HUMAN FRONTIER SCIENCE PROGRAM REVIEW

FINAL REPORT

Prepared for:

Human Frontier Science Program

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1. Introduction

The Board of Trustees of the Human Frontier Science Program (HFSP) commissioned the Programme for Policy Research in Engineering, Science and Technology (PREST) at the University of Manchester, KPMG Consulting Inc. (including the former ARA Consulting Group) of Canada, and Professor Akira Goto of Hitotsubashi University to carry out a follow-up review to the evaluation[1] conducted in 1995/96. In addition Mr. Wolfgang Glanzel (RASCI) provided expert input with the bibliometric analysis covered in section 5 of this report.

The objectives of the present study were to:

- Analyze the impact of HFSP on the career paths of grant holders and long-term fellows, using a survey methodology.
- Compare HFSP fellows with a reference group of fellows who obtained fellowships from similar programs.
- Conduct a bibliometric analysis in order to assess the impact of the research produced.
- Evaluate the scientific achievements of HFSP through conducting case studies with grant holders and fellows.
- Design an on-going continuous monitoring system for tracking the impacts of the program.

This report presents the analysis of all but the last item above; the continuous monitoring system will be sent as a separate part of this study to the HFSP Secretariat.

[1] *Summary Report: Evaluation of the Human Frontier Science Program*, 1996.

2. Evaluation Methodologies

A mix of evaluation methodologies was used, summarized below.

2.1 Surveys

There were three surveys - grant holders, long-term fellows, and a reference group for fellows drawn from participants in similar international programs.

2.1.1 Fellows Tracking Exercise

The tracking exercise focused on HFSP long-term fellows since they tend to be more mobile than grant holders. A short questionnaire was sent to 1,252 host laboratory supervisors, mainly via e-mail, regarding individuals holding fellowships in the period 1990 to 1998. This was also backed up with a bibliometric search. In total 548 fellows were tracked.

2.2 Survey response rates and tests

2.2.1 Survey distribution and "individual" response rates

HFSP grant holders and fellows were a census of award holders from 1990 through to 1998 for whom contact data were available. The reference group was sampled by contacting 50 fellows each from similar fellowship programs. These were the EMBO, Humboldt, JSPS and NIH fellowship programs[2]. The list of Fellows' contact names was kindly supplied by the management administrations of these 'reference group' bodies. Surveys were distributed by the last week of August 2000, and various reminders were sent after that. Details on the survey distribution are shown in Appendix B. The "individual" response rates were:

Survey	# Sent	# Returned	Response rate (%)
Grant holders	1,102	356	32
HFSP Long-Term Fellows	548	245	45
Reference Group of Fellows	200	43	22

[2] The reference group comprises the following:
- EMBO (European Molecular Biology Organization) – postdoctoral fellowships for research abroad.
- Alexander Von HUMBOLDT Foundation (Germany) – postdoctoral fellowships.
- JSPS (The Japan Society for the Promotion of Science) – postdoctoral fellowships for research abroad
- NIH (National Institutes of Health – USA) – postdoctoral fellowships

2.2.2 "Project" response rates

All HFSP projects have more than one investigator (Grantee) involved. Thus, for a given project, it is possible that some Grantees did not respond to our survey once they learned another scientist in that project (especially the principal investigator) had responded. Our records enabled us to estimate that we achieved a *65% Estimated Project Response* as opposed to the 32% individual Grantees response rate (mentioned in section 2.2.1 above). This analysis is outlined in Appendix B.

2.2.3 Checking for response bias

Because the response rates were somewhat lower than anticipated, we checked for response bias by contacting a small sample of non-respondents to check that they received a survey, see why they did not respond, and very briefly obtain their opinion of the HFSP grant or fellowship. The bias might be towards respondents (Fellows and Grantees) mainly responding where they have had a good experience with the HFSP and would provide positive feedback, whereas the non-respondents may have had a negative experience and therefore were reluctant to respond. *This was not borne out in the 'non-respondents' test sample and* ***confirmed that there was no bias present****.*

A random *sample of seventy non-respondents* was selected for this short test. This was a group who held HFSP grants and fellowships in the period 1990-1997. From the seventy people contacted by telephone in January 2001 we successfully *spoke to 52 people* (10 Japanese-based, 25 European-based and 17 North American-based). The make up of this sample of 52 people included 30 Grantees and 22 Fellows.

The non-respondents were kindly requested to briefly explain why they were unable to respond to our HFSP survey questionnaires sent to them in August 2000. From the 52 people contacted, five stated that they had not received the questionnaire. The two questions asked and the most commonly cited responses given by the 'survey non-respondents' are shown in Appendix B.

2.3 Case Studies

28 case study targets (both Grantees and Fellows) were contacted and 24 respondents agreed to be interviewed, which comprised 11 grant holders and 13 fellows. Interviews were mainly carried out by telephone. These cases represent scientists in Europe, Japan, and North America.

Cases were drawn from respondents to the surveys who indicated high impacts of HFSP on their careers. The general purpose of these studies was to describe in more detail the scientific achievements of respondents, the importance of HFSP compared to other research funding programs, and the impact of HFSP on the individuals' research projects and on subsequent research projects and programs. Appendices H and I have full reports of these case study findings.

2.4 Bibliometrics

A bibliometric analysis was carried out in order to assess the quality of the HFSP programmes. A full description is found in Section 5 and Appendix J.

Briefly, we set up a database to hold all publications (approximately 1,250 total entries) cited by the Fellows and Grantees in the surveys. This database was then used to study the range of journals that Fellows and Grantees are publishing in, as they were asked to list publications that directly arose from their HFSP project work. On the basis of this list of publications (where we could clearly identify the survey respondent, which was possible to do with the vast majority of entries) we conducted bibliometric analysis for the period 1990-1998 on the basis of the SCI (Science Citation Index) database. Here 12,474 records (comprising Grantees & Fellows HFSP named and non-highlighted publications) were generated for this analysis.

General goals of the exercise were to determine:

- If named HFSP publications exhibit a greater impact over other publications in the same journals;
- If named HFSP publications have a greater impact over other publications by the same authors;
- Compare the degree of international co-authorship for HFSP publications against non-HFSP publications; and
- Manually check a set of core journals for acknowledgements to HFSP.

2.5 Tracking "Home Returnees" Fellows

The extent to which HFSP fellows returned to their home countries after the award terminated was checked at the Year 2000 by carrying out an analysis on a sample of 470 fellows who held HFSP fellowships commencing in the period 1990 to 1997. (This sample group represents 43% of all HFSP fellowship holders contacted from this period). Each fellow's record was checked to establish if the fellow was still employed in the host laboratory country (i.e. country where fellowship was held), employed in a different country to the host laboratory country or employed in his/her home country (country where the fellow has nationality). This is illustrated in section 4.5.5 of this report.

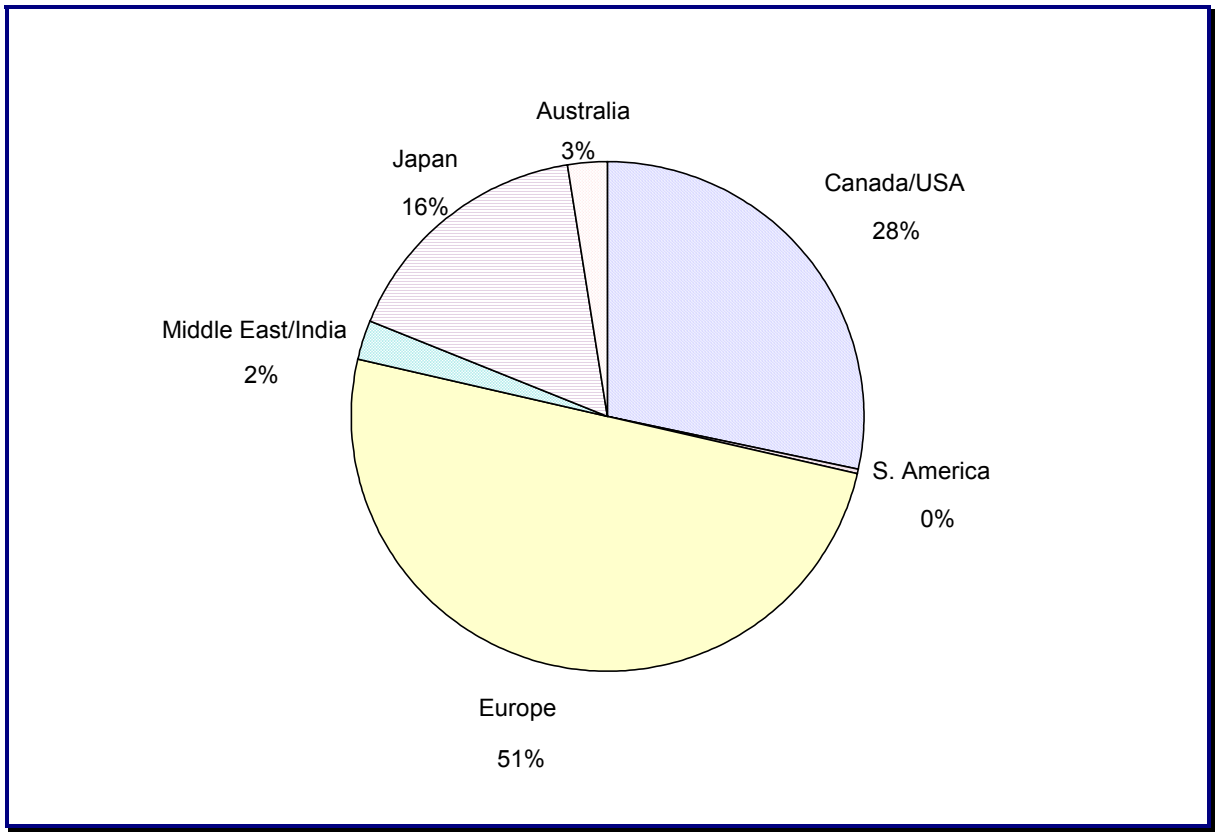
3. The Grants Program

Appendix C provides a copy of the Grantees survey instrument with the statistical data "filled in". Where appropriate, the text contains a note referring to the appendix and question(s) relevant to the discussion. For example, the distribution of the grant holders' responses regarding program reputation is found in Appendix C, question 31—this would be referenced as (C:31).

3.1 Background

As demonstrated by Figure 1, survey respondents originated mainly from three main continents—Europe, North America and Japan, with Europe accounting for over half of the respondents, followed by North America. The median age of respondents was about 45 years. There were very few substantial differences in findings by age group.

Figure 1: Distribution by Continent



3.2 Program Uniqueness

Overall, respondents identified two main features that differentiate the HFSP from other funding programs. The most important feature is the program's support for intercontinental and interdisciplinary research[3], which is very difficult to fund through other granting agencies. Another important feature identified is the flexibility of the program. Other features mentioned, but to a much lesser extent, included supporting young scientists, pursuing high-risk research, the broad intellectual perspective, the prestige of the program, and the amount of funding available.

3.2.1 Intercontinentality and interdisciplinarity—Alternatives to HFSP Grants

The survey results and case studies indicated that HFSP has a unique role compared to other programs in terms of supporting interdisciplinary research and fostering collaborations across continents—this was truly a unique aspect of the HFSP, reported by survey respondents (C:23 open-ended responses).

An overwhelming majority (nearly 90%) of grantees stated that no other program could have funded a similar project in terms of interdisciplinary and intercontinentality as that funded by the HFSP (C:9). In addition, nearly half of respondents indicated that the research could not have been done at all without the support of HFSP (C:10). The average HFSP award was roughly 5.5 times the average funding from all other programs combined that fund intercontinental research (C:14). There were a few differences in responses by continent, as demonstrated by Figure 2. Fewer Japanese respondents (20%) indicated that the research could not be conducted without the support of HFSP than North American and European respondents (over 50%).

About a third of respondents mentioned that similar research could have been conducted, but with different partners. Most of the respondents believed that the collaborations would have been more limited without the support of HFSP, and they stressed that international collaborations would have been very difficult to fund through other national sources (C:10 open-ended responses). Other programs were also criticized for requiring research partners to be found from particular countries to satisfy political balance criteria. These results indicate HFSP has a valuable role compared to other programs in terms of supporting interdisciplinary research and fostering collaborations across continents.

