

**THE INTERNATIONAL TRAINING AND SUPPORT
OF YOUNG INVESTIGATORS IN
THE NATURAL SCIENCES**

**BACKGROUND
REPORT**

November 2001

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EXECUTIVE SUMMARY

This report was prepared as a background document for the Workshop on “The International Training and Support of Young Investigators in the Natural Sciences” held in Strasbourg in November 2001.

The report reviews some of the wider human resources challenges facing Funding Agencies in the development of the training and careers of researchers in the natural sciences. These challenges are explored against a background of 1) rapidly changing disciplinary structures invoking tensions between specialisation and interdisciplinary, 2) changing university research management structures and procedures, 3) changing relationships and tensions with industrial research and commercialisation of research, and 4) the various trends (mobility, strategic alliances, joint bi- and multi-lateral research projects and programmes, etc.) which contribute to the apparent increased “globalisation” of scientific research.

We explore three major themes 1) the educational baseline at graduate and doctoral level, 2) the educational and training of doctoral and postdoctoral researchers and their first career moves and 3) the international mobility of researchers. In all cases we focus on the human resources implications and challenges for the policies of Funding Agencies.

1. The Educational Baseline

National Funding Agencies each have a very different set of “raw materials” upon which to work.

Such different educational systems and baselines can limit the opportunities for effective Funding Agency research policies – what is point of high research budgets, if the best brains are not available, or the society refuses to engage with the potential benefits of research. Such considerations present the Funding Agencies with perhaps the most difficult challenges of all.

- What are the responsibilities of research Funding Agencies in respect to 1) The public perceptions of science and scientific research and, 2) The quality of scientific education in schools? Both issues will have a major impact on the ability to attract the best brains into undergraduate science, medicine and engineering. What proportion of the budget, if any, should go to such issues¹? Is there room for an international, global effort to promote scientific education and culture?
- There are some wonderful examples of undergraduate research, research training and research publication in some Colleges. Should the Funding Agencies become more involved in encouraging (funding) such activities? Could efforts be made to collect and internationally publicise such innovative activities?
- Are there ways in which the Funding Agencies, Government and the private sector can work together to support the development of such school and undergraduate reform

2. The Doctoral Experience

Solid training structures for doctoral students have made much progress over the last 20 years in the developments in Graduate Schools, formalised year-one training courses, experience of a number of laboratories before commitment to a research topic, improved supervision and support structures. Students trained in such environments are better equipped to develop into creative, confident and highly motivated researchers. They are also more likely to have the broader skills to cope with changing research requirements – both technical and managerial - as well an ability to pursue careers outside the academic milieu, or even out of research if necessary. But there are still many

¹ See for examples for the UK Research Councils and Wellcome Trust, US American Association for Advancement of Science, Howard Hughes, NSF and Japan MEXT.

universities, even national research systems in which training structures are weak. The lone doctoral student in the thrall of an insouciant supervisor is still a common reality.

Many doctoral (and postdoctoral) students are funded through “project based” - as opposed to “training oriented” research funding. The former privileges speed and quality of research – and may lead to narrow specialisation, the latter emphasises the experience of the researcher. The same Funding Agency funds both forms of research involving doctoral (and postdoctoral) researchers:

- Should Funding Agencies have strong training policies in *all* its research funding programmes? Or would they damage research? Should international mobility be an expected part of doctoral research training?
- Should both “project” and “training” research programmes also seek institutional reform, particularly in universities: greater linkages between small Departments / research groups, greater interdisciplinary, better institutional and research management practices, etc?

If a doctoral student has some experience of undertaking research in another institution (government, industry, another university, etc.) they are better-equipped and more likely to move to postdoctoral research or research employment in the other sector. Given the labour market difficulties of some PhDs and the trends towards growth in industrial PhD employment,

- Should Funding Agencies seek to broaden and to “mix” the location of doctoral research? Would this lower the quality of the research or the research training? Would such measures be more costly? Obtaining part-time / occasional “assistant” jobs within universities seems a common financial support supplement for doctoral and even postdoctoral students, and one effective in helping to secure future university employment. Might this be extended on a more organised basis to industry and government research laboratories?

