 212 9 4.2% 2798 | 1998 All Japan Japan% 1992 |
| 24      | STRUCTURE | 7.85 USA | i-1 (1995) | 399- | 25 0 0.0% 153 | 1998 All Japan Japan% 1992 |
| 25      | STRUCTURE WITH FOLDING & DESIGN | 7.70 USA | i-1 (1995) | 399- | 257 10 3.5% 267 | 1998 All Japan Japan% 1992 |
| 26      | PORC METHODS AND APPLICATIONS | 7.70 USA | i-1 (1995) | 399- | na na na na na na | 1998 All Japan Japan% 1992 |
| 27      | GENOME RESEARCH | 7.58 USA | i-1 (1994) | 399- | na na na na | 1998 All Japan Japan% 1992 |
| 28      | BIODIVERSITY | 7.50 USA | i-1 (1994) | 399- | 167 0 0.0% 149 | 1998 All Japan Japan% 1992 |
| 30      | ONCOGENE | 6.303 USA | i-1 (1997) | 225 12 5.3% 333 | 1998 All Japan Japan% 1992 |
| 32      | MOLECULAR BIOLOGY | 6.086 USA | i-1 (1995) | 201 9 4.5% 337 | 1998 All Japan Japan% 1992 |
| **Total** | | | | | | | 1998 All Japan Japan% 1992 | | | | | | | | | | | | | | | | | | | 1998 All Japan Japan% 1992 |

* Title changed (i.e., t13a->t13b; t14a->t14b; t15a->t15b)
Appendix 2-1. Questionnaire in English

(The first page) http://www.ils.unc.edu/~sakay/survey_e.html

Welcome to a web survey on “the role of the Internet and international collaborative 
research in molecular biology between Japanese and other scientists”

You may fill out the form in Japanese from here

Please answer the questions (Q1-17) and click the submit button at the end 
only once by March 17, 2001.

Part 1.

Questions about your international collaborative research, which resulted in the article or the 
conference abstract mentioned in the cover letter (Q1-9).

Q1. To what degree did the following factors necessitate that the research be done by multiple 
institutions?

(Check one for each)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Least Likely</th>
<th>Most Likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) The research topic was suitable for the specific institutions</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>b) To share human ideas and thoughts</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>c) To share research techniques and skills</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>d) To share workforce</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>e) To share facilities</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>f) To share research data</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>g) To share financial support</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>h) Existing personal network</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>i) Existing institutional network</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>j) Higher likelihood of journal acceptance</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>k) Higher likelihood of conference acceptance</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>l) Other (Specify: )</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
</tbody>
</table>
Q2. To what degree did the following factors necessitate that the research be done by institutions in **multiple countries**? (Check one for each)

Least Likely | Most Likely
--- | ---

a) The research topic was suitable for the specific institutions in multiple countries | 1 -- 2 -- 3 -- 4 -- 5
b) To share human ideas and thoughts | 1 -- 2 -- 3 -- 4 -- 5
c) To share research techniques and skills | 1 -- 2 -- 3 -- 4 -- 5
d) To share workforce | 1 -- 2 -- 3 -- 4 -- 5
e) To share facilities | 1 -- 2 -- 3 -- 4 -- 5
f) To share research data | 1 -- 2 -- 3 -- 4 -- 5
g) To share financial support | 1 -- 2 -- 3 -- 4 -- 5
h) Existing personal network | 1 -- 2 -- 3 -- 4 -- 5
i) Existing institutional network | 1 -- 2 -- 3 -- 4 -- 5
j) Higher likelihood of journal acceptance | 1 -- 2 -- 3 -- 4 -- 5
k) Higher likelihood of conference acceptance | 1 -- 2 -- 3 -- 4 -- 5
l) Other (Specify: ) | 1 -- 2 -- 3 -- 4 -- 5

Q3. Who initiated the research topic? (Check one)

1) Individual researcher | 2) Multiple researchers
3) Other (Please specify: )
4) Not known

Q3a. Specify the nationality(ies) of institution(s) with which the person(s) who initiated the topic were affiliated. (Type in all names of the country):

( )

Q4. Who organized the research team? (Check one)