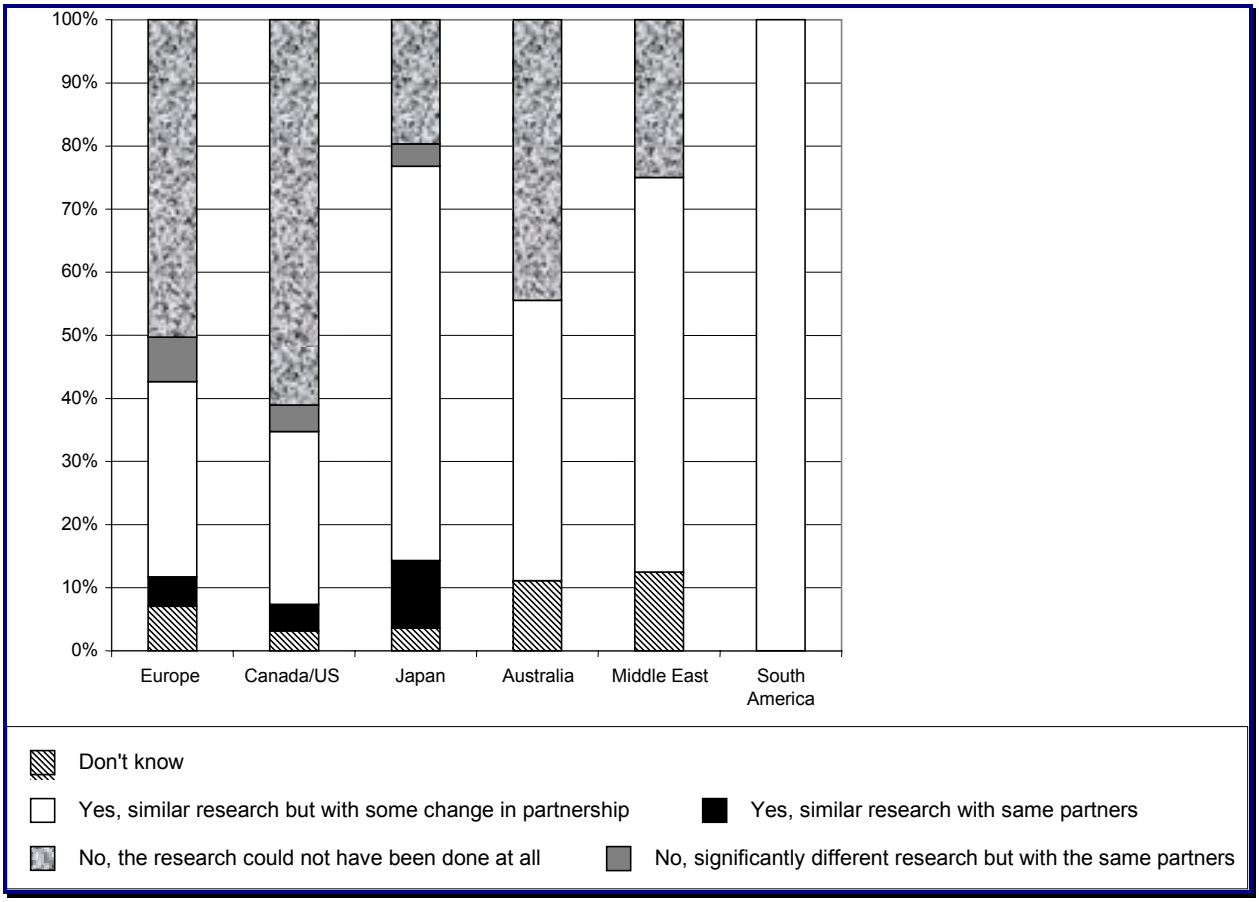
> *"HFSP is unique in being an international programme that does not carry the burden of politics to the same extent that other international programmes do."*

These findings were further validated through the case studies. All interviewees cited collaboration at an international level as the major unique feature of the program. This response was consistent for all respondents based in North America, Europe and Japan. More than half of the Grantees interviewed stated that the opportunity to collaborate with other researchers around the world was one of their major reasons for applying for HFSP grants.

[3] Research that draws upon results and expertise from a number of different scientific disciplines, or even fields.

Several respondents remarked that the HFSP encouraged more face-to-face contact via annual meetings and through the ability to travel to other laboratories, than did other programs.

Figure 2: Impact on Research if HFSP Grant Were Not Obtained



3.2.2 Flexibility

The survey results indicated that flexibility—in particular in the use of funding—was the second most important feature of the Grants program. It was the second most-reported feature considered unique (C:23, open-ended responses), and over 70% of survey respondents noted that the HFSP provided better flexibility in the use of funds compared to national granting agencies (C:21).

The case studies also demonstrated that the program allows flexible use of funding. Respondents noted it was often possible to switch money among salaries, equipment, and consumables as required, which is not possible with many alternative forms of funding. The low level of HFSP bureaucracy was also linked to flexibility: the HFSP is considered unique

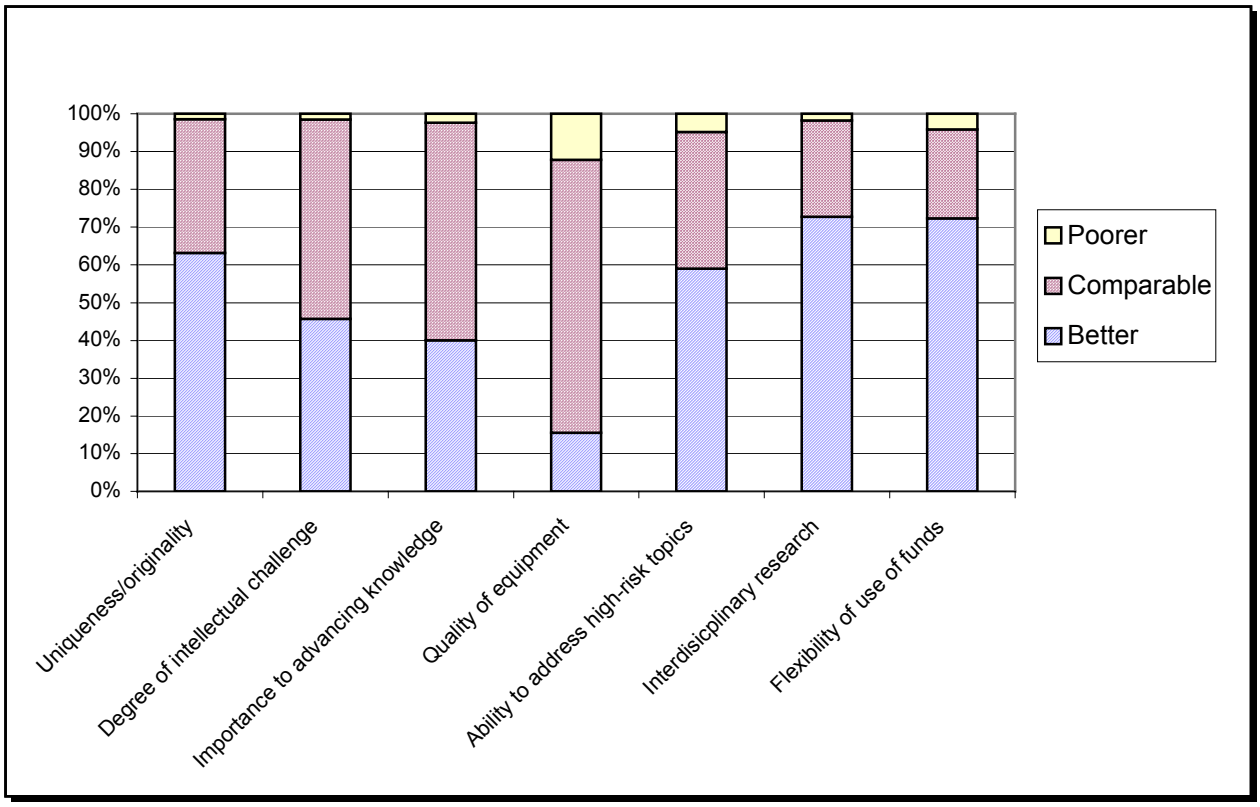
because, compared to most other programs, it does not require a great deal of paperwork for small adjustments to funding.

> *"Flexibility of HFSP. This is really the greatest attraction. For example, you can switch money from salaries to consumables/equipment as required, which is not possible with many government grants."*

3.2.3 HFSP compared to support from other programs

Figure 3 demonstrates that HFSP offers support for research that is at least comparable to—and often better than—that from other similar programs, with the most important aspects being its ability to flexibly support interdisciplinary research, unique and original projects, and high-risk topics (C:21). In fact, roughly a quarter of the grant holders originally began work on this specific research topic because of the HFSP support (C:11). Nor has the program gone "too far" in this regard—virtually all respondents felt that the HFSP was a well-balanced program in terms of funding risky *versus* conservative research (C:32).

Figure 3: Opportunities for Research - HFSP *vs.* Other Programs



3.3 Nature of Collaboration

The Grants program fosters collaboration on two levels:

- Across continents—by allowing researchers from different countries to collaborate and meet face to face; and

- Across disciplines—by encouraging experts from different disciplines to work together to solve complex research problems.

3.3.1 Intercontinentality

The survey results demonstrate that the grants create new, long-lasting and highly-skilled research teams, often working on a problem that could not be addressed without HFSP funding, or working on problems in new ways, with the intercontinental and collaborative aspects of the program being crucial to success. The HFSP brings new research teams together—roughly 60% of the core research team members had not collaborated previously in any significant way (C:15).

The HFSP provides researchers with the opportunity to work with the best in their field regardless of geographic boundaries. Very few other programs, if any, provide this kind of support. It is not surprising that respondents identified the opportunity to work with leading researchers from another continent as the top reason for applying for HFSP funding (C:18).

There was a general agreement in the survey results that this collaboration was either important or critical to the achievement of their own research results (C:16), and that the research conducted through HFSP funding was fully to partially integrated with other research in their laboratories (C:13).

In the case studies, many Grantees confirmed that they would have been unable to carry out their project without HFSP because there were no alternative sources of funding that supported such collaborative projects. Intercontinental collaboration was accepted as being very useful in facilitating links across continental boundaries and generally helping to build a world-wide scientific community in the HFSP research areas.

3.3.2 Interdisciplinarity

General results. The HFSP brings together world-class experts from various disciplines. Almost 90% of respondents described their research as interdisciplinary, with half saying it drew extensively on a number of disciplines (C:19). On average, an HFSP project involved about three different disciplines, and many of these appear to be outside "traditional" fields in brain research. Some of these represent non-life sciences such as physics and engineering, but note that there is an increasing blurring of the lines between life and non-life sciences as principles are applied across disciplines. See Appendix E.1 for all disciplines listed by respondents. Results from the case studies were not as clear-cut. Half of the Grantees interviewed described their HFSP research project as interdisciplinary. For example, areas

like biology, physics and mathematics were mentioned as distinctly separate disciplines that were drawn upon in conducting interdisciplinary research. However, from the remaining half of this sample of Grantees, a few were unsure whether their project could be described as interdisciplinary. One respondent stated that it depends on the definition of discipline; e.g., how narrowly it is defined. Another respondent stated that his project was not interdisciplinary in the sense of bringing together two different subject domains, but it was interdisciplinary in terms of bringing together differing techniques like microscopy, molecular biology and genetics.

Network analysis. To assess the extent and nature of interdisciplinarity in HFSP projects, Grantees were asked to list all of the disciplines involved in their projects. This yielded over 800 responses that were then grouped under 26 disciplines with the kind help of the HFSP Secretariat. From these responses the five most frequently cited disciplines are: molecular biology (40% of respondents); neuroscience (36% of respondents); genetics (34% of respondents); biochemistry (33% of respondents); cell biology (18% of respondents). The remaining 21 disciplines account for lesser proportions.

In order to present a picture of the way in which the 26 disciplines cited in the survey are connected, a network analysis technique was used. Two main assumptions form the basis of the network analysis: first, that disciplines cited by one respondent form relationships; and second, that the data is symmetrical, or in other words that a relationship of the type A-B (e.g., cell biology and physics) is the same as B-A (e.g., physics and cell biology). Thus, to transform the data into a relational format, the responses were paired according to the formulae: if there are columns A, B, C and D then the relationships are AB, AC, AD, BC, BD and CD. This procedure resulted in 681 pairs (or relationships), which were the basis for constructing the matrix. The network analysis software used to analyse the matrix and plot the actual network of disciplines was UCINET IV[4] and KrackPlot[5] respectively.