3. The Postdoctoral Experience

The postdoctoral experience has changed radically in the last 20 years, particularly in the Life Sciences. Major growth in doctoral research programmes has not been matched by a similar expansion in tenured research positions and in some countries the number of tenure track positions has actually decreased. This has led to what labour market people would call “the casualisation of research”²: large numbers of researchers on a variety of poorly paid, short-term contracts which may offer no health or social welfare benefits.

Attempts to improve the postdoc system have usually been in the form Research Fellowship / Training Programmes providing reasonable wages and conditions of employment and aimed at the very best researchers. The mass of postdoctoral researchers survives under the “project research” regime. Improving the lot of the latter has been more difficult, but attempts are being made³. Yet, at a time - late 20s, early 30s- researchers are expected to be at their most creative.

- Do Funding Agencies have a view on “the postdoc problem”: is it market forces or human exploitation. Does it have any negative impacts on research? How different is the problem in different countries? What are the main types of solution? Do Funding Agencies have any responsibility for equipping / helping researchers to leave the system?

² While this is true in most countries, France, for example, requires full civil service employment for most of its researchers once they have finished the PhD. Japan’s researchers have a much stronger tradition of training and employment in industry.

³ UK Royal Society’s *Concordat for Research Management*, US COSEPUP’s *Enhancing the Postdoctoral Experience*.

4. The Bridge to Independence

In many countries, the age at which postdoctoral researchers achieve research independence has increased substantially over the last 20 years. In other countries, some believe that the system provides independence at too late a stage in research careers. Most countries have now developed programmes, which provide this bridge by providing various forms of longer term, stable, finance associated with an outstanding young researcher and often focusing on the creation of new research groups.

- What are the characteristics of the most successful independence bridge programmes? What are the best funding approaches / systems to catalyse the opening up of universities' own systems for providing independence? Is there the potential to develop a global flagship programme in this area in cutting edge research areas?

5. International Mobility

The quality, size and openness of the US research system is a magnet to researchers globally (as such, it can also be seen as a global resource). The UK system is also very open. German and Japanese research systems seem far less accessible. These differences, along with differences in system resources, and levels of research development generate patterns of net research migration; from Europe to the US, from the South to North of Europe, from less developed countries to the West. They also generate both political tensions and development opportunities. At the same time, mobility is essential in developing high level research careers, research centres and keeping research systems up to date.

- What, if anything should Funding Agencies do about politically sensitive migration imbalances? Are they best tackled by developing sustainable "institutional attractiveness" or are Return Programmes sufficient?
- Can Global mobility programmes, such as the HFSP, play a stronger role in balanced mobility developments?
- Should Funding Agencies give greater consideration to cross-Agency cooperation, or Global cooperation programmes in the development of their *own* research programmes and systems? Could this present forum help?

6. Research Programme Support

There is a wide variety of schemes addressing all aspects of training as well as cross-cutting mechanisms. In addition, there are programmes, which consciously fund postdoctoral research training but starting from an institutional or disciplinary (rather than individual) development viewpoint. Such programmes might include 1) Cluster awards to institutions or across institutions with the objective of developing interdisciplinary research activities. 2) Cross over awards / Conversion awards which help to bring skills into new research areas. Most funding structures emphasise historic success rather than moving skills. 3) Networking awards, which bring geographically dispersed research groups together.

Here Funding Agencies might ask:

- Which type of Programme gives the best return on investment within the current research structures? Do programmes, which aim to develop institutional or discipline structures, provide an added value over and above individual-centred programmes? Is there such a thing as "a good balance" of funding across the Programme spectrum?
- At what point could Funding Agencies collaborate with each other to support multinational and multidisciplinary career pathways for researchers?

7. The Overall Research Careers

There seem to be four fundamental human resources issues, Funding Agencies alone certainly cannot resolve such questions but how might they help?

- **Strengthening Management** – What “carrots and sticks” are available to Funding Agencies and which are most effective in developing university research management⁴?
- **Family & Gender.** Are there structural changes in university research systems which could lead to better use of female researchers –or at least less wastage? Or do we have to continually rely on additional “Advancement” Programmes?
- **Improving Employment Conditions.** Can Funding Agencies work with Universities to develop better employment conditions, particularly for those on “project” research. Can academic centres such as CERN or the EMBL be developed as alternative or complementary employment routes?
- **On Improving Pay Structures.** Academic research pay scales and contract rates are poor in most countries. Should Funding Agencies move to performance-related pay scales and pay differentials to mirror the private sector? Are there other solutions?

