

# Summary Report

## Highlights

**HFSP grant holders find the Program a unique source of support for intercontinental interdisciplinary research.** 89% of grant holders were not aware of alternative sources of funding and nearly half (47%) could not have performed the research at all without HFSP support; a further 36% would have been unable to work with the same partners.

**New collaborations are created that are vital to the execution of the research and continue after the project,** thus building an intercontinental community of researchers. There was a general agreement (83% of grant holders) that their collaboration was either important or critical to the achievement of their own research

**The Fellowships are not unique but rather are one of a number of elite schemes** that collectively ensure that the top echelon of fellows who wish to work in the best laboratories in other countries are able to do so. Half of the fellows were aware of other programs that could have supported their research and 44% thought that, without HFSP, they would definitely have secured a position in the host lab supported from another source. However, in the great majority of cases the superior terms offered by HFSP made it the first choice of fellows.

**The return rate of fellows is balanced at a point where both host and home countries benefit.** Visible career benefits to fellows are evident, including maintenance of links with the host labs after they have moved on. Over a 10 year period, 52% of fellows have returned to work in their home country, 32% are still based in the host country (usually the USA) and 16% are in a third country.

**For both grants and fellowships, the top HFSP publications have a citation performance well above the norm.** Citation rates for publications of grant holders and fellows are as much as 26% and 21% better, respectively, than citations of other papers in the same journals. Compared with other papers by the same authors, their citations were up to 88% and 109% better, respectively. This confirms the participants' strong view that HFSP has a reputation for supporting science of the highest quality.

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# 1 Introduction

This is the summary version of the final report of the review of the Human Frontier Science Program (HFSP) commissioned by the Board of Trustees. It was carried out by the Programme of Policy Research in Engineering, Science and Technology (PREST) at the University of Manchester, United Kingdom, KPMG Consulting Inc. (including the former ARA Consulting Group) of Canada, and Professor Akira Goto of Hitotsubashi University, Japan. It follows up an earlier review carried out in 1995/96. The objectives of the present study were to analyze the impact of HFSP on the career paths of **grant holders** and **long-term fellows** and to assess their scientific achievements.

The findings are based upon:

- Survey returns from 356 HFSP grant holders, representing an individual response rate of 32% and a project response rate<sup>1</sup> of 65%;
- Survey returns from 245 HFSP Long-Term Fellows, representing a response rate of 45%;
- Interviews with 11 grant holders and 13 fellows who had achieved high impacts;
- A bibliometric analysis, which compared citations of HFSP-supported publications with other publications in the same journals over the lifetime of the Program and with other publications by grant holders and fellows. International co-authorship of publications was also compared;
- Supporting exercises, including a tracking exercise to identify the current location of fellows, a comparison of fellows with a reference group supported by other programmes, a survey of non-respondents to ensure that there was no response bias, and a manual check of core journals to ensure that papers were correctly attributed to HFSP.

Key issues addressed were derived from HFSP's objectives. These were the uniqueness of the Program, the impact on collaboration and interdisciplinarity, the support for young scientists, and the outputs and impacts achieved. The findings are *illustrated by quotes from the scientists themselves*.

## 2 Grant Program

### 2.1 Program uniqueness

*"It is very attractive since you can bring together people from different countries that might not otherwise work together."*