Exhibit 3.1 shows the degree of centrality for the disciplines as a measure of the number of relationships in which these are with all other disciplines. It can be observed that the five most connected components of the network are: molecular biology (213 connections); biochemistry (159); genetics (148); cell biology (105); and neuroscience (96).

The network consists of 1,362 links, altogether[6]. From this analysis the seven most closely connected pairs of disciplines are: (1) molecular biology and biochemistry; (2) genetics and biochemistry; (3) genetics and molecular biology; (4) cell biology and molecular biology; (5) cell biology and biochemistry; (6) genetics and cell biology; (7) cognitive science and neuroscience. Appendix E.1 shows more detail on the structural relationships among disciplines.

[4] UCINET IV Reference: Borgatti, Everett and Freeman (1992), UCINET IV Version 1.0 Columbia: Analytic Technologies.
[5] KrackPlot Reference: Krackhardt, D., Lundberg, M. and O'Rourke, L. (1993), "KrackPlot: A picture's Worth a Thousand Words", *Connections,* Vol. 16 (1&2): 37-47.
[6] The difference between 'number of pairs' and 'total number of links' can be explained by the treatment of data as symmetrical.

Exhibit 3.1—Degree of Centrality (Number of Relationships) by Discpline

Code	Discipline	Centrality
MB	**Molecular biology**	213
BC	**Biochemistry**	159
GN	**Genetics**	148
CB	**Cell biology**	105
NU	**Neuroscience**	96
BP	Biophysics	60
DB	Developmental biology	57
CSM	Computer science & Mathematics	56
B	Behaviour	53
SB	Structural biology	43
EP	Electrophysiology	41
CS	Cognitive science	41
AN	Anatomy	40
CH	Chemistry	37
IM	Immunology	27
CR	Crystallography	25
I	Imaging	25
PH	Physics	20
EB	Evolutionary biology	20
PR	Pharmacology	17
V	Virology	17
BT	Biotechnology	15
NS	Nuclear studies	14
EN	Engineering	13
PS	Plant studies	12
CO	Cancer & Oncology	8
Total		1 362

3.4 Supporting Young Scientists

The majority of respondents felt that the HFSP supports a mix of well-established researchers as well as young scientist who are trying to build their career, although with some small sentiment that established researchers are favored slightly too much (C:33). (There is very little difference in the breakdown of the responses of Grantees to this question by their age.)

In a number of ways, the program specifically provides better support for younger scientists than other national funding schemes (C:22).

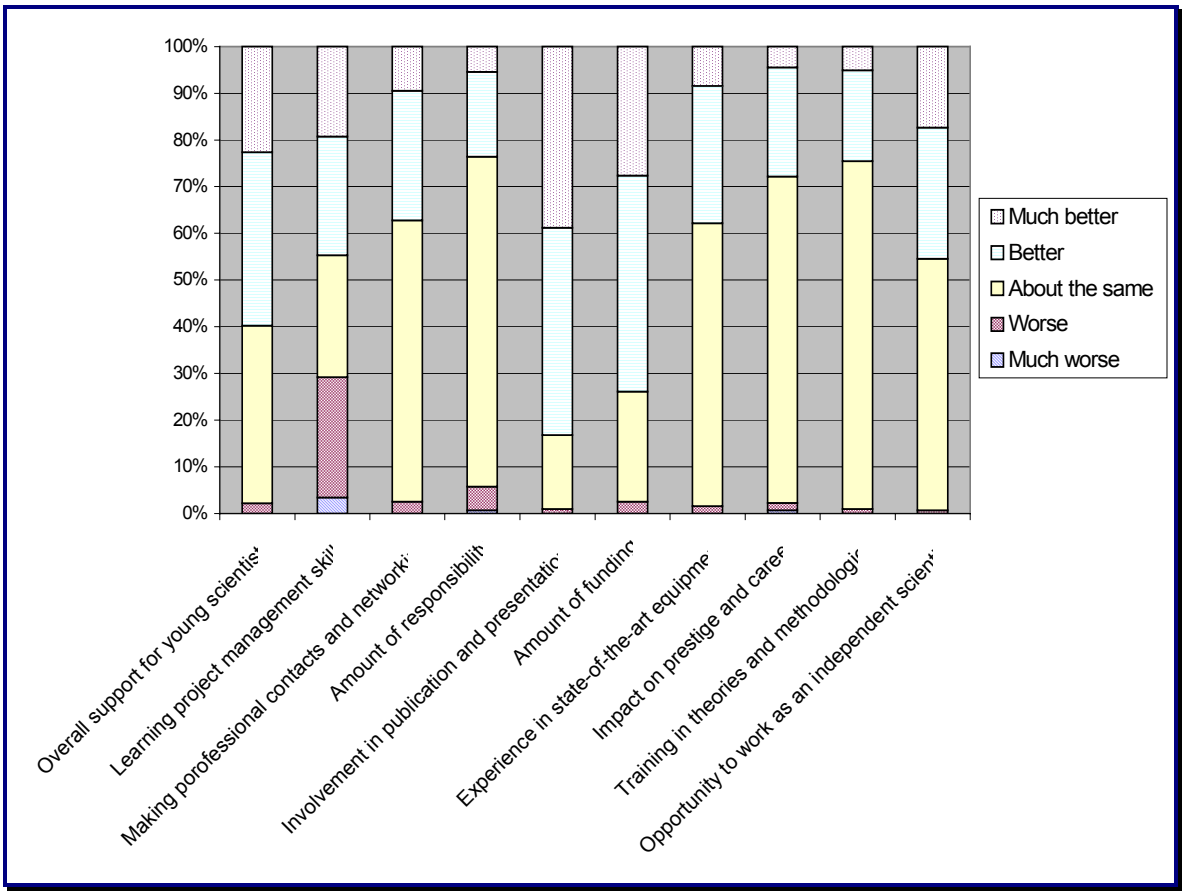
> *"In my view, the most important feature of HFSP projects is the emphasis on multidisciplinary intercontinental research projects. This encourages young scientists to work together and join forces. It establishes groups that can have a stronger impact on the field, and stimulates the investigators intellectually. I think that the sum of such projects, at least from my own experience, is more than the weight of each researcher separately."*
>
> *"HFSP allows young investigators, or those with a very original project to start a project that can have moderate to high risks, but might lead to important new discoveries in a format where international collaboration is essential."*
>
> *"It allows much greater flexibility and an ability to work in a very effective way with international collaborators."*

As shown in figure 4, roughly 60% of respondents felt that the HFSP provided better or much better overall support for young scientists than other granting agencies; only 2% thought it was worse. HFSP's support to junior scientists far exceeded the support of other agencies in terms of their involvement in publication and presentations, as well as in the amount of funding. The only area in which a significant number of respondents believed HFSP was not clearly superior to other agencies was in the area of developing project management skills: almost 30% of respondents felt that the HFSP was either worse or much worse than other agencies in this regard.

The case studies indicated that the HFSP provided strong support to young scientists. Many interviewees (and all fellows) said that support for a younger scientist through both grants and fellowships was a strong component of the HFSP. A common concern highlighted by Japanese respondents was that it is often difficult for younger researchers to apply for HFSP international collaborative research projects. At an early stage of their career, Japanese researchers will not have normally developed extensive international overseas contacts, which can make it more difficult for them to meet international collaborative requirements of the HFSP (e.g. long-term fellowships must be held at an overseas laboratory).

In general, interviewees who were aware of the new program for 'Young Investigators' and the extension of the term for long-term fellowships were very enthusiastic about these mechanisms to support the career development of young researchers.

Figure 4: Supporting Young Scientists - HFSP *vs.* Other Programs



3.5 Outputs And Impacts

3.5.1 Research Outputs and Longer-Term Impacts

The results demonstrate that there is a good mix of scientific outputs from the HFSP projects especially including articles, seminar presentations, and papers published in conference proceedings (C:24). The average number of publications produced with HFSP collaborators is a significant proportion (about a quarter) of the respondents' total output, and roughly half of the total output produced in collaboration with scientists outside the respondents' lab. The impact of these publications in bibliometric terms is described in Section 5. Along with the findings described earlier regarding creation of new research teams and HFSP's impact on total research funding, these results indicate that the HFSP grant is a significant incremental addition to the ability of scientists to work collaboratively.

Although HFSP primarily supports fundamental research, there have been a modest number of "practical" applications to date. These have been mainly in the area of instrumentation used in both medical and non-medical research, with more expected in these and other areas (e.g., a few industrial applications are anticipated) in the next 5-10 years (C:28). See Appendix G for examples of these applications; note that most appear to be in the preliminary stages, as is only to be expected. HFSP intellectual property guidelines have not hampered these applications in any way (C:30).

3.5.2 Quality of the HFSP Research—Case Study Results

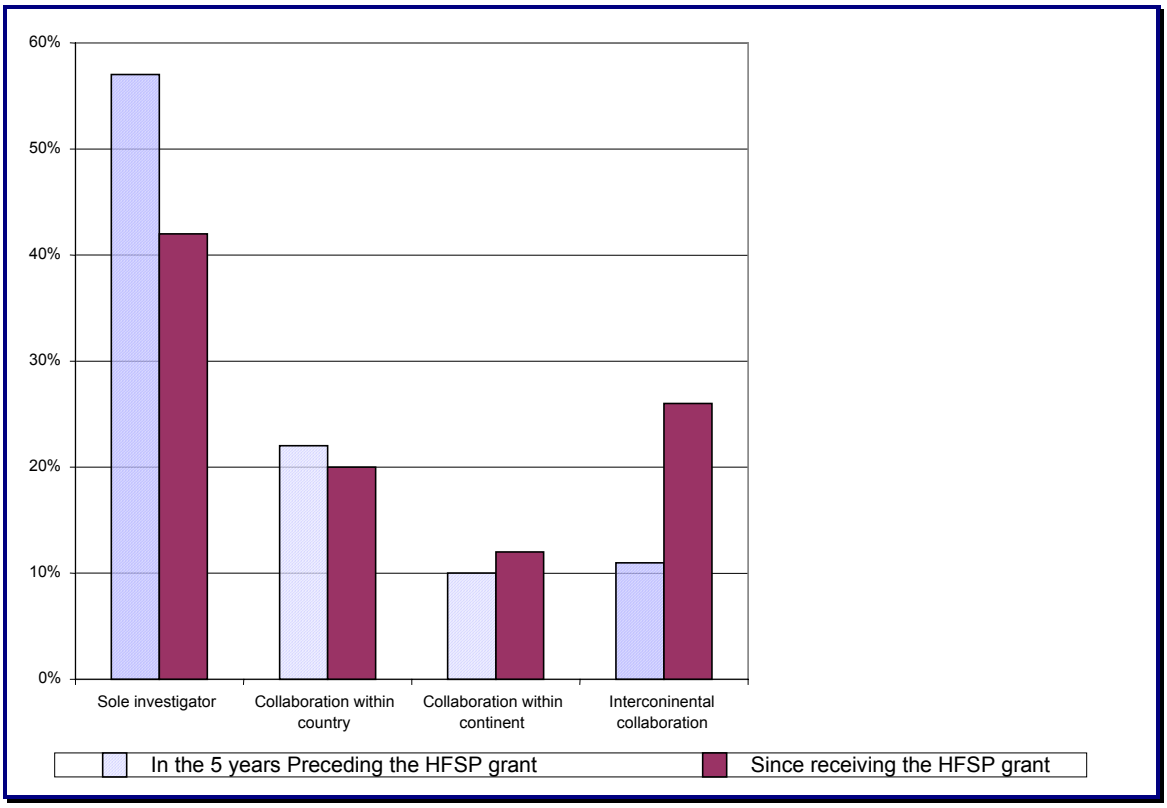
In the case studies, virtually all grantees interviewed stated that the science conducted through the HFSP grant was either significant or very significant. Most of these respondents linked the significance of the science to the quality of the publications accepting the resulting papers, some of which were highly prestigious international journals like *Nature*, *Science* and *Cell*. The number of publications arising from the HFSP project ranged from two to eight in this small sample of grantees.

3.5.3 Impact of HFSP on subsequent collaboration and research

The HFSP has had a substantial long-term impact on intercontinental collaboration between scientists, helping build strong relationships among scientists from different continents. Scientists are more aware of the benefits of intercontinental collaboration, and therefore have become more open to this kind of collaboration. Figure 5 demonstrates that, on average, researchers are carrying out roughly twice as much intercontinental collaboration as they did prior to receiving the HFSP grant (C:12). Almost all grant holders have continued to collaborate formally (50%) or informally (40%) with their former HFSP partners (C:17).