8. Global Action by Funding Agencies

Cooperation between Funding Agencies by creating global forums, such as the current meeting, can provide practical benefits. But can we improve the returns to the researcher, research and the Funding Agencies themselves?

- **At the Administrative Level** how can we 1) Establish a better understanding of the flow of researchers and improve ongoing data collection, 2) Improve the exchange of useful detailed experience on programme targeting, operation and evaluation.
- **At the Training Programme Level,** how can we 1) Advance cooperation in developing postdoctoral training in cutting-edge areas where national resources may be sub-optimal, 2) Better target areas where global research training support would be particularly beneficial - such as the development of skills in creating proteomics databases and data handling tools 3) For the individual researcher, provide a wider choice of better structured mobility programmes.
- **At the National Level,** can we 1) Develop better structured, supported and more accessible paths for less experienced research communities to participate in global research, 2) Create effective forums for developing initiatives for balancing researcher flows.
- **At the Political Level,** recent events strongly point to the necessity of establishing stable, *equitable*, international communities. The research community has much to offer in this context and should be in the vanguard of such a movement.

⁴ The Volkswagen Foundation’s “*Efficiency Through Autonomy*” Programme funds German universities to develop university management and decision making structures as organisational and administrative preconditions for successful research

1 INTRODUCTION

The last decade of scientific research in most countries has seen:

- the emergence of new – very fast moving - fields of research: proteomics, bioinformatics, nanotechnologies, quantum computation, etc.;
- the merging of previously separate areas across all disciplines - significant interdisciplinarity has become necessary;
- problem-based rather than discipline based approaches to research;
- new trends in research structures: research-led universities, semi-independent research units both within universities and loosely linked to universities;
- new funding and management relationships between government, research in universities and research institutes;
- a major new interest from industry, allied to funding and IPR agreements; and
- issues related to the “globalisation” of research and its exploitation.

It is evident that such changes present major challenges to traditional forms of research training, research careers, research institutions and – without doubt – research Funding Agencies whose policy and programmes have such a direct and widespread impact on the national research and innovation system.

There is also concern among many countries over the perceived brain drain of young investigators either to the US or from less favoured to more favoured regions.

This meeting will concentrate on issues related to the “International training and support of young investigators in the natural sciences” and in this context will

- in light of the changing scientific opportunities, review how Funding Agency policies can be changed to develop new investigators ready to meet these challenges;
- identify potential areas in which Funding Agencies can cooperate in the development of truly world class training and the establishment of the basic career stepping-stones for such young researchers;
- identify mechanisms for promoting increased mobility with the goal of a brain circulation rather than brain drain; and
- finally, detail out a number of initial, exploratory actions and recommendations for long-term solutions.

This document contains background information for Funding Agency discussions including data and analysis of the current production and supply of scientists including geographic mobility and early career development of scientific researchers. The annexes include: national data on doctoral and postdoctoral training and employment; national career pathways and funding opportunities, and analysis of changing research labour markets.

The comparisons in the paper are based on data either publicly available (from publications and on the Web) or provided by the Funding Agencies. However, there are areas where no data were collected. There are also many areas where data are incomplete. Indeed, a more regular and comprehensive data collection system could assist in the development of soundly based policies and contribute to successful outcomes.

2 THE EDUCATIONAL BASE FOR THE “RESEARCH PIPELINE”

The formation of human capital for science and technology (S&T) in any country can be affected by three main factors, namely, the supply of graduates by higher education institutions, the international movement of labour involved in S&T, and the investment and commitment to R&D. This section deals with these three factors:

- the supply of graduates in science and engineering (S&E);
- the growing role of the of international supplies of science and engineers; and
- overview of R&D investment and science and technology outputs in the OECD.

2.1 THE BASE LINE AT GRADUATE LEVEL

Data collection across countries is a difficult task as information is collected from different cultural perspectives. Where possible, we have prepared tables and charts that will provide statistical support on which to base the discussions at the meeting. One of the valuable outcomes of this meeting would be the development of transnational data collection that would provide easily comparable statistical information.