1) Individual researcher | 2) Multiple researchers
3) Other (Please specify: )
4) Not known

Q4a. Specify the nationality(ies) of institution(s) with which the person(s) who organized the team were affiliated. (Type in all names of the country):

( )

Q5. What was the financial source? (Check all that apply)

1) Japanese government
2) Other government (Please specify the country name[s]: )
3) Other public funding in Japan
4) Other public funding in other countries (Please specify the country name[s]: )
5) Private funding in Japan
6) Private funding in other countries (Please specify the country name[s]: )

Q6. To what degree were the following tools used for communication for the research in your **institution**? (Check one for each)

Least frequently | Most frequently
--- | ---

a) Face-to-face meeting | 1 -- 2 -- 3 -- 4 -- 5
b) Email | 1 -- 2 -- 3 -- 4 -- 5
c) Fax | 1 -- 2 -- 3 -- 4 -- 5
d) Telephone | 1 -- 2 -- 3 -- 4 -- 5
e) Letter | 1 -- 2 -- 3 -- 4 -- 5
Q7. To what degree were the following tools used for communication for the research among researchers in your country? (Check one for each)

<table>
<thead>
<tr>
<th>Tool</th>
<th>Least frequently</th>
<th>Most frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Face-to-face meeting</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>b) Email</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>c) Fax</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>d) Telephone</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>e) Letter</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>f) Other (Please specify:</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>g) Other (Please specify:</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>h) Other (Please specify:</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
</tbody>
</table>

Q8. To what degree were the following tools used for communication for the research among researchers in multiple countries? (Check one for each)

<table>
<thead>
<tr>
<th>Tool</th>
<th>Least frequently</th>
<th>Most frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Face-to-face meeting</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>b) Email</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>c) Fax</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>d) Telephone</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>e) Letter</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>f) Other (Please specify:</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>g) Other (Please specify:</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>h) Other (Please specify:</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
</tbody>
</table>

Q9. What kind of tools supported by information technology did your research team use other than communication tools for the research? (Check all that apply)

1) Literature databases (e.g., MEDLINE, BIOSIS)
   → Please specify name and interface (e.g., Web, telnet, CD-ROM)
   ( )

2) Genome databases (e.g., GenBank, DDBJ)
   → Please specify name and interface (e.g., Web, telnet, CD-ROM)
   ( )

3) Other databases including integrated databases (e.g., Entrez)
   → Please specify name and interface (e.g., Web, telnet, CD-ROM)
   ( )
4) Data search/analysis service or software (e.g., BLAST, PC/Gene)  
   → Please specify name and interface (e.g., Web, telnet, email, CD-ROM, PC installed)  
   ( )

5) Attachment email for preparation of a draft or a presentation material.

6) Email for submitting an article to a journal

7) Web interface for submitting an article to a journal

8) Email for submitting an abstract and/or paper to a conference

9) Web interface for submitting an abstract and/or paper to a conference

Part 2.
Questions about your consideration on the relationship between information technology and research in molecular biology (Q10)

Q10. Evaluate each information technology as to its related importance to each aspect of molecular biology research. (Please type the number 1-5, with 1 as the least; 3 as neutral; 5 as the most important.)

A) Progress of investigation
   ( ) a. Genome databases  ( ) b. Literature databases  ( ) c. Data search/analysis software
   ( ) d. Email  ( ) e. File transfer  ( ) f. Web browser

B) Productivity of research
   ( ) a. Genome databases  ( ) b. Literature databases  ( ) c. Data search/analysis software
   ( ) d. Email  ( ) e. File transfer  ( ) f. Web browser

C) Collaboration for research
   ( ) a. Genome databases  ( ) b. Literature databases  ( ) c. Data search/analysis software
   ( ) d. Email  ( ) e. File transfer  ( ) f. Web browser

D) “International collaboration” for research
   ( ) a. Genome databases  ( ) b. Literature databases  ( ) c. Data search/analysis software
   ( ) d. Email  ( ) e. File transfer  ( ) f. Web browser