*"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."*

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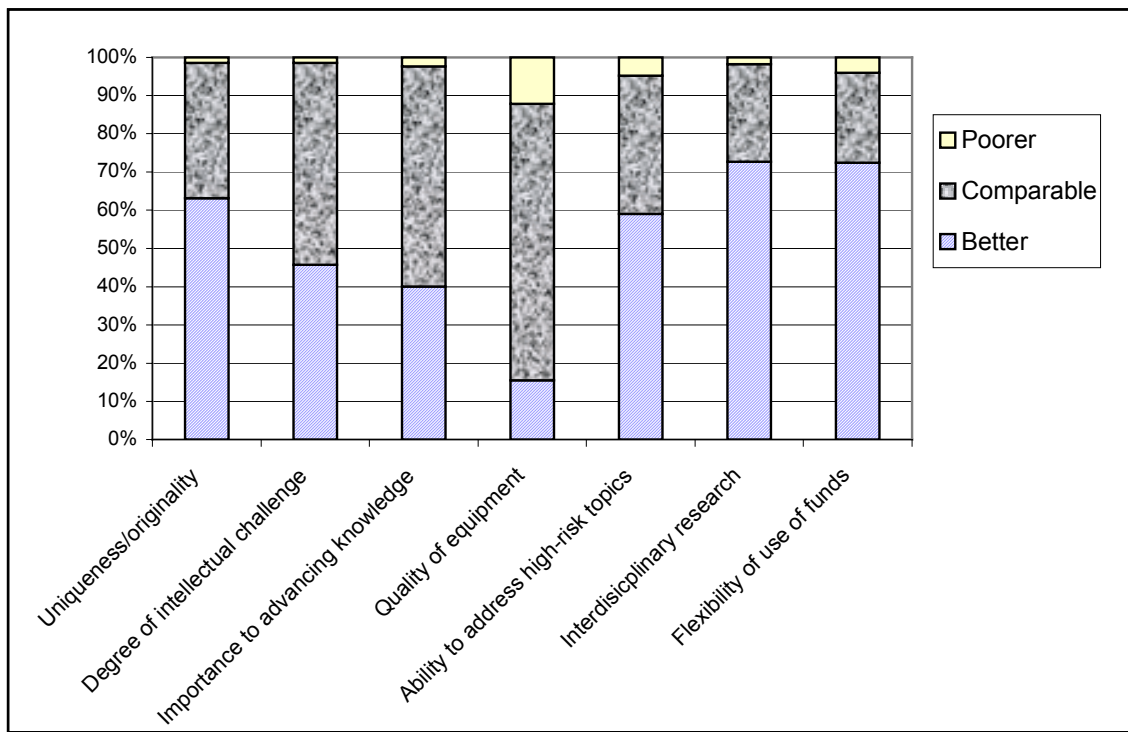
<sup>1</sup> The proportion of projects for which at least one participating grant holder responded.

For the great majority of respondents the program has a unique niche. No other program could have funded similar projects in terms of intercontinental cooperation or interdisciplinarity. About 89% of grantees were not aware of alternative sources of funding and nearly half (47%) could not have performed the research at all without HFSP support; a further 36% would have been unable to work with the same partners.

In general, participants rated HFSP as at least equal to and—in several dimensions better than—funding from national sources. Over half of respondents rated HFSP better in terms of uniqueness/originality, interdisciplinarity and flexibility. Flexibility in the use of funds was particularly appreciated.