> *"The results of the HFSP collaboration provide the building blocks for two of the most significant lines of my current research."*

Figure 5: Collaboration Before and After HFSP Grant



Some respondents (about 35%) stated that the HFSP has intensified and stimulated collaborations, especially at the international level. They stressed that the HFSP helped them develop international networks and contacts (C:27). However, many respondents (about half) indicated that their subsequent collaborations were limited compared to those supported by HFSP (C:17 open-ended). The lack of non-HFSP funding for intercontinental collaboration diminished the possibility of travel and face-to-face meetings.

The case studies also confirmed the program's impact on collaboration. The majority of Grantees interviewed stated that the HFSP project had increased the international scope of their collaborations. Most respondents were carrying out more collaborative research since completion of their HFSP projects than before, although this was not always at an intercontinental level. About half the interviewees were still either formally collaborating or keeping in touch with their HFSP project collaborators.

Opinions varied as to whether the collaborative aspects of the program helped Grantees to learn more about conducting collaborative research and developing international networks in subsequent projects. The majority of respondents did not feel that the program helped them to learn much in this arena, as at this stage of their career they were already familiar with good practices for collaborative projects. A few mentioned that some collaborating partners on their projects already knew each other, although HFSP had fostered a continuation of this

collaborative link. Although some respondents were positive about how these international networks enabled them to work with other leading researchers in their area, some networks had been developed informally pre-HFSP grant; it appears that HFSP helped solidify and formalize such situations.

3.5.4 Impact on Grant holders' subsequent careers

Most respondents stressed the high impact of HFSP on their research career. The major impacts, roughly ordered from most to least frequent, included (C:27):

- HFSP helped foster and stimulate collaborations with their international peers.
- HFSP helped them discover and pursue new lines of research, and therefore advance their research career.
- HFSP strengthened their reputation and increased their international visibility. Many respondents, for instance, are being invited as guest speakers in international conferences. Others are being invited to sit on advisory and review boards. This in turn has helped grant holders attract more funding.
- The HFSP experience has helped secure an academic position.

> *"Provided crucial funding at any early stage in my career as an independent researcher, to allow me to recruit postdoctoral fellows and to collaborate with well-known researchers in the field in Japan and the USA. This was important for the development and reputation of my laboratory."*
>
> *"Significant impact. I have forged several ongoing collaborations with colleagues inside and outside the HFSP grant and been able to establish my own research projects. In addition, I have obtained an independent academic track position."*
>
> *"The HFSP grant enhanced my ability to start up research in my laboratory and to benefit from the expertise of my collaborators."*
>
> *"HFSP support enabled research to be done that would not have been possible otherwise. It fostered a long-term international relationship with Japanese scientists that continues to be important to this day."*

3.6 Differences by Continent and Country

There are a few interesting differences in the grant holders' responses depending on which continent, in which country, they live: these are summarized in Appendices E.2 and E.3, respectively. The differences in response rates by continent make these results somewhat

harder to interpret, and the results of all questions are not completely consistent internally with each other. However, a general interpretation is that HFSP fills a somewhat similar niche for scientists in Europe and Canada/US, while scientists in Japan have a somewhat different perspective on the program:

- For European, Canadian, and American scientists, HFSP is somewhat more additional, especially in terms of access to new research topics, collaboration, critical mass, etc., but is somewhat less important in terms of the extra funding provided and its superiority to national funding mechanisms (except for ability to address high-risk topics).

- For Japanese scientists, HFSP is more important than national funding agencies with respect to the intellectual challenge of the research, its importance to the field, and in the flexibility afforded by the funding, but is somewhat less additional in its impact on collaboration and critical mass, the ability to work on the same research or on new research topics, and general access to additional funding. There is a feeling that too many established researchers are being funded, and perhaps a bit too much conservative research.

- Although HFSP's reputation is high everywhere, it is slightly higher in Europe, followed by Canada/US, and slightly lower in Japan.

3.7 Suggestions made by Grantees

These suggestions are taken from C:34 and the case studies.

- **The HFSP grants program should continue and be expanded –** About 50% of survey respondents stated that the HFSP program was one of the best in the world. They applauded the program for its various benefits, which included fostering international collaborations, flexibility, friendly HFSP staff and simplicity of procedures. These respondents felt that the program has numerous advantages and that it should be continued and expanded. Many of the interviewees stated that the HFSP has been very successful and it should continue to provide this good service to the international scientific community. These interviewees also suggested that it is important for the HFSP to keep the quality of the science front and foremost, the politics low, and bureaucracy "in check".

- **Provide applicants (both successful and unsuccessful) with feedback** – It would be very valuable for the HFSP to provide applicants with feedback as to why they were awarded or not awarded the grant. A few respondents have criticized the HFSP for the lack of feedback, for instance when they (Grantees from our survey) had not been awarded a project grant in a separate application made to the HFSP with a different set of project collaborators. This issue was also raised in the last evaluation.

- **Build more balanced research teams** – Some respondents suggested that the teams should be more balanced; e.g. half being young researchers and the other half being more experienced researchers. This would ensure that young scientists could benefit from the experience of the more mature scientists.

- **Improve visibility of the program** - A few Grantees commented that the visibility of HFSP in countries like the USA and UK should be improved. If the money could be found by increasing contributions from the national governments then this could help to increase the size and visibility of the program.

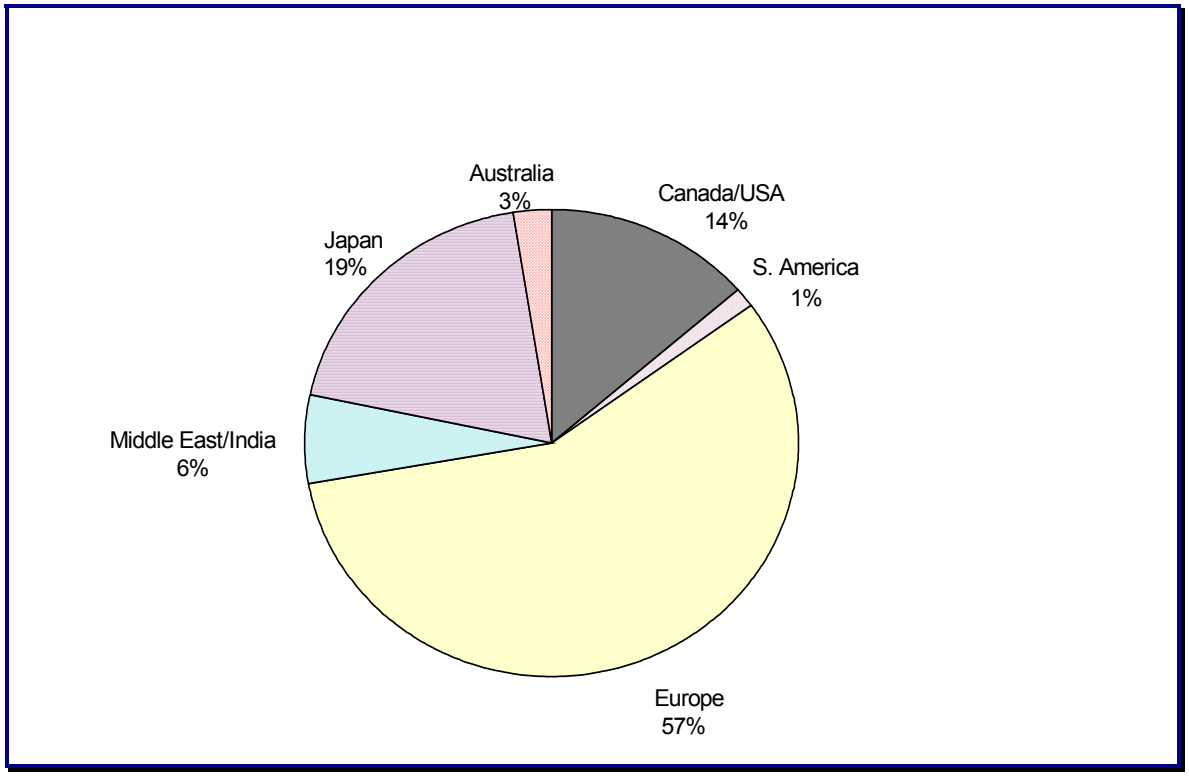
4. The Long-term Fellowship Program

Appendix D provides a copy of the L-T Fellows survey instrument with the statistical data "filled in". References to individual survey results are as for the grantees survey.

4.1 Background

Similar to the grants program, respondents of the fellowship program mainly originated from three continents – Europe, North America and Japan, with Europe accounting for over half of the respondents. However, the distribution of the respondents differs slightly from the grantees' survey. Japan accounted for the second highest source of fellows, followed by North America. Virtually, all respondents were under the age of 45, with a median age of about 30.

Figure 6: Distribution of Fellows Respondents by Continent



4.2 Program Uniqueness

Even though about half the fellows were aware of other programs that could have supported their research (D: 11), fellows preferred the HFSP award. Two-third of fellows had applied to other agencies (to about 70 agencies in total among our respondents) which offer funding for

post-doctoral research at both the national and international levels (D:9). And two-thirds of HFSP fellows were offered funding from at least one other agency. Very few respondents, however, would have preferred another fellowship to their HFSP fellowship. For example, almost one third of the fellows applied to EMBO and two-third of these were offered an EMBO fellowship. Only 2% of these fellows, however, stated that they would have preferred the EMBO fellowship (D:10). These findings were further validated by the case study interviews. One-third of the case study interviewees stated that they had actually switched to a HFSP fellowship some months into an alternatively funded fellowship because of the HFSP's unique features.

In order to further investigate the uniqueness of the fellowship program, we compared it to similar fellowships elsewhere (reference group: EMBO, JSPS, NIH, Humboldt). As demonstrated by the Exhibit 4.1, the HFSP fellowship is very competitive.

Exhibit 4.1—Preferred Program for Fellows

Respondents	Offered other fellowships	Preferred another fellowship
HFSP Fellows	66%	4%
Reference Group Fellows	44%	25%

> *"The reason to switch to HFSP was because it offered better financial remuneration although both EMBO and HFSP have an excellent international reputation. It not only meant receiving a high yearly stipend compared to normal fellowships, but also meant that money was directed into the host laboratory."*

> *"I had to go for an international funding fellowship and this was one of the most prestigious. There were very few alternative sources of international funding available."*

On the other hand, 44% of HFSP fellows indicated that they "definitely" would have obtained a similar research position at the same host laboratory without HFSP support, and another 31% "probably" would have done so (D:13). As demonstrated by Figure 7, this is higher than for the reference group, for which the equivalent figures were about 24% and 29%, respectively.

In addition, Figure 8 indicates that almost three-quarters (73%) of HFSP fellows would have carried out the same research and at the same laboratory without their award (D:14), compared to about 50% of the reference group. The requirement to do different research in a different lab in the absence of the award was thought likely by 30% of the reference group, but only 6% of HFSP fellows. When reading these results, it should be borne in mind that whilst the HFSP survey was based on 245 returned questionnaires from 548 fellows

contacted, the Reference Group survey was based on a more constrained sample of 43 returned questionnaires from 200 people contacted.

Overall, these results indicate the fellowship program is not as additional as the grants program, at least in terms of fellows being accepted and working in the host laboratory, but it is probably superior (in the "value added" sense) to similar fellowships elsewhere since it is the program of choice of the majority of fellows[7]. However, care is needed in interpreting these results. The fact that the majority of HFSP fellows were offered fellowships elsewhere demonstrates that HFSP attracts top-notch applicants. Such individuals would probably not have had difficulty obtaining funding from other sources and a research position at the lab of their choice. Furthermore, there is a difference between additionality and value added. The HFSP fellowship was preferred for good reasons over other funding—fellows chose the HFSP support for reasons such as the HFSP's better level or funding, ability to use the support for both research and travel, HFSP's good reputation, longer duration of the award, etc. (D: 12). Finally, other fellowship programs that focus on the highest-quality scholars are likely to suffer similar problems with additionality[8].

[7] It does, however, suggest that the fellowship program may not have had a tremendous impact in changing the *early* career paths of these individuals—the impacts may be more from the host lab experience itself. There is then an opportunity for HFSP to increase early-stage impacts on young scientists through other means—e.g., through offering scholarships or fellowships to graduate or undergraduate level students, or through outreach to even younger pre-university students, through which individuals who had never considered a research career might be encouraged to follow a scientific career in the medical sciences.