Table 1 provides information on the levels of participation in higher education institutions across the member states of the OECD. The data is presented by percent of the population having attained a tertiary degree by age bands for each country. The shaded area identifies the age group 25-34 which is the primary age range covered in the discussion, as it represents the segment of the population completing doctoral studies and transiting into independent positions. Given the wide variation in higher education participation rates, it is evident that some countries will consequently face certain difficulties in developing a strong research system. The data show that research Funding Agencies are working of very different base lines.

Table 2 shows the percentage of the age group from 20-29 that had obtained a first degree in science or engineering in 1999. While it is notoriously difficult to make such comparisons across education systems, certain EU countries show a more marked tendency towards outputting science and engineering graduates from their systems- essentially an indication of the “raw material” with which research Funding Agencies can work in the future.

The two tables indicate interesting trends:

- Japan and Canada report the highest rate of their 24-34 years having obtained tertiary education – almost half of the population in that age group.
- Though US have a high proportion of the 24-34 year old population receiving tertiary education, they report a relatively low rate of S&E first-degree holders.
- In the UK, France, and Ireland less than a quarter of the population have tertiary level degrees, yet they have the highest proportion of S&T graduates.

Table 1. Entry into Higher Education by Cohort in OECD Countries

OECD countries	At least tertiary-type B				
	25-64	25-34	35-44	45-54	55-64
Canada	39	46	39	37	28
United States	35	36	36	37	27
Japan	30	45	40	23	13
Finland ⁽²⁾	29	36	33	27	18
Sweden	28	31	31	29	20
New Zealand	27	26	28	27	23
Norway ⁽²⁾	26	30	28	24	18
Australia	25	28	28	25	17
Denmark	25	27	27	27	19
Belgium	25	34	28	22	14
Netherlands ⁽³⁾	24	27	26	23	17
United Kingdom	24	26	25	23	17
Switzerland	23	25	25	22	18
Germany	23	22	26	25	19
Korea	22	34	23	12	8
Ireland	21	29	22	16	11
Country mean	21	25	23	19	14
Iceland	21	24	24	19	11
France	21	30	20	18	11
Spain	20	32	21	14	8
Greece ⁽²⁾	16	22	19	13	8
Mexico	13	17	15	10	5
Hungary	13	14	14	14	10
Poland ⁽³⁾	11	12	10	11	10
Austria ⁽²⁾	11	12	13	10	6
Czech Republic	10	10	12	10	8
Portugal	9	11	9	8	7
Italy ⁽³⁾	9	9	11	9	5

1. The category "at least tertiary-type A" includes tertiary-type A and advanced research programmes.

3. The level of educational attainment of tertiary-type A includes tertiary-type B.

Table 2. Science and Engineering Graduates

New Science and Engineering Graduates (% of 20-29 age class)

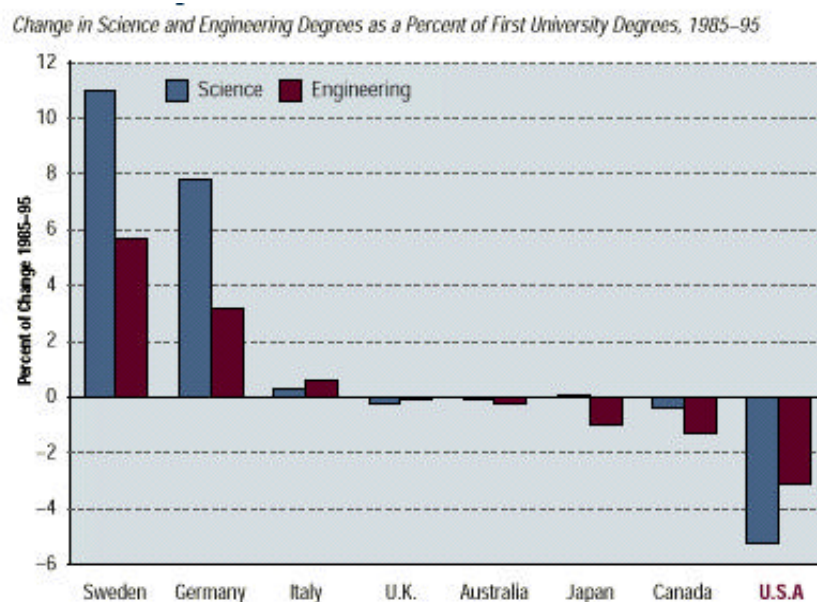
UK	17.8
France	15.8
Ireland	15.6
Finland	10.4
Sweden	9.7
Germany	8.6
Austria	7.8
Netherlands	5.8
Portugal	5.5
Italy	9.6
Belgium	5.1
Denmark	4.7
US	8
Japan	11

Source: Eurostat, US Census. Data are for 1999. Except DK, F, IRL, Italy are 1997.