**Figure 1** shows how survey respondents rated HFSP in comparison with national granting agencies.

**Figure 1: Opportunities for Research – HFSP vs. Other Programs**



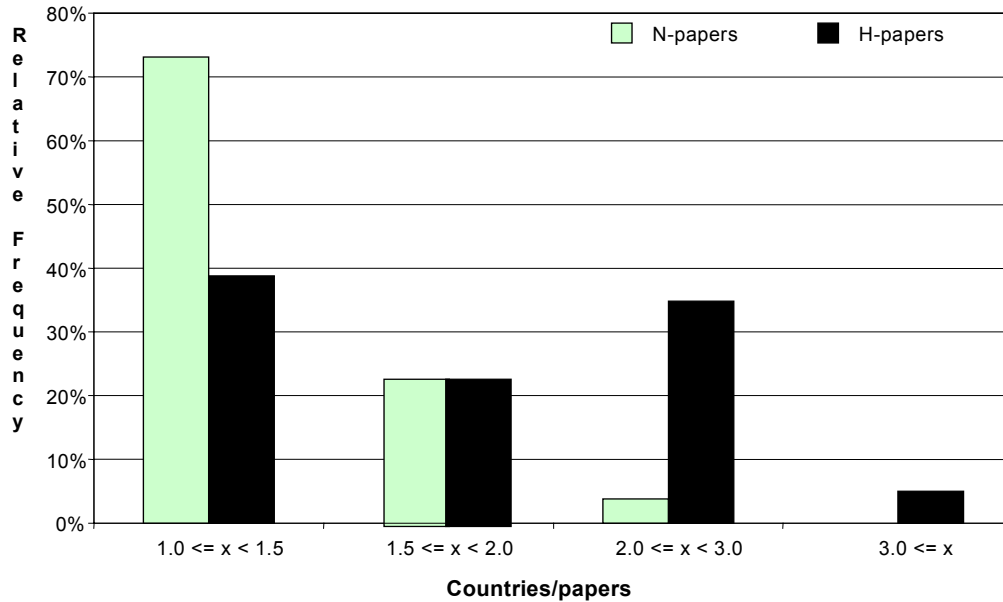
## 2.2 Impact on Collaboration

*“HFSP allowed me to work with people who bring different expertise. I learned more about how people from other countries do research since each country has its own style.”*

The survey results demonstrate that the grants create new, long-lasting and highly-skilled research teams, 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—59% of the core research team members had not collaborated previously in any significant ways and another 22% had experienced only low-level collaboration.

There was a general agreement (83% of survey respondents) that this collaboration was either important or critical to the achievement of their own research results, and that the research conducted through HFSP funding was fully to partially integrated with other research in their laboratories.

**Figure 2: International Co-publication of Grant Holders (1990-1999)**



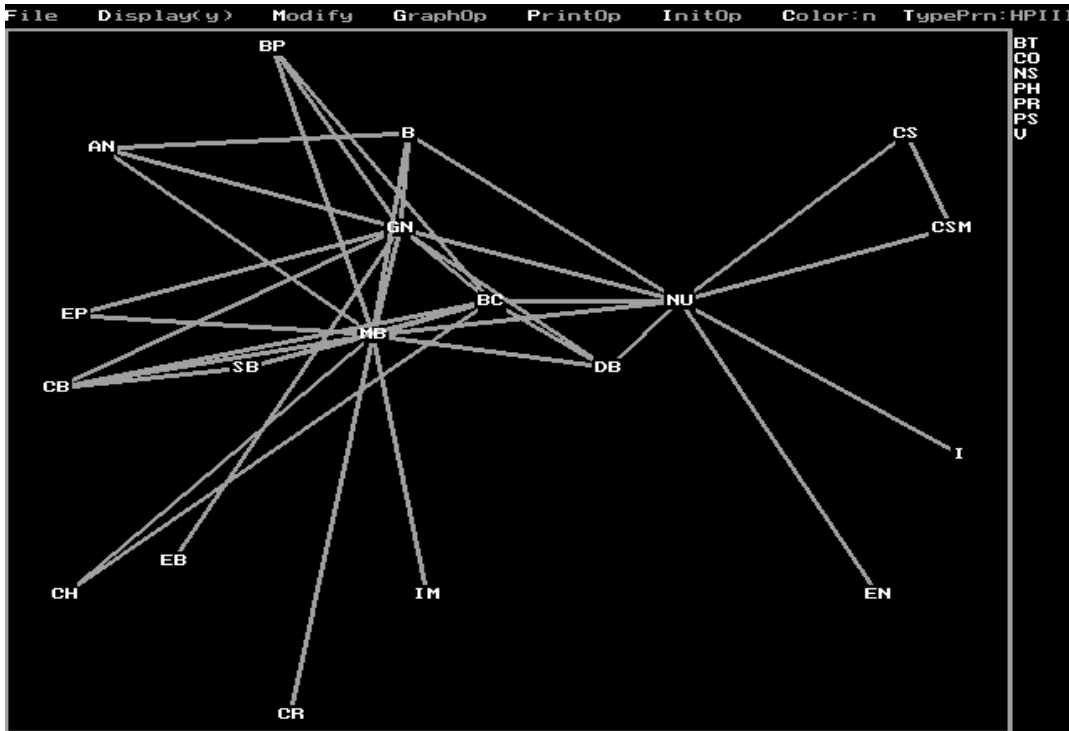
**Figure 2** examines the degree of international co-authorship of papers identified as HFSP outputs (H-papers) in comparison with other papers (N-papers) by the same authors. HFSP papers clearly exhibit a higher degree of international co-operativity (as measured by the number of countries represented per publication). About 40% of HFSP papers involve two or more countries, compared to fewer than 4% of non-HFSP papers. 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  $\bar{x} = 1.35$ ).