[8] In our review of the scholarships and fellowships programs of Canada's Natural Sciences and Engineering Research Council, for example, we found that the graduate and post-doctoral awards were almost completely non-additional, since they were offered to individuals of such high calibre that they would have been accepted almost anywhere without the award. However, there were other value-added aspects to the awards. The NSERC situation was exactly the reverse for scholarships offered at more junior levels.

Figure 7: Would Fellow Have Obtained a Similar Research Position at Same Lab Without HFSP?

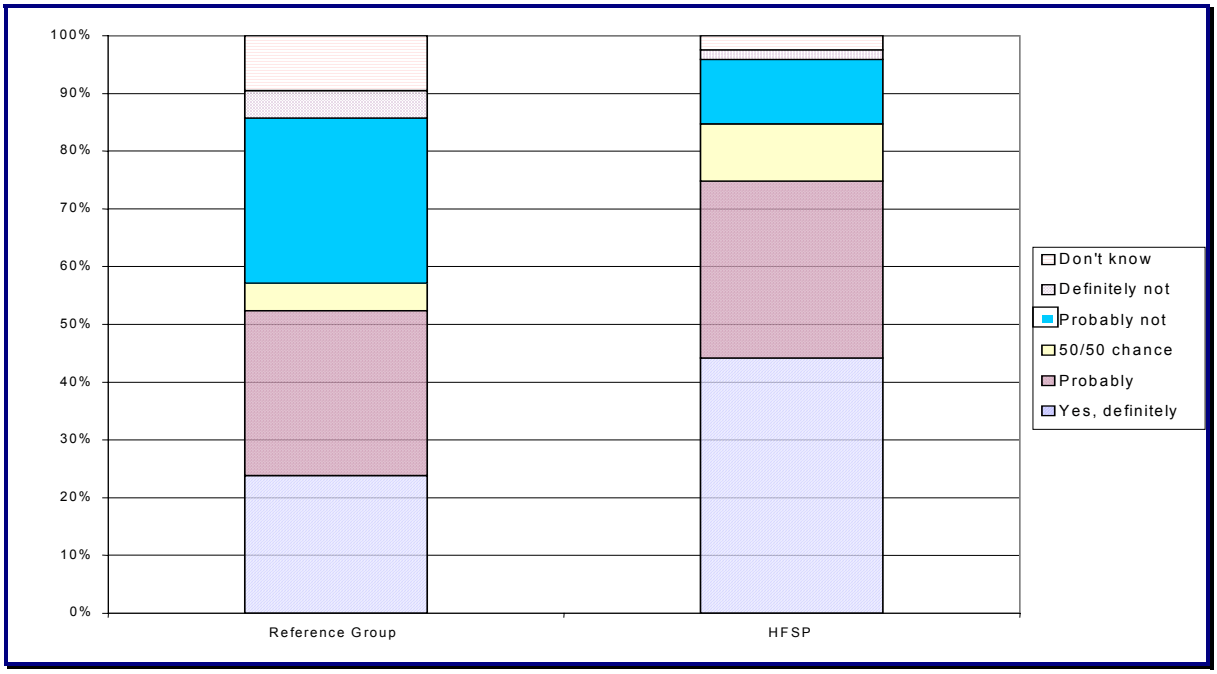
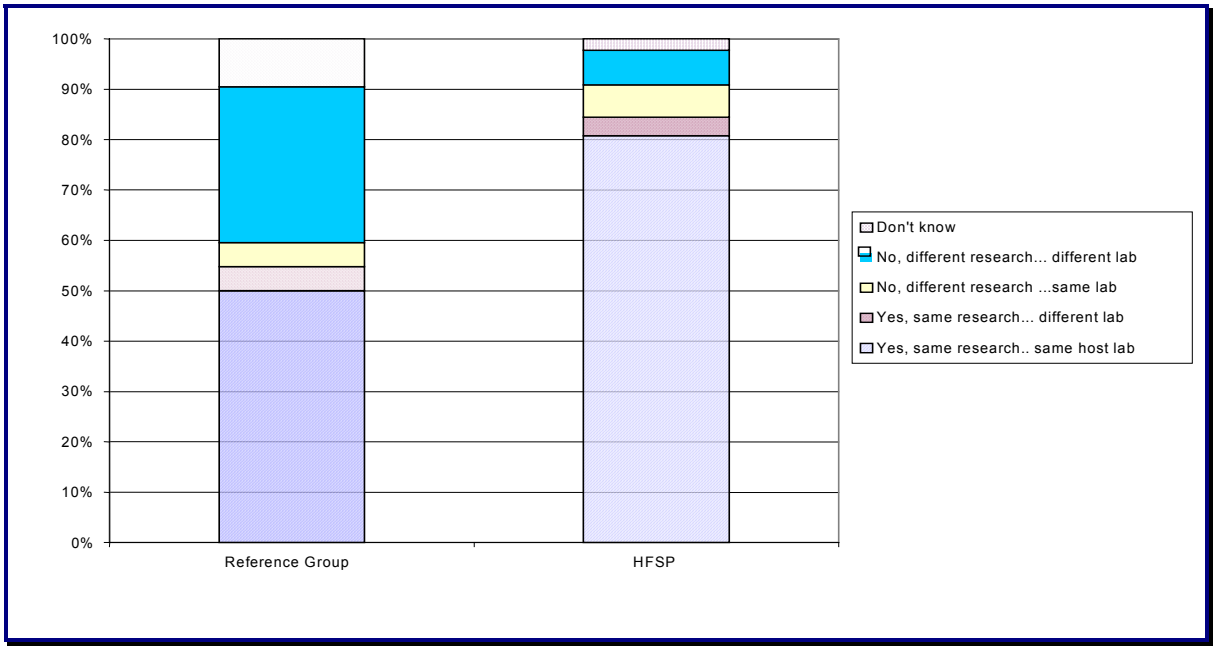


Figure 8: Would Fellows Have Done the Same Research Without HFSP Award?



4.3 Relationship with Host Laboratory

Three quarters of respondents stated that they were not in the host laboratory at the time of application and had had little contact with it (D:16). However, most respondents said that they were familiar with its outputs (D:17). Thus, even more than for the grants program, these awards have helped support the creation of new scientific working relationships.

There was a general consensus that the fellowship research was fully or partially integrated with other research in the host laboratory, indicating an excellent fit between the fellows' research interests and the research conducted at their host laboratories (D:18). The collaboration at the host lab was important or critical to most of the fellows' own research programs (D:19).

4.4 Nature of Research

The HFSP fellowships have played a major role in encouraging interdisciplinary research. The HFSP has achieved comparable and perhaps even slightly better results than similar programs elsewhere. First, the HFSP fellowship has helped a slightly higher proportion of fellows (over 70%) to move to a new area of research (D:21)[9] compared to awards offered by other fellowship programs (60%). See Figure 9. Also see Appendix F for details on how fellows moved into new research areas.

Second, the majority of both HFSP respondents (80%, D:22) and the reference group respondents (78%) described their research as interdisciplinary. However, a slightly higher proportion of HFSP respondents (48%) than reference group respondents (40%) stated that their research drew extensively on more than one discipline. See Figure 10. As noted earlier, it should be borne in mind that the reference group was based on a more constrained sample in comparison to the HFSP sample.

Also the case studies confirmed that the vast majority of HFSP fellows interviewed believed that the science conducted during their HFSP research project was 'very significant'. One important aspect mentioned was that results were published in high impact journals (examples given include 'Nature', 'Science', 'Neuroscience' and 'Cell Biology').

[9] Not surprisingly, this is a much higher figure than the equivalent figure for grant holders (C:11).

Figure 9: Fellowship's Impact on Causing Fellow to Move into New Area of Research

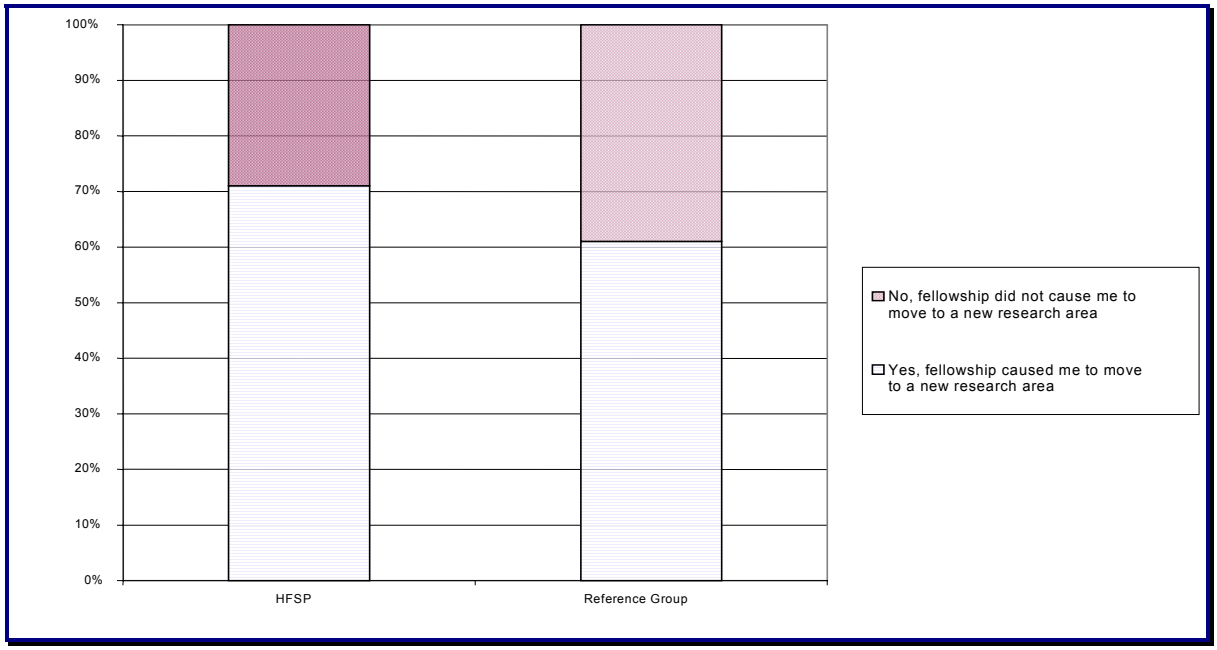
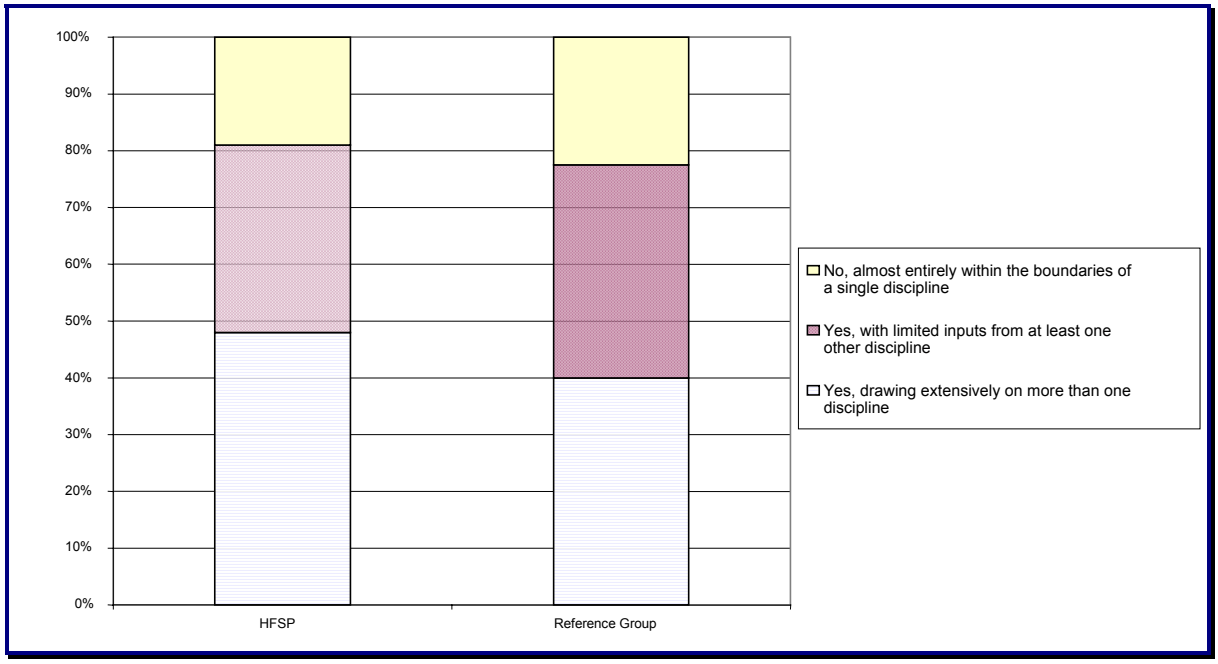


Figure 10: Interdisciplinarity of Fellows' Research



4.5 Outputs and Effects

4.5.1 General impacts of HFSP fellowship

Overall, the experience of working at the host laboratory resulted in a number of benefits to the young scientists. Impacts rated as very important by over half the respondents (D: 23), from most to least frequently quoted, were:

- Opportunity to work with leading scientists;
- Opportunity to work as an independent scientist;
- Impact on prestige and career; and
- Opportunity to enter a new area of research.