Source: OECD, 2000, OECD Education Database.

The table below shows the trends in the science and engineering (S&E) composition of first-degree output in the decade 1985-95. Again while such comparisons are subject to the vagaries of changing definitions and statistical collection procedures, there may be some concern in North America due to the falling proportion of S&E graduates in that it represents, at first glance, a weaker base for research and Funding Agencies' work.

Table 1 Change in Science & Engineering Degrees as a Percentage of First Degrees 1985-95



Source: NCES, *International Education Indicators: A Time Series Perspective, 1985-95*, February 2000.

Not all S&T graduates pursue careers in related areas; many choose positions in other fields. Indicators from the UK reveal that out of 450,000 science graduates in the country, only 150,000 (33%) of them are employed as scientists. Detailed data from the US shows a similar story; almost 35% of S&E graduates are employed in sectors not related to their area of graduation, as may be seen in the table below.

Table 2 S&E Degree Holders Employed in Non-S&E Occupations

S&E degree-holders employed in non-S&E occupations, by relationship of degree to job and highest degree received: 1995
(Percentages)

S&E degree obtained	Total number in non-S&E occupations	Relationship of degree to job		
		Closely related	Somewhat related	Not related
All degree-holders	4,690,200	32.6	32.4	35.0
Bachelor's	3,821,100	29.0	32.9	38.1
Master's	699,200	48.3	29.8	21.9
Ph.D.	166,500	48.2	34.1	17.6
Other professional	3,400	71.5	0.0	28.5

SOURCE: National Science Foundation, Science Resources Studies Division, 1996 SESTAT (Scientists and Engineers Statistics Data System) Surveys of Science and Engineering College Graduates, unpublished tabulations.

2.2 THE BASE LINE AT DOCTORAL LEVEL

The table below shows the number of PhDs awarded in selected OECD countries and begins to point towards some more of the issues facing Funding Agencies.

The sheer size of the US doctoral mass (labour market) has implications:

- The US may exert a potential gravitational force on other countries' PhDs. Mobility to the US may be attractive.
- This attractiveness may make it difficult to develop mobility programmes from the US to other countries. Imbalances in participant flows create difficulties for financing and operating programmes.
- The US is a massive homogenous training and career area. This has major implications for Funding Agency programmes.

The European Union's doctoral mass is very different

- Germany is by far the dominant producer of PhDs – and one might expect it to have a similar effect attracting researchers within the EU. However this, as we shall see, is not the case.
- The EU is composed of a heterogeneous set of small doctoral labour markets. This has implications for Funding Agencies operating in small countries and presents major challenges to the EU as a Funding Agency dealing with 15 culturally and structurally distinct research labour markets.

In Japan production of graduates has increased significantly over between 1990 and 1997 and serves as a significant site for training of scientists from Asian countries.

Table 3 Doctoral Degrees Awarded in Selected OECD Countries 1990-99

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<i>(Total all degree disciplines)</i>										
Canada		2925	3109	3334	3525	3684	3885	3914	3945	
US	36067	37534	38890	39801	41034	41743	42415	42705		
UK						7559	9761	10214	10993	11338
Germany				21032	22404	22387	22794	27174	24890	24545
France								10218	10173	
Austria					1581	1641	1762	2144	1901	1843
Belgium				854		619	602		670	580
Denmark				320	333	453	533	365	365	467
Spain			4458	5193	5157	5620	5852	6120	5931	6307
Finland				1672	1953	1483	1397	1422	1708	1725
Ireland				344	497	369	423	449	475	475
Netherlands				4477	4685	4781	5014		2517	2483
Sweden				1763	2101	2216	2416	2549	2725	2916
Switzerland	2176	2174	2349	2479	2621	2578	2730	2826	2796	2732
Japan	10240	10833	11576	12486	13044	13532	13921	15396		