The benefits of collaboration persist beyond the end of the project – almost all grant holders have continued to collaborate formally (50%) or informally (40%) with their former HFSP partners. However, the lack of subsequent non-HFSP funding for inter-continental travel diminished the possibility of travel and face-to-face meetings.

### 2.3 Interdisciplinarity

*“Biology and Physics were the main disciplines involved and we applied nanotechnology techniques to biology”*

**Figure 3: Networks of Disciplines<sup>2</sup> in HFSP Projects Involving 5 and More Relationships**



AN	Anatomy	EN	Engineering
B	Behaviour	EP	Electrophysiology
BC	Biochemistry	GN	Genetics
BP	Biophysics	I	Imaging
* BT	Biotechnology	IM	Immunology
CB	Cell Biology	MB	Molecular Biology
CH	Chemistry	* NS	Nuclear Studies
CS	Cognitive Science	NU	Neuroscience
CSM	Computer Science & Mathematics	* PH	Physics
* CO	Cancer & Oncology	* PR	Pharmacology
CR	Crystallography	* PS	Plant Studies
DB	Developmental Biology	SB	Structural Biology
EB	Evolutionary Biology	* V	Virology

**NOTE:** Symbol \* above denotes the unconnected components produced by a cut-off point of 5 and more relationships.

<sup>2</sup> 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. The network analysis software used to analyse the matrix and plot the actual network of disciplines was UCINET IV and KrackPlot, respectively. [References: Borgatti, Everett and Freeman (1992), UCINET IV Version 1.0 Columbia: Analytic Technologies; & Krackhardt, D., Lundberg, M. and O'Rourke, L. (1993), "KrackPlot: A Picture's Worth a Thousand Words", *Connections*, Vol. 16 (1&2): 37-47.]

HFSP brings together world-class experts from various disciplines. The great majority of respondents described their project as interdisciplinary, with 55% drawing extensively on more than one discipline and 33% identifying limited inputs from at least one other discipline. This finding needs to be treated with a degree of caution as the disciplines concerned are often neighbouring sub-disciplines in the life-sciences. The linkage may also involve access to experience in a particular technique such as microscopy.

Grant holders named 26 disciplines as being involved in HFSP projects, an average of about 3 per project. The most frequently cited disciplines are molecular biology (40% of respondents), neuroscience (36%), genetics (34%), biochemistry (33%) and cell biology (18%). **Figure 3** uses network analysis to map the co-occurrence of disciplines in projects. It shows those relationships co-occurring five or more times. It confirms the two central themes of HFSP, Molecular Biology and Neuroscience, as the most connected disciplines, with 13 and 9 links, respectively.

## **2.4 Support for Young Scientists**

*“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.”*

The majority of respondents felt that the HFSP supports a mix of well-established researchers as well as young scientists who are trying to build their career. (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.

Around 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. Nonetheless, a few respondents from Japan noted that younger scientists might not have had the opportunity to develop the overseas contacts needed to mount a proposal.

## **2.5 Outputs and impacts**

The average number of outputs produced by grant holders and fellows from their HFSP projects was 21.78, of which just over 12 were articles in refereed journals. Respondents were asked to list their three most important publications arising from the project. The 686 papers listed formed the main basis for the analysis of scientific impact.

### **2.5.1 Bibliometrics**

**Table 1** shows the most frequently cited journals among the 686 papers listed. It may be observed that these are virtually all in journals of the highest scientific standing with *Nature* alone accounting for 11%. (Note: these are journals cited by both Grantees and Long-term Fellows combined.)