> *"The HFSP Fellowship provided the funds and research expenses to work in a fantastic lab where I have learnt a lot and have been able to make many essential contacts and undertake collaborations."*

> *"The HFSP fellowship allowed me to work in a extraordinary laboratory with a very supportive supervisor who taught me independence of thinking and self-confidence. Two crucial qualities for a scientist."*

4.5.2 Research Outputs

The publications output and quality of research conducted by HFSP Fellows in bibliometric terms is described in Section 5. Fellows have contributed to a wide variety of scientific outputs[10], mainly through collaborative activities with other scientists in their host laboratory—over 80% of outputs are produced jointly with the host lab (D:25). These research outputs are essentially equal in nature and quantity as produced by fellows of other similar programs surveyed in the reference group[11]; see Exhibit 4.2.

4.5.3 Impact on subsequent collaboration and research

The fellowship has led to continued and long-term collaborations between the fellows and their colleagues. Virtually all former fellows stated that they maintained some form of contact (e.g., formal, conferences, informal, or through reading their publications) with their host laboratory colleagues (D:30); half maintained formal collaborations such as joint projects. The case study findings also confirm that for two-thirds of the HFSP fellows interviewed, they state that their experience with the fellowship has led to an increase in collaborations at

[10] At a rate roughly one-third that of HFSP grant holders (C:24).

[11] The one notable difference is that HFSP fellows published roughly half as many peer-reviewed articles as single authors or in collaboration with non-host lab scientists (in practice, this probably mainly represents single-authorship).

the intercontinental level and that they are now more interested in forming more collaborative relationships as a direct result of their HFSP fellowship experience.

Exhibit 4.2—Outputs of HFSP and Reference Group Fellows				
	Number jointly authored/produced with host laboratory		Other (singly authored or in collaboration with researchers not in the host laboratory)	
	HFSP Fellows	Reference Group	HFSP Fellows	Reference Group
A. Articles in peer-reviewed/refereed journals	**2.64**	**3**	**0.61**	**1.1**
B. Papers in published conference proceedings	**1.22**	**1.21**	**0.27**	**0.24**
C. Other conference/seminar presentations	**1.98**	**1.81**	**0.33**	**0.17**
D. Other publications (please specify what type)	**0.23**	**0.31**	**0.13**	**0.12**
E. Computer software/dataset	**0.01**	**0**	**0.0**	**0**
F. Any other academic qualification	**0.0**	**0**	**0.0**	**0**
G. Patents/licenses or other intellectual property	**0.06**	**0.02**	**0.0**	**0**
H. Other (please specify)	**0.03**	**0**	**0.02**	**0**
TOTAL	**6.17**	**6.35**	**1.36**	**1.63**
GRAND TOTAL	**7.53**		**7.98**	

In addition, the vast majority of survey respondents stated that their current work is closely or very closely related to the research area/theme of their HFSP fellowship. The few fellows that pursued a completely new area of research noted that it was mainly because their subsequent position did not allow them to pursue the HFSP research topics (D:33).

These results are not surprising since the HFSP fellowship encouraged fellows, early in their career, to freely pursue their research interests even if they were risky. In fact, one third of

respondents stated that the HFSP fellowship contributed to their achievements by allowing them to freely pursue their research interests (D:35).

4.5.4 Impact on fellows' careers and job positions

Almost all ex-fellows are now employed, with the majority holding either a tenured or untenured position with a university (D:31). About 70% of respondents felt that their HFSP fellowship had a moderate to large influence on securing their current position (D:32). There was a wide variety of achievements and indicators of scientific esteem listed by fellows that resulted from the awards, including (D:34):

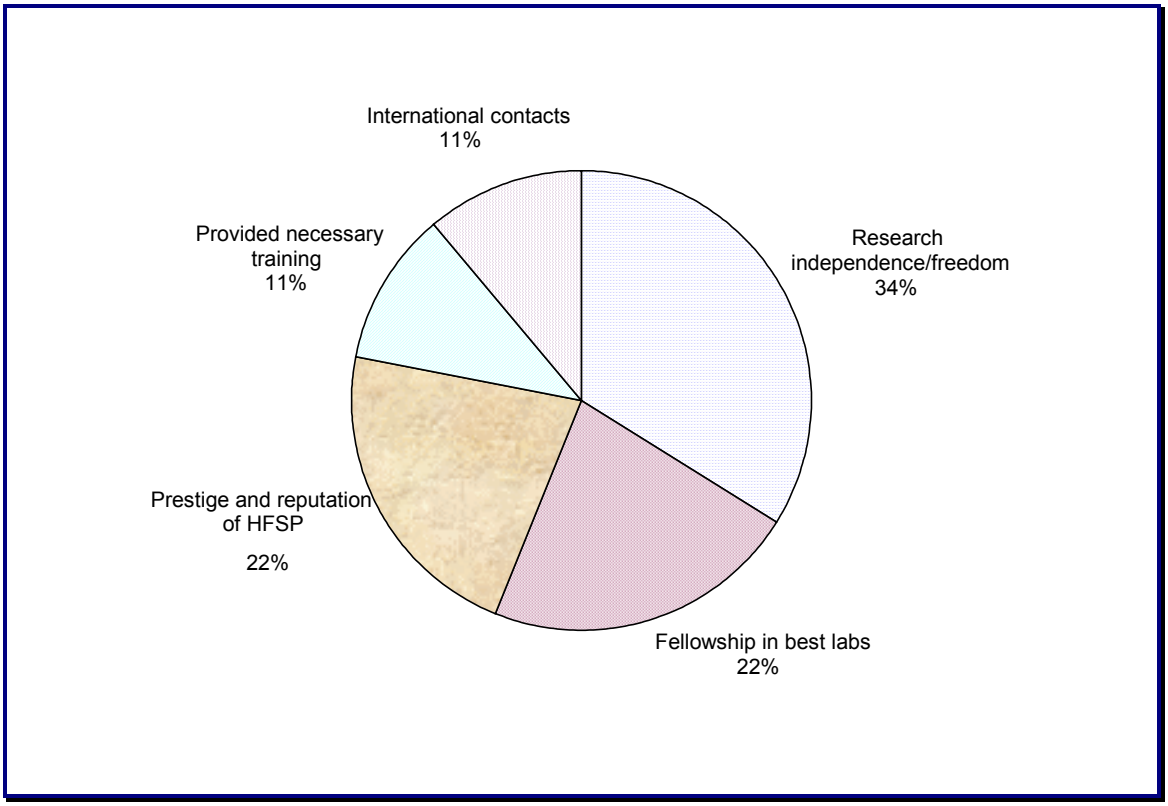
- Obtaining academic positions;
- Obtaining research funding;
- Establishing their own labs and independent research programs;
- Making major scientific advancements; and
- Building strong national and international reputations.

The case studies also confirmed that half of the fellows interviewed managed to 'stay-on' in their HFSP research host laboratory, typically for an additional year, by securing funding from other sources, which helped them to build a stronger relationship with the host laboratory and helped them to move into their preferred job positions more rapidly.

There was a general agreement that the HFSP fellowship and the host lab experience made a great contribution to these subsequent career achievements. Figure 11 shows the nature of these impacts (D:35 and D:36).

> *"My main career achievement since the completion of the HFSP fellowship is the establishment of my own research team 2 years ago, and we have since published 2 independent research papers in international peer reviewed journals… The HFSP fellowship provided the means for me to obtain the proper training as a scientist and enabled me to work in a stimulating environment. This gives me the confidence to start my own research group subsequently."*
>
> *"The combination of the ability to perform independent, high level research and the ability to publish in high profile journals together with the reputation of the HFSP fellowship allowed me to get an academic position in my home country."*
>
> *"We had two papers published in 'Nature' and 'Journal of Cell Biology' and another two in other journals. The science conducted in my own lab now is extensively based on the research that was conducted during my HFSP fellowship period in the Japanese lab."*

Figure 11: Impacts of HFSP Fellowship on Fellows' Careers



4.5.5 Impact on host countries and fellows' countries

The survey results indicate that, after completing their fellowship, roughly half the fellows returned to work in their home country, while about a third obtained a position in the country where they held their fellowship (D:26). Thus both countries are able to benefit from the HFSP fellows' expertise. About two thirds of respondents noted that they decided to remain at the host country because it offered them better career and research opportunities than their native country (D:28), and 10% thought that obtaining a position in their home country was simply impossible.

Analysis of post-fellowship records confirmed that a significant proportion of fellows are now located in their 'home countries'. Exhibit 4.3 summarizes the results, which are very similar to the survey findings.

Exhibit 4.3—HFSP Fellows Movements After Completion of Award

Fellows' Subsequent Job Position	1990/91	1992	1993	1994	1995	1996	1997	Average % figure over this period (N)
Returned to work in 'home country'	57% (43)	59% (36)	57% (52)	50% (54)	52% (24)	41% (16)	36% (18)	**52%** (243)*
Still based in host-lab country	32% (24)	21% (13)	28% (25)	31% (34)	31% (14)	44% (17)	50% (25)	**32%** (152)*
Moved from host-lab country to a 'third country' to work	11% (8)	20% (12)	15% (14)	19% (20)	17% (8)	15% (6)	14% (7)	**16%** (75)*

* Figures based on sample of 470 tracked fellows from 1,087 contacted for 1990-97.

Exhibit 4.4 expands on Exhibit 4.3 by illustrating the distribution of Fellows' movements by showing in which continents they are currently located (based on figures taken from Exhibit 4.3). For the 'third country' location (where fellows moved from host-lab to a different country to their home country) the list of all countries represented in this grouping is shown individually in Exhibit 4.4.

The new "repatriation" third-year fellowship and Career Development Award would likely have increased the number of fellows returning to their home country. Almost half the survey respondents indicated that these changes would have allowed them to more easily re-integrate into their home country and that it would have facilitated their job search (D:29).

Exhibit 4.4—HFSP Fellows working locations

Distribution Within Cells							
Fellows' Position	**1990/91**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Returned to work in 'home country'	Europe (53%) Japan (32%) Canada (5%) USA (5%) Rest of World (5%)	Europe (42%) Japan (28%) USA (13%) Canada (6%) Rest of World (11%)	Europe (40%) Japan (38%) USA (9%) Canada (6%) Rest of World (7%)	Europe (55%) Japan (19%) Canada (11%) USA (8%) Rest of World (7%)	Europe (38%) Japan (25%) Canada (17%) USA (4%) Rest of World (16%)	Europe (62%) Japan (19%) Canada (13%) USA (6%)	Europe (61%) Japan (5%) USA (22%) Rest of World (12%)
Still based in host-lab country	USA (79%) Canada (8%) Europe (13%)	USA (76%) Canada (8%) Europe (16%)	USA (84%) Canada (8%) Europe (8%)	USA (76%) Canada (3%) Europe (21%)	USA (71%) Europe (19%)	USA (76%) Europe (24%)	USA (72%) Europe (18%)
Moved from host-lab country to a 'third country' to work	N=8 (Australia, USA, France, Sweden, Italy)	N=12 (USA, UK, Germany, France, Sweden, Kuwait, China, Israel)	N=14 (Germany, UK, France, Switzerland, USA, Canada, Finland, Norway, Australia)	N=20 (France, UK, USA, Switzerland, Germany, China, Argentina)	N=8 (Canada, USA, Germany, Italy, France, Israel)	N=6 (USA, Austria, Finland, UK, Australia)	N=7 (France, USA, Germany Netherlands)

4.6 Differences by Continent

As for grant holders, there were some notable differences depending on the continent of the fellow's home country, as summarized in Appendix F. Again, the results are not entirely internally consistent, but some general themes are that:

- The fellows from Japan have fewer opportunities to access similar sources of funding, and the collaboration and opportunities to enter new areas of research provided by the fellowships are more important.