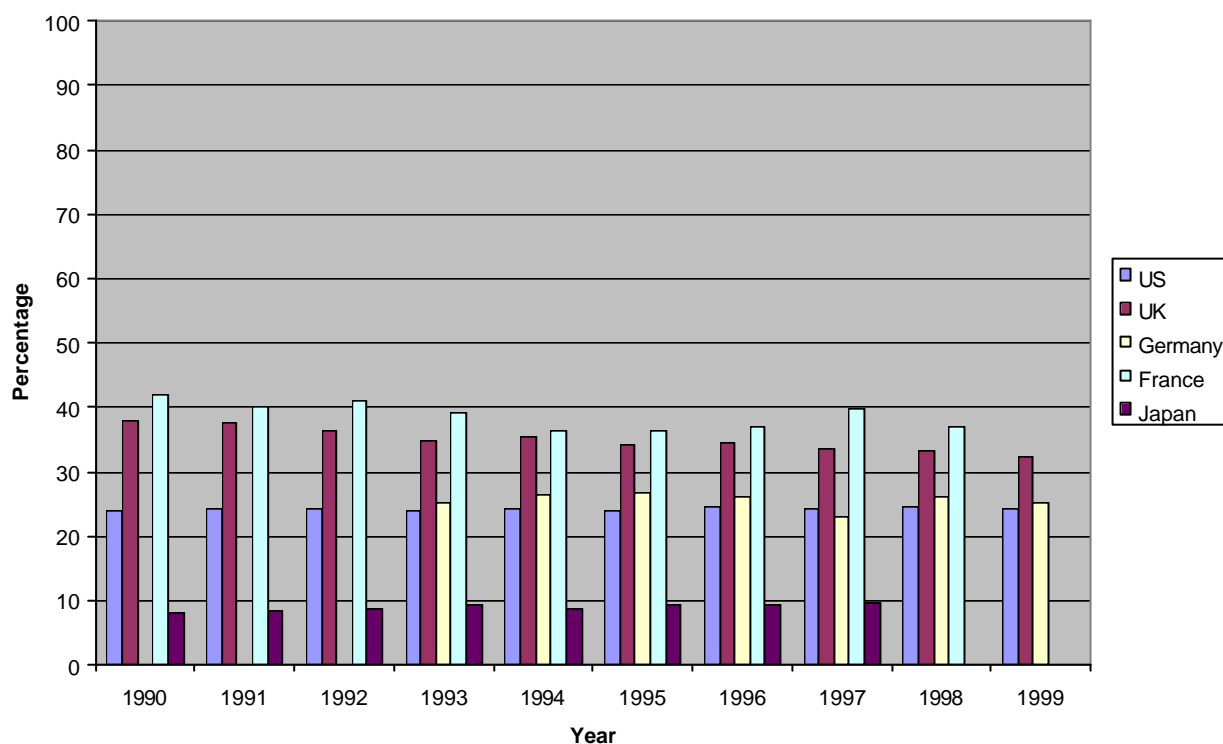
Source: Canada Canadian Association for Graduate Studies 32nd Statistical report table 25; US From NSF Indicators 2000; Germany Provided by Bundesministerium für Bildung und Forschung; UK Higher Education Statistics Agency (HESA); Switzerland Office federal de la statistique Section Hautes ecoles et science; Eurostat, Japan MEXT,

The figure below shows the percentage of all PhDs that were awarded to natural scientists in selected countries. A number of points may be made:

- The very low proportion of natural science PhDs in Japan is indicative of a very different research system being in place, and very different relationships with industry and the training of researchers.
- In the West there seems to be a coming together of the proportion of PhDs being awarded in the natural sciences. Whether this has any substance or significance is not evident.

Figure 1 Percentage of Doctoral Degrees in Natural Sciences in Selected Countries

The percentage of doctoral degrees obtained in the natural sciences in selected countries by year:
1990-1999