**Table 1: Table of Most Frequently Cited Journals—% of Listed Papers**

<u>JOURNALS</u>	<u>Proportion of total references</u>	<u>JOURNALS</u>	<u>Proportion of total references</u>
- <b>Nature</b>	11%	- Neuron; - J. of Cell Biology	4%
- <b>J. Biological Chemistry</b>	10%	- Genes & Development; - Biochemistry	3%
- <b>Cell</b> ; - <b>PNAS</b> <sup>3</sup>	9%	- Molecular Cell Biology; - Plant Cell	2.5%
- <b>Development</b> ; - <b>EMBO J</b> ; - <b>Science</b>	8%	- J. of Neurophysiology; - J. of Molecular Biology; - Developmental Biology	2%
- <b>Jnl. of Neuroscience</b>	6%	- J. of Bacteriology; - Mechanisms of Develop.; - FEBS Lett. ; -Biophysical J.	1.5%

Tables 2, 3, and 4 below present key highlights from the bibliometric analysis that compared citations to named (HFSP project) grantee publications with others in the same journals and to other papers by the same authors in order to assess impact of papers arising from HFSP projects.

**Table 2: Comparison of the Citation Impact of H-Papers by Grantees with all Publications in the Same Set of Journals (1990-1999)**

<b>Year</b>	<b># HFSP Papers</b>	<b>Share of Citations</b>	<b># Citations</b>	<b>Avg. HFSP Citation Rate</b>	<b>Avg. Journal Citation Rate</b>	<b>Ratio HFSP to Journal Citations</b>
<b>1990-94</b>	119	20.4%	4068	<b>34.18</b>	27.16	<b>1.26</b>
<b>1995-99</b>	464	79.6%	6272	<b>13.52</b>	11.54	<b>1.17</b>
<b>Total</b>	583	100%	10340	<b>17.74</b>	14.73	<b>1.20</b>

<sup>3</sup> PNAS – Proceedings of the National Academy of Science of the USA

**Table 3: The Citation Impact of non-HFSP -papers by the Same Grantees for Comparison**

N-papers	# Papers	Share of Papers	# Citations	Avg. N-paper Citation Rate
1990-94	4239	45.8%	77001	<b>18.16</b>
1995-99	5011	54.2%	61519	<b>12.28</b>
<b>Total</b>	9250	100.00%	138520	<b>14.98</b>

**Table 4: Grantees Paper Citation Ratio Values for Papers by Same Author**

Year	Avg. Citations per HFSP Paper	Avg. Citations per Other Paper	Ratio HFSP to Other
1990-94	34.18	18.16	<b>1.88</b>
1995-99	13.52	12.28	<b>1.10</b>

**Table 5** below lists a set of the most highly cited papers by HFSP grantees and fellows.

**Table 5: Highly Cited Papers**

Author	Paper Title	Journal	Year/Vol.	No. of Cites
Riddle, R. et al.	“Sonic hedgehog mediates the polarizing activity of the ZPA”	<i>Cell</i>	1993, Vol. 75	<b>310</b>
Brenman, J.E. et al.	“Interaction of Nitric Oxide Synthase with the Postsynaptic Density Protein PSD-95 and 1-Syntrophin Mediated by PDZ Domains”	<i>Cell</i>	1996, Vol. 84	<b>251</b>
Miyamoto, S. et al.	“Synergistic roles for receptor occupancy and aggregation in integrin transmembrane function”	<i>Science</i>	1995, Vol. 267	<b>201</b>
Cohen-Fix, O. et al.	“Anaphase initiation in <i>S. cerevisiae</i> is controlled by the APC-dependent degradation of the anaphase inhibitor Pds1p”	<i>Genes &amp; Develop.</i>	1996, Vol. 10	<b>137</b>
Hecht A. et al.	“Histone H3 and H4 N-termini interact with SIR3 and SIR4 proteins: a molecular model for the formation heterochromatin in yeast”	<i>Cell</i>	1996, Vol. 80	<b>137</b>