E) Diversity of research topics
   ( ) a. Genome databases  ( ) b. Literature databases  ( ) c. Data search/analysis software
   ( ) d. Email  ( ) e. File transfer  ( ) f. Web browser

Part 3.
Questions about your participation in the research (Q11-16)

Q11. Country in which your affiliated institution was located, when you did this research
   1) Japan  2) U.S.A.
   3) Other (Please specify the name of the country:  )

Q12. Were you a visiting researcher when you did this research?
   1) Yes  2) No

Q13. Your title in the institution, when you did this research (  )

Q14. Your age, when you did this research (As of 1999, if the research extends more than one year) (  )

Q15. How many times have you ever been involved in an international collaborative research publication other than this research? (Please count based on the number of articles or conference papers published in a journal)
   1) 0  2) 1 to 3  3) 4 to 6  4) 7 to 9  5) more than 10
Q16. Had you ever been to Japan before the research started? (Please answer if your residency is NOT Japan.)
1) Yes
2) No

Q16a. Specify the purpose of the stay or visit in Japan (Please answer if you chose 1) for Q16)
1) Visiting research
2) Conference
3) Teaching
4) Pleasure
5) Other (Please specify:)

Part 4.

Q17. Please type in comments on international collaborative research and information technology in molecular biology or this survey, if you have any.

Thank you very much for your participation in this important study.

Please make sure to click the submit button only once.

Submit

If you wish to start over, click the reset button Reset

Last modified by Yukiko Sakai (sakay@ils.unc.edu):

---------
(The second page) http://www.ils.unc.edu/~sakay/thanks_e.html

Thank you very much for your participation
You may provide your name and email address on the follow-up form
to receive a 5 USD or 500 JPY online gift certificate from Amazon.com or Amazon.co.jp.

Please click the proceed button

Proceed

If you’d rather not receive the certificate, please close the browser window.

Close
Please provide your name and email address, choose the preference (Amazon.com or Amazon.co.jp) on this form and click the submit button to receive a 5 USD or 500 JPY online gift certificate.

Name: _________________________ Email address: _________________________

☐ Amazon.com (US) ☐ Amazon.co.jp (Japan)

Submit

Thank you very much for your participation. The gift certificate will be sent to you by Amazon.com or Amazon.co.jp by email.

Close
Appendix 2-2. Questionnaire in Japanese

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(1ページ目)http://www.ils.unc.edu/~sakay/collaboration/survey_j.html

「分子生物学分野の国際共同研究におけるインターネットの役割
—日本人研究者と海外研究者」アンケート調査

質問は17問で4部門に分かれています。

2001年3月17日までにご記入の上、ページ最後の

「送信ボタン」を一度だけクリックしてください。

パート1.

先生が参加された国際共同研究（お手紙に記入してございます）についてお答えください。（Q1 - 9）

Q1. 該当の研究が「複数の機関」で行われた理由として、以下の項目はどの程度あたっているでしょうか。（各項目につき強さをひとつずつ選んでください）

<table>
<thead>
<tr>
<th>項目</th>
<th>弱い</th>
<th>強い</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 研究課題が特定の機関に適していた</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>b) 研究者のアイデアや考察力の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>c) 研究テクニックや技術の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>d) 研究労力の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>e) 研究施設の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>f) 研究データの共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>g) 研究資金の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>h) 人間的ネットワークが存在していた</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>i) 組織的なネットワークが存在していた</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>j) 雑誌论文の受領の可能性が高い</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>k) 学会発表の受領の可能性が高い</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>l) その他(具体的に：)</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
</tbody>
</table>

Q2. 該当の研究が「複数の国」で行われた理由として、以下の項目はどの程度あたっているでしょうか。（各項目につき強さをひとつずつ選んでください）

<table>
<thead>
<tr>
<th>項目</th>
<th>弱い</th>
<th>強い</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 研究課題が複数国の特定の機関に適していた</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>b) 研究者のアイデアや考察力の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>c) 研究テクニックや技術の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>d) 研究労力の共有のため</td>
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<td></td>
</tr>
<tr>
<td>e) 研究施設の共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>f) 研究データの共有のため</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
</tbody>
</table>
g) 研究資金の共有のため 1 -- 2 -- 3 -- 4 -- 5
h) 人的ネットワークが存在していた 1 -- 2 -- 3 -- 4 -- 5
i) 組織的なネットワークが存在していた 1 -- 2 -- 3 -- 4 -- 5
j) 雑誌論文の受理の可能性が高い 1 -- 2 -- 3 -- 4 -- 5
k) 学会発表の受理の可能性が高い 1 -- 2 -- 3 -- 4 -- 5
l) その他（具体的に：） 1 -- 2 -- 3 -- 4 -- 5