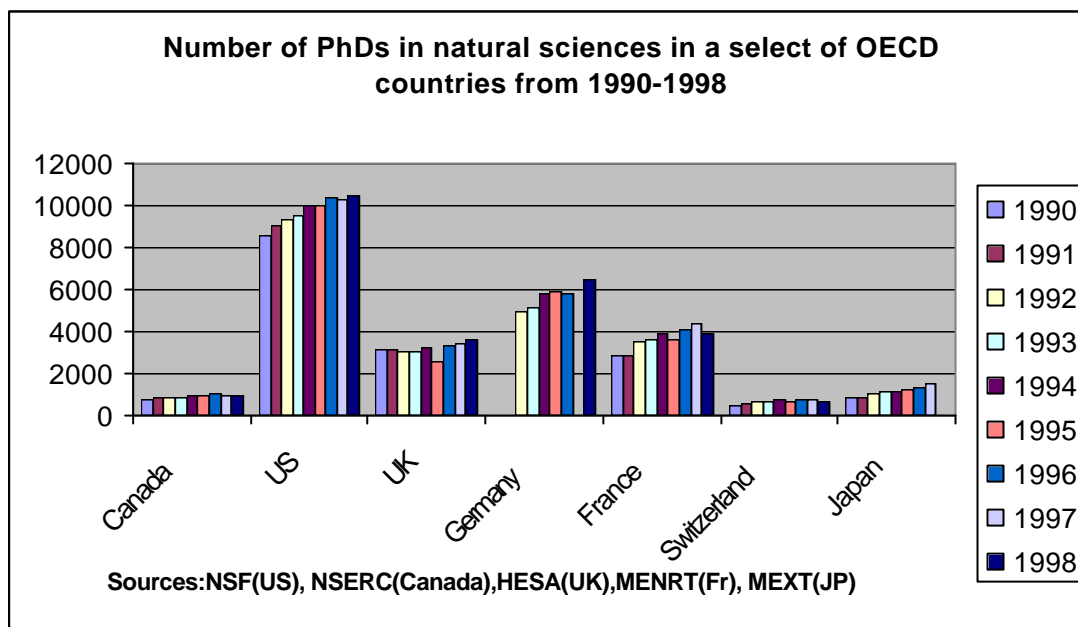
The percentage of doctoral degrees awarded to women in the natural sciences have remained relatively constant over the past 10 years for the countries from which data was made available. The per cent per country is listed below:

Table 4 Percent of Women Doctorates in the Natural Sciences 1992-1999

Country	US	UK	Germany	France	Italy	Switzerland
% Women Graduates	30-35%	39-40%	24-27%	47-51%	41-47%	40-47%

The trends in the number of annual PhD graduate awards in natural sciences are shown below (Table 2). The dominance of the US continues, but the source of the relatively rapid rise in numbers certainly does not come from domestic undergraduate programmes where participation in science seems to be falling (see Table above), rather one must look to the well known phenomenon of non-US citizens moving to the US for doctoral studies.

Figure 2 Numbers of PhDs in Natural Sciences in Selected Countries



2.3 THE BASE LINE OF RESEARCHERS

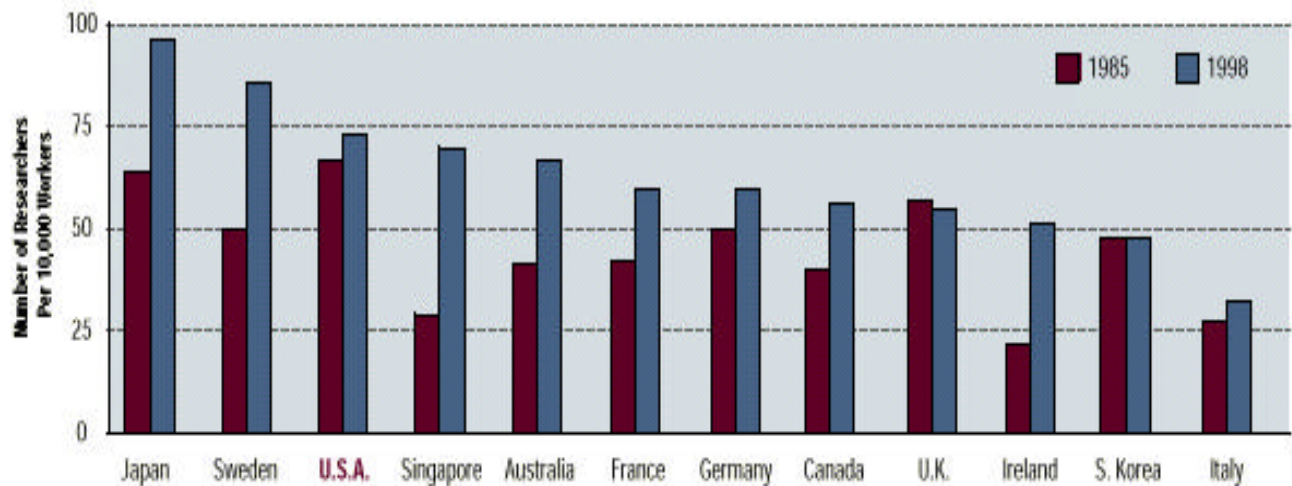
The table below shows the proportion of researchers – number per 10000 population - in the workforce for 1985 and 1998. Most significant is the high proportion in Japan. These are not traditional academically trained researchers – a rather low number in Japan, as we have seen – but excellent graduate students who have been trained as researchers within industry and government.