### **2.5.2 Long term practical applications**

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. Typical examples of practical applications listed by Grantees include the following:

*“In very general terms our research showed that, against many expectations, anti-idiotypic antibodies are poor substitutes for antigen in clinical applications”*

*“New understanding of the disease process in the central nervous system is being applied to the study of patients with genetic diseases”*

*“This was a basic research project. Its importance relates to our understanding of disease such as diabetes and oncogenicity”*

*“The aspect of our project, which is already commercialized, includes some monoclonal antibodies offered by several companies”*

### **2.5.3 Impacts on Grantees’ subsequent career**

*“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.”*

*“Also since the grants that I apply for are peer reviewed, then the HFSP is certainly regarded as a ‘high profile’ grant and has a good standing in the scientific community.”*

Most respondents stressed the high impact of HFSP on their research career. The major impacts (roughly ordered from most to least frequent) on grantees’ subsequent research career were: fostering and stimulating international collaborations with their peers (35% of respondents); helping in discovery of new lines of research that could be pursued (25%); increasing international visibility and strengthening their reputation (17%); and helping them to secure an academic position (6%).

## **3 Long-term Fellowship Program**

### **3.1 Program uniqueness**

*“The number of countries covered by the HFSP is wider than most in terms of country participation, which alternative funding programs cannot offer”.*

The majority of HFSP fellows (64% of survey respondents) were offered fellowships elsewhere, which demonstrates that HFSP attracts high caliber applicants. The HFSP fellowship was preferred for good reasons over other funding—e.g., the HFSP’s better level of funding, ability to use the support for both research and travel, HFSP’s good reputation, and longer duration of the award.

### 3.2 Impact on collaboration

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 and half maintained formal collaborations such as joint projects. The case study findings also confirm that, for two-thirds of the HFSP fellows interviewed, their experience with the fellowship has led to an increase in collaborations at the intercontinental level and that they are now more interested in forming more collaborative relationships as a direct result of their HFSP fellowship experience.

### 3.3 Outputs and impacts

Fellows have contributed to a wide variety of scientific outputs<sup>4</sup>, mainly through collaborative activities with other scientists in their host laboratory – over 80% of outputs are produced jointly with the host laboratory. These outputs mainly comprise articles in peer reviewed/refereed journals, papers in published conference proceedings, and seminar presentations.

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 survey respondents, 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.

**Table 6** below presents data from the bibliometric analysis. The listed HFSP publications are, on the average, more often cited than other papers by the same authors in the same time period. In our survey, about four-fifths of all listed HFSP papers were published in the second sub-period (1995-99). **Table 7** shows a useful ratio comparison of citations to HFSP papers and citations to other papers by the same authors.

**Table 6: Comparison of the Citation Impact of H-Papers by Fellows with all Publications in the Same Set of Journals (1990-1999)**

Year	# HFSP Papers	Share of Citations	# Citations	Avg. HFSP Citation Rate	Avg. Journal Citation Rate	Ratio HFSP to Journal Citations
1990-94	79	19.3%	2290	28.99	25.49	1.14
1995-99	330	81.7%	6606	20.02	16.48	1.21
<b>Total</b>	409	100%	8896	21.75	18.22	1.19

<sup>4</sup> At a rate roughly one-third that of HFSP grant holders.