Q3. 研究トピックを提案したのはどなたですか？（ひとつ選択してください）
2) ひとりの研究者 2) 複数の研究者
3) その他（具体的に：）
4) 不明
Q3a. 研究トピックを提案された方の当時の所属組織の所在国はどこですか？（複数の場合
はすべてご記入ください。）

Q4. 研究グループを組織されたのはどなたですか？（ひとつ選択してください）
1) ひとりの研究者 2) 複数の研究者
3) その他（具体的に：）
4) 不明
Q4a. 研究グループを組織された方の当時の所属組織の所在国はどこですか？（複数の場合
はすべてご記入ください。）

Q5. 研究資金はどちらから得られましたか？（該当のものすべてを選択してください）
7) 日本政府機関
8) 海外の政府機関（国名をすべてご記入ください：）
9) 政府機関以外の日本の公共組織
10) 海外の政府以外の公的組織（国名をすべてご記入ください：）
11) 日本の私的組織
12) 海外の私的組織（国名をすべてご記入ください：）

Q6. 該当研究のためのコミュニケーションツールとしてあなたの「機関内」では以下のツール
をどの程度利用されましたか？（頻度をそれぞれひとつずつ選択してください）

<table>
<thead>
<tr>
<th></th>
<th>ほとんど利用しない</th>
<th>頻繁に利用</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 直接会う</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>b) 電子メール</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>c) Fax</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>d) 電話</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>e) 手紙</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>f) その他（具体的に：）</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>g) その他（具体的に：）</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>h) その他（具体的に：）</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
</tbody>
</table>

Q7. 該当研究のためのコミュニケーションツールとしてあなたの「国内」では以下のツールを
どの程度利用されましたが？（頻度をそれぞれひとつずつ選択してください）

<table>
<thead>
<tr>
<th></th>
<th>ほとんど利用しない</th>
<th>頻繁に利用</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 直接会う</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>b) 電子メール</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>c) Fax</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
<tr>
<td>d) 電話</td>
<td>1 -- 2 -- 3 -- 4 -- 5</td>
<td></td>
</tr>
</tbody>
</table>
e) 手紙  1 -- 2 -- 3 -- 4 -- 5
f) その他 (具体的に: )  1 -- 2 -- 3 -- 4 -- 5
g) その他 (具体的に: )  1 -- 2 -- 3 -- 4 -- 5
h) その他 (具体的に: )  1 -- 2 -- 3 -- 4 -- 5

Q8.  該当研究のためのコミュニケーションツールとして「複数国」間では以下のツールをどの程度利用されましたか？（頻度をそれぞれひとつずつ選択してください）

<table>
<thead>
<tr>
<th></th>
<th>ほとんど利用しない</th>
<th>頻繁に利用</th>
</tr>
</thead>
</table>
a) 直接会う | 1 -- 2 -- 3 -- 4 -- 5 |
b) 電子メール | 1 -- 2 -- 3 -- 4 -- 5 |
c) Fax | 1 -- 2 -- 3 -- 4 -- 5 |
d) 電話 | 1 -- 2 -- 3 -- 4 -- 5 |
e) 手紙 | 1 -- 2 -- 3 -- 4 -- 5 |
f) その他 (具体的に: ) | 1 -- 2 -- 3 -- 4 -- 5 |
g) その他 (具体的に: ) | 1 -- 2 -- 3 -- 4 -- 5 |
h) その他 (具体的に: ) | 1 -- 2 -- 3 -- 4 -- 5 |