- For fellows from Europe and North America, there are more opportunities to access similar funding, and the fellowship had less influence in their ability to obtain the position at the host lab. The collaborative experience is somewhat less important, but learning to work as an independent scientist is more important. The impact on obtaining their subsequent job position was least important for North Americans.

4.7 Suggestions made by Long-term Fellows

The survey (D:37) and case study recommendations were:

- **Continue and expand the HFSP fellowship program** – Respondents applauded the program and stressed that it should continue and be expanded. They enumerated various advantages including great management and friendly people, access to travel money, flexibility, and ease of application procedures. For most of the case study interviewees, they have confirmed that they could not have carried out their chosen research, especially in a US host laboratory, without the support of the HFSP.

- **Make the "repatriation year" more flexible**—Fellows suggested that the recent extension of the fellowship (the repatriation year) be more flexible, by allowing the fellows to spend the additional year in any country.

- **Organize a one-day symposium on an annual basis**–Some fellows felt that it would be useful to organize an annual meeting so fellows can meet more HFSP members and their colleagues in order to exchange ideas and develop contacts. The fellows who had attended the HFSP's 10th anniversary awards ceremony confirmed that this type of experience was most useful for their career development, as it enabled them to make direct contact with other scientists from around the world.

Individuals who received awards in earlier years commented that the (original) two-year fellowship duration should be extended to allow them to conduct complex collaborative research. As in the grants program, HFSP has already addressed this situation through the new "repatriation" third-year fellowship and the Career Development Awards announced last year.

5. Bibliometric Analysis

5.1 Rationale

A bibliometric analysis was carried out in order to assess the quality of the programmes and this analysis helps to illustrate the use of citation data in a comparative way. After receiving all HFSP Grantee and Long-term Fellow questionnaire returns we created a database that held a list of 1,229 publication references that were provided by the HFSP survey respondents (219 Grantees and 189 Fellows). These figures represent the number of survey respondents that could be clearly identified by their name, since some respondents could not be identified where they anonymously returned completed questionnaires by post or fax (Note: actual number of respondents was Grantees = 356 and Fellows = 245 as stated earlier in report). The 'publications database' contains the names of the Grantees/Fellows and their 3-5 top publications in the period 1990-1999. The list of top publications was selected by the authors themselves, which directly arise from their HFSP project work. On the basis of the highlighted names of Grantees and Fellows, all papers by these authors were retrieved from the 1990-1999 annual cumulations of the *Science Citation Index* (SCI) database of the *Institute for Scientific Information* (ISI, Philadelphia, PA, USA). The set of papers representing the top HFSP publications are called **"*H-papers*"** (for 'Highlighted'), and the set of papers not indicated as top publications by the corresponding authors are called **"*N-papers*"** ('Not-highlighted'). Altogether 12,474 records served as the basis of the following analysis[12]. Although there is some overlap, the N-papers mainly represent non-HFSP supported research (but not entirely since some N-papers can also include HFSP work that was not listed in the H-papers).

5.2 Main Tasks Covered

The bibliometric analysis covered the following main subtasks:

(i) Comparison of citations to named publications with others in the same journals [i.e. whether the listed HFSP publications (H-papers) by Grantees/Fellows exhibit a greater impact than all publications in the same set of journals in the same period].

(ii) Comparison of citations to named papers with citations to other papers by same authors [i.e. impact of the listed HFSP publications (H-papers) is compared with that of other publications by the authors (N-papers)].

(iii) The degree of international co-authorship for named and other papers.

(iv) Manual checking of core journals for acknowledgements to HFSP.

[12] We acknowledge the expert input of Mr. W. Glanzel (RASCI) with compiling and analysing the raw data generated from the survey responses and producing the tables and graphs presented in section 5 of this report.

5.3 Main Finding

5.3.1 Comparison of citations to named publications with others in same journals

This was done on the basis of 3-year citation windows (the year of publication plus the subsequent two years) for each of the publication years 1990-1997, and for a 2-year citation window in the case of publication year 1998, and a 1-year citation window in the case of publication year 1999.

The first step taken here was to analyse the trends in publication activity of both Grantees and Fellows separately for the period 1990-1999. This showed that:

- the number of H-papers increased by a factor of 1.8 (Fellows) and 1.4 (Grantees) for the two groups studied, which is above the overall growth of the SCI database (1.2). Here the number of H-papers for Fellows has dynamically grown in the period 1990 to 1995 and then remained stable between 1996 and 1998, with a slight decrease in 1999. The Grantee H-papers also increased between 1990 and 1999 (see Appendix J.1)
- the papers not highlighted (N) by Grantees/Fellows are almost uniformly distributed over this period. Here the papers are about constant in numbers per year,
- Note: only about 20% of H-papers for both groups combined, have been published in the period 1990-1994. Therefore the periods 1990-1994 and 1995-1999 were subdivided into two sub-periods of five years each and the trends for these publication activities are shown in Appendix J.1 with graphical illustrations.

The following measures were used to measure the expected and observed **citation impact** of H-papers against N-papers:

- Citation Rate per Publication (*Mean Observed Citation Rate, MOCR*). The ratio of citation count to publication count on the basis of citation windows as defined above.

- Expected Citation Rate per Publication (*Mean Expected Citation Rate, MECR*). The expected citation rate of a single paper is defined as the average citation rate of all papers published in the same journal in the same year.

- *Relative Citation Rate* (RCR). *RCR* measures whether a given publication set attracts more or less citations than expected on the basis of the average citation rates of the journals in which they appeared. This indicator is defined as the ratio of the Citation Rate per Publication to the Expected Citation Rate per Publication, that is, $RCR = MOCR/MECR$. The indicator ranges between 0 and infinity, its neutral value is 1. $RCR < 1$ ($RCR > 1$) means "citation attractivity" is below (above) expectation.

Exhibit 5.1 presents the citation data for highlighted publications of Grantees in the full period and two sub-periods of (1990-94 and 1995-99). Exhibit 5.2 presents the citation data for highlighted publications of Fellows over the same period.

Exhibit 5.1—Comparison of the Citation Impact of H-Paper by Grantees with all Publications in the Same Set of Journals (1990-1999)						
H-papers	**Papers**	**Share of papers**	**Citations**	**MOCR**	**MECR**	**RCR**
1990-94	119	20.4%	4068	**34.18**	27.16	**1.26**
1995-99	464	79.6%	6272	**13.52**	11.54	**1.17**
Total	583	100.00%	10340	**17.74**	14.73	**1.20**

Exhibit 5.2—Comparison of the Citation Impact of H-Papers by Fellows with all Publications in the Same Set of Journals (1990-1999)						
H-papers	**Papers**	**Share of papers**	**Citations**	**MOCR**	**MECR**	**RCR**
1990-94	79	19.3%	2290	**28.99**	25.49	**1.14**
1995-99	330	81.7%	6606	**20.02**	16.48	**1.21**
Total	409	100.00%	8896	**21.75**	18.22	**1.19**

Overall, the listed HFSP publications (H-papers) of both sub-populations (Fellows and Grantees) exhibit a distinctly greater impact over the standard in the same set of journals in the same sub-periods. Note that, in our sample of survey respondents, about four-fifths of all listed HFSP papers were published in the second sub-period (1995-1999). In this context it has to be noted that the powerful growth of H-papers results in an 'over-proportional' weighting of papers published in the last two years (1998-99).

5.3.2 Comparison of citations to named papers with citations to other papers by same authors

Here the MOCR values of 'not highlighted' (N-papers) were calculated and the basic indicators and citation impact values are shown in Exhibit 5.3 for Grantees and Exhibit 5.4 for Fellows.

Exhibit 5.3—The Citation Impact of N-papers by the Same Authors for Comparison (Grantees in 1990-1999)				
N-papers	**Papers**	**Share of papers**	**Citations**	**MOCR**
1990-94	4239	45.8%	77001	**18.16**
1995-99	5011	54.2%	61519	**12.28**
Total	9250	100.00%	138520	**14.98**

Exhibit 5.4 - The Citation Impact of N-papers by the Same Authors for Comparison (Fellows in 1990-1999)				
N-papers	**Papers**	**Share of papers**	**Citations**	**MOCR**
1990-94	999	44.8%	13888	**13.90**
1995-99	1233	55.2%	13232	**10.73**
Total	2232	100.00%	27120	**12.15**

From the above comparisons of Mean Observed Citation Rates (MOCR) it can be concluded that the indicator values of the Fellows' H-papers are, on average, significantly higher than the corresponding values of the other papers of the same authors, while those of the Grantees are somewhat higher. In effect, the HFSP award is supporting research that is slightly more important than that normally done by the established researchers (the Grantees), while dramatically increasing the importance of work done by the Fellows.

In addition to the analysis presented above, the comparison between the distribution of MOCR and MECR values for both HFSP Fellows and Grantees is presented in Appendix J, showing the citation patterns of the highlighted (H-papers) and other papers via graphical illustrations. This also includes illustrations showing the 'cumulative' affect of the MOCR values, which gives a clearer representation of the differences between H-papers and N-papers.

5.3.3 Ratio of HFSP paper citations compared to other paper citations for same authors

The ratio of HFSP paper citations can be compared to other paper citations by the same authors using the MOCR values presented in the previous sections here. This provides a useful comparison of citations to HFSP papers and citations to other papers for the same authors (Grantees and Fellows). Exhibits 5.5 and 5.6 illustrate these ratio values for both author groups over the two sub-periods studied (1990-94 and 1995-99).

Exhibit 5.5 - The Citation Impact of N-papers by the Same Authors for Comparison (Grantees in 1990-1999)			
Year	**HFSP paper citations**	**Other paper citations**	**Ratio**
1990-94	34.18	18.16	**1.88**
1995-99	13.52	12.28	**1.10**

Exhibit 5.6 – Fellows Paper Citation Ratio Values			
Year	**HFSP paper citations**	**Other paper citations**	**Ratio**
1990-94	28.99	13.90	**2.10**
1995-99	20.02	10.73	**1.90**

5.3.4 Degree of international co-authorship for named and other papers

International co-operativity can be measured by the number of countries involved in the publication under study. For each highlighted author the ratio of the sum of countries involved in each papers and the number of papers has been calculated to measure the authors' average co-operativity.

International co-operativity has been subdivided into four zones according to the range of indicator values *x*:

- Zone 1: co-operativity is below 1.5;
- Zone 2: co-operativity is at least 1.5 but less than 2.0;
- Zone 3: co-operativity is at least 2.0 but less than 3.0, and
- Zone 4: co-operativity exceeds 3.0.

Co-operativity scores greater than 2.0 means that, on average, co-authors from more than 2 countries are involved. The international co-operativity of Fellows and Grantees are presented in Figures 12 and 13. About 16% of H-papers by Fellows are in zones 3 and 4, whereas fewer than 6% of N-papers have such high co-operativity. On the other hand, the share of papers with low co-operativity is somewhat higher in the set of not highlighted papers. In case of Grantees this effect is even more striking: About 40% of H-papers are in zones 3 and 4, whereas less than 4% of N-papers can be found in these zones. The degree of international co-authorship of listed HFSP publications (total average co-operativity $\bar{x} = 1.50$) is significantly higher than that of other publications by the same authors (total average co-operativity $\bar{x} = 1.35$).