**Table 7: Fellows Paper Citation Ratio Values for Papers by Same Author**

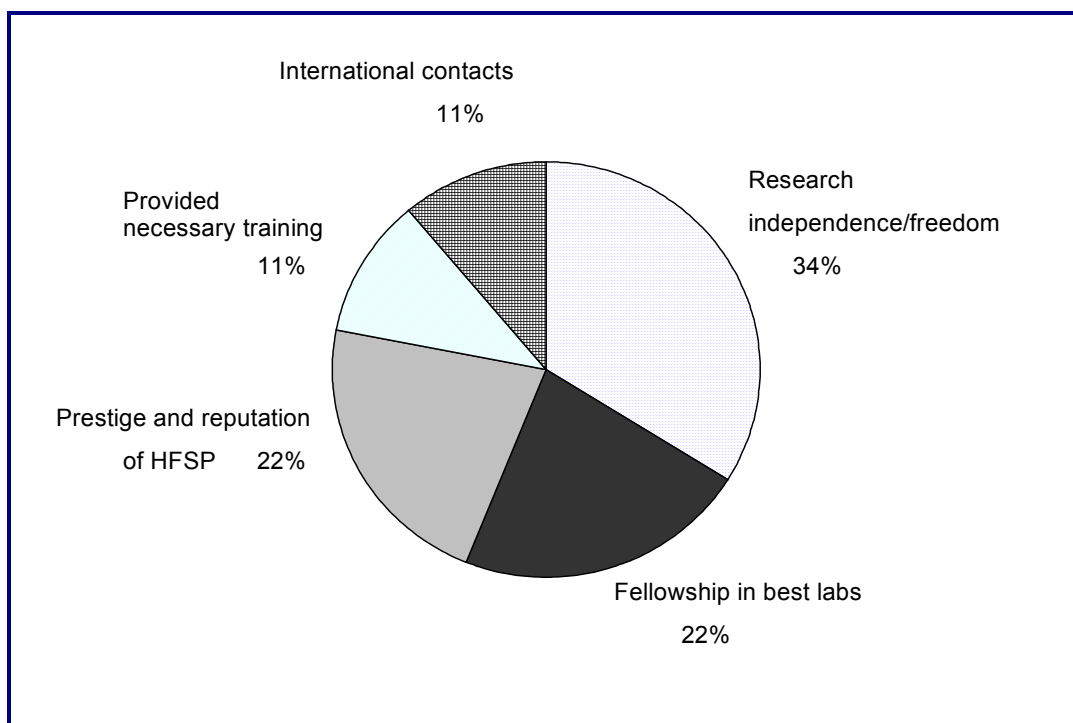
Year	Avg. Citations per HFSP Paper	Avg. Citations per Other Papers	Ratio HFSP to Other
1990-94	28.99	13.90	<b>2.10</b>
1995-99	20.02	10.73	<b>1.90</b>

**3.4 Impact on Fellows’ subsequent careers**

*“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.”*

Almost all ex-fellows are now employed, with the majority holding either a tenured or untenured academic position (32% hold tenured university posts and 36% hold untenured university posts). About 70% of respondents felt that their HFSP fellowship had a moderate to large influence on securing their current position. There was a wide variety of achievements and indicators of scientific esteem listed by fellows that resulted from the awards, including: 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. **Figure 4** illustrates the nature of impacts on fellows’ careers, based on the survey responses.

**Figure 4: Impacts of HFSP fellowship on fellows’ careers**



The survey results indicated 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. Thus both countries are able to benefit from the HFSP fellows' expertise. Analysis of post-fellowship records confirmed that a significant proportion of fellows are now located in their 'home countries'. **Table 8** summarizes the results, which are very similar to the survey findings.

**Table 8: 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=470)
Returned to work in 'home country'	57% (43)	59% (36)	57% (52)	50% (54)	52% (24)	41% (16)	36% (18)	<b>52%</b> (243)*
Still based in host-lab country	32% (24)	21% (13)	28% (25)	31% (34)	31% (14)	44% (17)	50% (25)	<b>32%</b> (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)	<b>16%</b> (75)*

#### 4. Main Conclusions

- HFSP grant holders find the Program a unique source of support for intercontinental interdisciplinary research.
- New collaborations are created that are vital to the execution of the research and continue after the project, thus building an intercontinental community of researchers.
- The Fellowships are not unique but rather are one of a number of elite schemes that collectively ensure that the top echelon of fellows who wish to work in the best laboratories in other countries are able to do so.
- The return rate of fellows is balanced at a point where both host and home countries benefit.
- For both grants and fellowships, the top HFSP publications have a citation performance well above the norm.