Q9. あなたの研究チームは、以下の情報技術を応用したツールを使いましたか？（該当のものすべてを選択してください。）

1) 書誌データベース (例. MEDLINE, BIOSIS)
   → データベース名とインターフェース（Web, telnet, CD-ROMなど）をご記入ください。

2) ゲノムデータベース (例: GenBank, DDBJ)
   → データベース名とインターフェース（Web, telnet, CD-ROMなど）をご記入ください。

3) 統合型データベース (例. Entrez)
   → データベース名とインターフェース（Web, telnet, CD-ROMなど）をご記入ください。

4) データ検索・分析サービスまたはソフトウェア (e.g., BLAST, PC/Gene)
   → サービスまたはソフトウェア名およびインターフェース（Web, telnet, email, CD-ROM, PC installedなど）をご記入ください。

5) 論文執筆や学会発表用資料作成のための添付電子メール。
6) 電子メールによる論文投稿
7) Webによる論文投稿
8) 電子メールによる学会発表要旨投稿
9) Webによる学会発表要旨投稿

パート2.
情報技術と分子生物学研究の関係について「お考え」をお答えください。（Q10）

Q10. 分子生物学分野の研究において、以下の情報技術の貢献度を評価してください。（それぞれの見地につき、3を中間として、1から5の点数を選択してください。）
A.研究の進展
( ) a. デノムデータベース ( ) b. 書誌データベース ( ) c. データ検索分析ソフトウェア
( ) d. 電子メール ( ) e. ファイル転送 ( ) f. Web ブラウザ
B.研究の生産性
( ) a. デノムデータベース ( ) b. 書誌データベース ( ) c. データ検索分析ソフトウェア
( ) d. 電子メール ( ) e. ファイル転送 ( ) f. Web ブラウザ
C.共同研究
( ) a. デノムデータベース ( ) b. 書誌データベース ( ) c. データ検索分析ソフトウェア
( ) d. 電子メール ( ) e. ファイル転送 ( ) f. Web ブラウザ
D.「国際」共同研究
( ) a. デノムデータベース ( ) b. 書誌データベース ( ) c. データ検索分析ソフトウェア
( ) d. 電子メール ( ) e. ファイル転送 ( ) f. Web ブラウザ
E.研究トピックの多様化
( ) a. デノムデータベース ( ) b. 書誌データベース ( ) c. データ検索分析ソフトウェア
( ) d. 電子メール ( ) e. ファイル転送 ( ) f. Web ブラウザ

パート3．
該当研究に関連してあなたご自身についてご回答ください（Q11-16）

Q11.研究当時に所属されていた機関の所在国はどちらですか。（ひとつ選択してください。）
　1) 日本　2) 米国　3) その他（具体的に）
Q12.その機関では訪問研究員として所属していましたか？
　1) はい　2) いいえ
Q13.当時の名書きをご記入ください（ ）
Q14.当時の年齢をご記入ください
（研究が複数年にわたる場合は、論文が出版された1999年当時の年齢をお答えください）
Q15.現在までにいくつの国際共同研究出版に参加されましたか？雑誌に掲載された論文の数でお答えください。
　1) 0　2) 1から3　3) 4から6　4) 7から9　5) 10以上
Q16.（日本国籍以外の方のみお答えください。）該当研究が始まる以前に日本にいらしたことがありますか？
　1) はい　2) いいえ
Q16a.日本にいらした目的は何ですか？（Q16で1)はい を選んだ方のみお答えください。）
　1) 訪問研究　2) 学会参加　3) 講義・教育
　4) 観光　5) その他（具体的に）

パート4
Q17. 分子生物学における国際共同研究と情報技術について、あるいは本調査にコメントがある方は、下記のスペースにご記入ください
ご協力ありがとうございました。
送信ボタンを一度だけクリックしてください

送信

回答を空白に戻したい場合はリセットボタンをクリックしてください。リセット

Last modified xx/xx/xx by Yukiko Sakai (ysakai@mindspring.com)
-----
(2ページ目) http://www.ils.unc.edu/~sakay/collaboration/thanks_j.html

ご協力ありがとうございました。
次のページでお名前と電子メールをご記入いただいた方には
Amazon.comの5アメリカドルまたはAmazon.co.jpの500円の