Figure 12 - International Co-publication of Fellows (1990-1999)

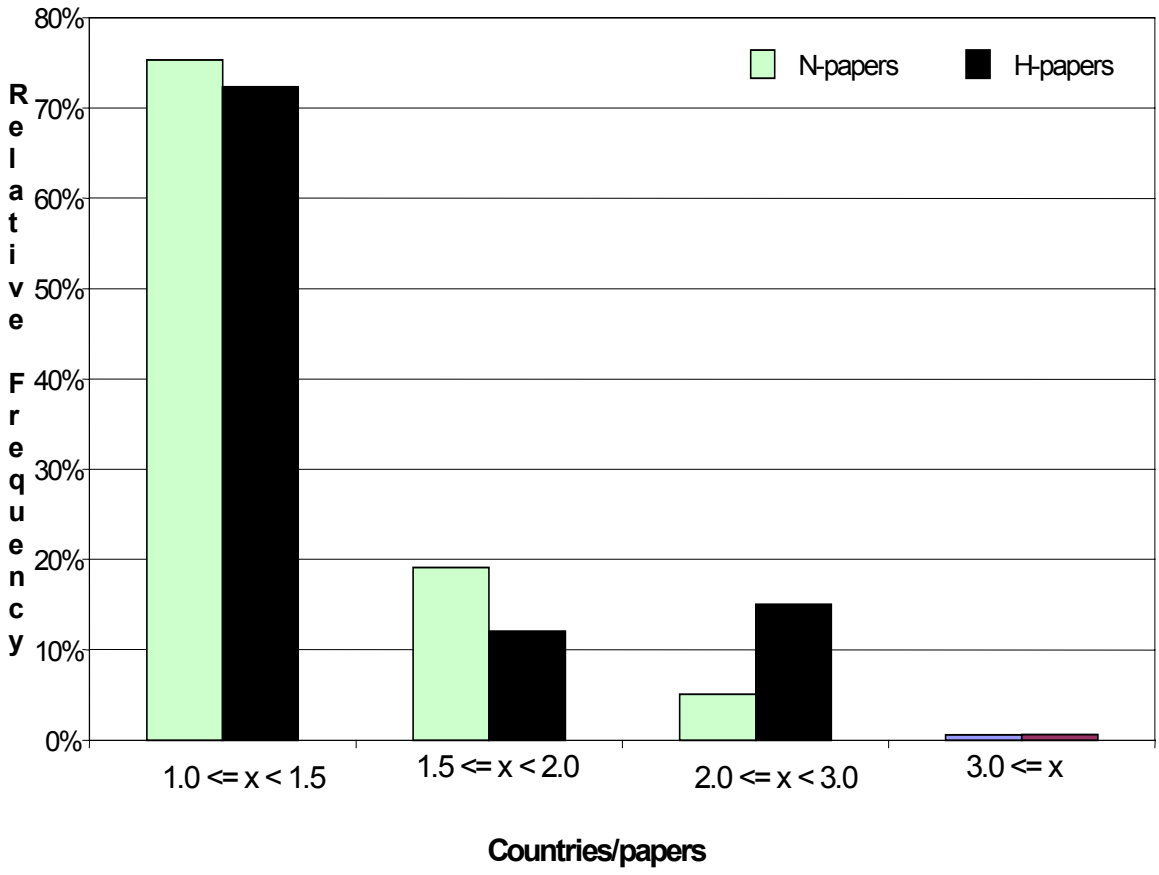
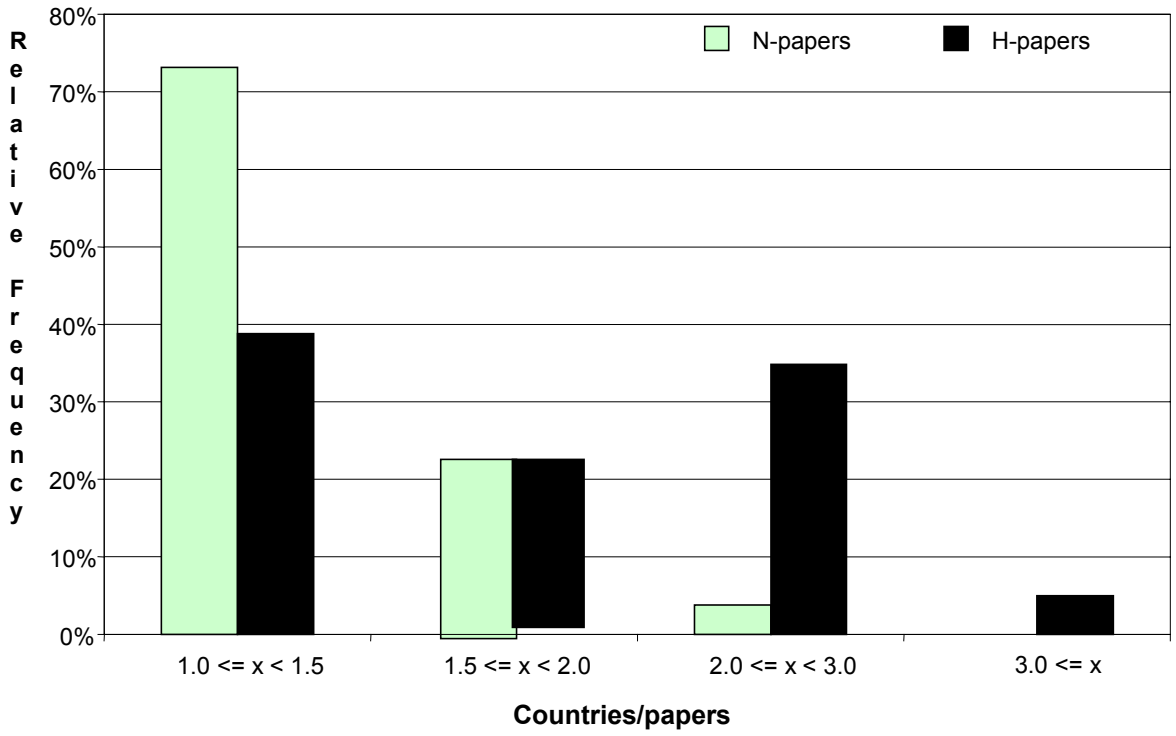


Figure 13 - International Co-publication of Grantees (1990-1999)



5.3.5 Manual checking of core journals for acknowledgements to HFSP

For this exercise a sample of six core journals was selected, which were amongst the top ten most commonly-cited references by the HFSP survey respondents (Fellows and Grantees combined). Then a random selection of 100 articles, which had been cited by the survey respondents in their survey returns, were taken from the core journals and each article was manually checked to establish if the Fellow/Grantee had acknowledged HFSP funding. The list of core journals selected comprises: - *Nature;* - *J. Biological Chemistry;* - *Proceedings of the National Academy of Science of USA;* - *Cell;* - *EMBO Journal;* and – *Neuron.*

From this sample of 100 articles:

- 85 authors had acknowledged that HFSP funding was received for the project that was being reported in the article concerned;
- The remaining 15 articles did not acknowledge any HFSP support

Also a table listing the survey respondent's most commonly cited top 20 journals are shown in Appendix J.

5.4 Summary of bibliometric analysis

- The distribution of papers listed by HFSP grantees and fellows over time is skewed as about 80 % of these papers have been published in the second half of the period analysed (1995-1999).
- The listed HFSP publications exhibit, on average, a greater impact than the expectation on the basis of all publications in the same set of journals and in the same time period.
- The impact of the listed HFSP publications is, on the average, more often cited than other papers by the same authors in the same time period. This is dramatically true for Fellows, but is also the case to a small extent for Grantees. Nevertheless, a certain share of listed papers in the second half-period have lower citation impact which is in part a consequence of the large number of papers published in the last year.
- The degree of international co-authorship in the listed HFSP papers is somewhat higher than that of other papers by the same Fellows, and considerably higher for Grantees.
- From a random selected sample of 100 articles it appears that HFSP funding is being acknowledged in a range of core journals covering the areas of biomedical science research. As 15% of this sample group did not acknowledge HFSP support in core journals, it is important for the HFSP to direct further effort in this area to ensure that all HFSP funded research findings reported in journals acknowledge HFSP support.

6. Conclusions

6.1 Overall Conclusions

The findings of the present study are very positive, and reinforce those findings from the previous evaluation. HFSP is a unique and valuable program in the context of both national and international funding support mechanisms. It has succeeded in fostering the creation of intercontinental research teams working in a multidisciplinary manner, and the results of this research have been important to the understanding of molecular biology and brain processes, as well as beneficial to the careers of the award holders, both grantees and long-term fellows.

6.2 Program Uniqueness

Grants. Within the spectrum of funding sources available to university scientists, the grants program has a unique niche. It supports interdisciplinary, intercontinental research teams that are virtually impossible to create through other funding mechanisms. These collaborations are facilitated by the funding available for face-to-face meetings, travel and visits to other labs, and the ease and flexibility of the program in allowing the funds to be used for many purposes. Much of the HFSP research would simply not have been done at all without the award, and substantial proportions of projects were initiated specifically because of the availability of HFSP support. If the research had gone forward without the grant, different partners and/or more limited collaborations would have resulted. The average HFSP support was 5.5 times higher than that available from all other sources combined that fund intercontinental research. Overall, HFSP support is considered at least equal to—and often better than—support from national funding bodies, especially with respect to supporting high-risk topics.

Fellows. The long-term fellowships program is best understood as one of a number of elite schemes that collectively ensure that those among the top echelon of fellows who wish to work in the best laboratories in other countries are enabled to do so. The additionality of the long-term fellowships program has been low in terms of influencing the initial career paths of fellows. As is the case for similar programs that attract the highest-calibre applicants, the fellows have many funding options available to them, and few would not have been able to carry out the same research, at the same laboratory, without the HFSP award. Nevertheless, the HFSP fellowship adds value. It is preferable to awards from other agencies because in most cases it offers a higher level of stipend, it is more flexible in terms of how the funds are spent, the duration is longer than most others, and it is highly prestigious.

6.3 Impact on Collaboration

Grants. Although many grant holders knew each other in some informal way prior to the grant, few had worked formally on joint projects prior to the grant. The resulting HFSP research was heavily dependent on the success of the collaborations, and well-integrated into the award holders' "normal" research. The teams were interdisciplinary, and there is evidence

for many "non-traditional" fields being represented in the work. Not only are highly-skilled research collaborations created, but these teams are long-lasting: the grantees now do about two and a half times as much intercontinental collaborative work as prior to the grant, and almost all maintain some type of ongoing collaboration with the team members after the grant terminates (though often it is necessarily more limited in scope and interaction). The bibliometric analysis confirms that Grantees' top HFSP publications tend to involve scientists from more countries than do their other publications.

Fellows. The fellowships, even more than the grants, have supported the creation of new collaborative teams. This collaboration has been critical or important to most of the fellows' research projects, and has been quite well integrated into the research of the host laboratory. Again, bibliometric analysis confirms that HFSP publications tend to involve investigators from more countries than non-HFSP work.

6.4 Supporting Young Scientists

Many grant holders believe that HFSP grants provide superior support to younger scientists; very few believe the opposite. The intercontinental, multidisciplinary team approach is intellectually stimulating, allows research that is high-risk—but potentially ground-breaking—to be addressed, and fosters linkages that persist over time. A small proportion of grant holders believe that HFSP concentrates slightly too much on supporting established scientists rather than younger ones, but most find the balance entirely appropriate.

6.5 Outputs and Impacts

Grants. The bibliometric analysis indicates that the Grantees' top HFSP publications are more highly cited (by about 20%) than the average for the journals involved, and are also cited slightly more than other publications by the same authors. HFSP is a significant addition to the grant holders' research funding—almost a third of their total funding. Publications and other similar outputs from the HFSP projects represent a significant fraction (about a quarter) of the grant holders' total output, and about half of the output produced collaboratively. The HFSP research has been significant in the careers of the award holders: new collaborations were created, new lines of research were pursued, and their reputations have been strengthened. A modest number of "practical" applications have resulted from the research, mainly in the areas of techniques and instrumentation used in both medical and non-medical research.

Fellows. The fellowships have played a major role in encouraging interdisciplinary research, even slightly better than other programs that attract top-quality applicants. Many fellows entered new research areas during their fellowships, and the work is highly interdisciplinary (again, to a slightly higher degree than fellows in comparable programs). Of course, the ability to work with, and visit, leading scientists across continents is a major impact of the program, as is the ability to work on moderate- to high-risk topics, and act as independent scientists. Bibliometric analysis shows that the Fellows' top HFSP publications are also more highly cited than average (again by about 20%) than the average for these journals, and are

much more highly cited than other work by the same authors. The HFSP research has led to continued, long-term collaboration between virtually all ex-fellows and their host laboratory colleagues, usually in fields closely related to the fellowship research. The prestige, visibility, and international contacts associated with the HFSP research has led, almost without exception, to ex-fellows being employed in research positions, mostly in academia. Many now lead their own laboratories and have achieved significant scientific accomplishments that have a basis in the HFSP work. Roughly half the ex-fellows returned to work in their home country, while about a third obtained a position in the host laboratory country; thus both countries have benefited significantly. The new "Repatriation" third-year fellowship and Career Development Award will likely increase the proportion returning to their home countries.

7. Glossary of acronyms

EMBO - European Molecular Biology Organization

ISI - Institute for Scientific Information

JSPS - The Japan Society for the Promotion of Science

MECR - Mean Expected Citation Rate

MOCR - Mean Observed Citation Rate

NIH - National Institutes of Health (USA)

NSERC - Natural Sciences and Engineering Research Council (Canada)

RCR - Relative Citation Rate

SCI - Science Citation Index