ギフト券を進呈させていただきます。

「次へ」ボタンをクリックしてください。

次へ

(ご希望でない方は、閉じるボタンをクリックしてください。)
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Last modified xx/xx/xx by Yukiko Sakai (ysakai@mindspring.com):
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(3 ページ目) http://www.ils.unc.edu/~sakay/collaboration/name_j.html

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Appendix 3. A list of databases and tools reorganized

<table>
<thead>
<tr>
<th>Name of databases and tools</th>
<th>Annotation</th>
<th>Input as</th>
<th>Count as</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabidopsis thaliana database</td>
<td>Plant sequence database</td>
<td>Genome</td>
<td>Bio</td>
</tr>
<tr>
<td></td>
<td>Bibliographic service for the academic community in the UK including SCI, EMBASE, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIDS (Bath Information and Data Services)</td>
<td>INSPEC</td>
<td>Lit</td>
<td>Lit</td>
</tr>
<tr>
<td>C. elegans genome databases</td>
<td>Organism specific database</td>
<td>Genome</td>
<td>Bio</td>
</tr>
<tr>
<td>DDBJ (DNA Data Bank of Japan)</td>
<td>Sequence databases including literature citations</td>
<td>Genome</td>
<td>Bio</td>
</tr>
<tr>
<td>Entrez</td>
<td>NCBI's search and retrieval system for integrated databases</td>
<td>Other</td>
<td>Bio</td>
</tr>
<tr>
<td>EST (Expressed Sequence Tags) database</td>
<td>A division of GenBank that contains sequence data and other information on &quot;single-pass&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expacy (Expert Protein Analysis System)</td>
<td>DNA sequences, or Expressed Sequence Tags, from a number of organisms.</td>
<td>Genome</td>
<td>Bio</td>
</tr>
<tr>
<td></td>
<td>Protein sequences and structures as well as 2-D PAGE</td>
<td>Other</td>
<td>Tool</td>
</tr>
<tr>
<td>GCG (Genetics Computer Group)</td>
<td>The industry standard for sequence analysis, containing over 130 interrelated software</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDB (Genome Data Base)</td>
<td>programs to analyze nucleic acid and protein sequences.</td>
<td>Genome</td>
<td>Tool</td>
</tr>
<tr>
<td>Japanese Rice Genome Program</td>
<td>Mapping database</td>
<td>Lit,Genome</td>
<td>Bio</td>
</tr>
<tr>
<td>NCBI databases</td>
<td>Organism specific database</td>
<td>Genome</td>
<td>Bio</td>
</tr>
<tr>
<td></td>
<td>Integrated databases (nucleotide sequences, protein sequences, macromolecular structures, whole genomes, and MEDLINE, through PubMed) used via Entrez</td>
<td>Lit,Genome</td>
<td>Bio</td>
</tr>
<tr>
<td>OMIM (Online Mendelian Inheritance in Man) and links to MEDLINE and sequence databases.</td>
<td>A catalog of human genes and genetic disorders containing textual information and references</td>
<td>Lit,Other</td>
<td>Bio</td>
</tr>
<tr>
<td>PubMed</td>
<td></td>
<td>Lit,Genome</td>
<td>Lit</td>
</tr>
<tr>
<td>PDB (Protein Data Bank)</td>
<td>3 dimensional structure of proteins, nucleic acids and other biological macromolecules</td>
<td>Other</td>
<td>Bio</td>
</tr>
<tr>
<td>Roslin Institute Web</td>
<td>Local Web service</td>
<td>Lit</td>
<td>Lit</td>
</tr>
<tr>
<td>Saccharomyces Genome Database</td>
<td>Sequences, maps, literature, name registry of the yeast &quot;Saccharomyces&quot; (US)</td>
<td>Other</td>
<td>Bio</td>
</tr>
<tr>
<td></td>
<td>A repository of mapping, sequencing and phenotypic information about the C. elegans nematode.</td>
<td>Lit</td>
<td>Bio</td>
</tr>
<tr>
<td>WormBase</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Genome=Genome databases  
  Lit= Literature databases  
  Other = Other databases  
  Tool= data handling tools