Most countries show a substantial increase in the proportions of researchers in the period 1985 to 1998 as the “knowledge economy” takes hold.

- The large jumps in small countries such as Singapore, Ireland and Sweden possibly indicate how rapidly aggressive research policies linked to strong, parallel, industrial policies can affect such indicators. It may also remind research Funding Agencies of the benefits of being supported in their work by coherent industrial policies which value research.
- The slow growth in the proportion of researchers in the large countries may reflect economies of scale in research, the different composition of the industrial base or simply the inertial difficulties of large countries. The small decrease in the UK is unique and may be due to the changing composition of its industry in the 1980s.

Figure 3 Numbers of Researchers per 10000 Population in Selected OECD Countries, 1985, 1998

Total Researchers Per Ten Thousand Workers



Source: Organization for Economic Cooperation and Development, *Science and Technology Indicators*.

Some Issues

Nearly all Research Committees and Funding Agencies recognise two closely related challenges that underpin (or undermine) their own possibilities for effective research action: 1) The public perceptions of science and scientific research and 2) The interest in and quality of science in secondary education. These are bedrock issues.

- But are they issues for Funding Agencies? Can / should Agencies increase funding to such areas to ensure that the first stages of the “research pipeline” are healthy and well nurtured?

Increasingly, undergraduates are taking part in forms of research. Work with front line research publications is being incorporated into courses. Journals, run by undergraduates, dedicated to the publication of undergraduate research, are to be found on the Net. These activities enthuse undergraduates and help assure the best move into the “research pipeline”.

- Are there successful examples of Funding Agencies supporting the development of such activities? As with work with schools, should such funding become as normal a part of research Funding Agency budgets as postdoctoral fellowships – or is such work someone else’s responsibility?

3 THE EDUCATION & TRAINING OF SCIENTIFIC RESEARCHERS

Before considering mobility, one needs to ensure that the pipeline is in place to produce the researchers with the skills and attitudes to tackle the scientific challenges in a changing landscape. Success will ultimately depend on national strategies; however, these policies can be informed by international comparisons and by ensuring that young people are open early to global opportunities.

This section reviews three important issues conditioning the formation of students into young scientists:

- identifying mechanisms that ensure a continuing supply of young scientists;
- the issue as to whether doctoral students are perceived as trainees or researchers;
- the location of their PhD studies and contact with future possible research environments (government, industry).

3.1 FILLING THE PIPELINE

The new knowledge-based economy requires a highly skilled workforce that is trained to work in a multidisciplinary and international environment. The natural sciences, particularly the life sciences, are experiencing unprecedented opportunities for growth but these will require scientists from many disciplines to address the explosion of information that has been obtained through mapping of the genome, etc. Students need to be attracted to the sciences, and particularly the life sciences, from a variety of new disciplines and be educated broadly to be able to profit from these new developments. A proactive approach is required to attract and retain the best.

- In the UK, Research Councils and the Wellcome Trust direct sizeable proportions of their budgets to the development of innovative curriculum support for secondary and initial university education. In addition, the Wellcome Trust has inaugurated a programme of regional science centres providing interactive educational activities.
- In the US three completely different organisational structures, the American Association for the Advancement of Science (AAAS), Howard Hughes Medical Institute, and the National Science Foundation (NSF), are actively involved in providing resources and guidance to pre-college education and assessing outcomes. The AAAS Directorate for Education supports 50 education programmes, ranging from an award-winning radio programme to teaching resources as well as the Science 2061 programme to reform science curricula in pre-university education. NSF, the lead US agency in K-12 science is leading a programme on Educational System Reform that reaches into the local school districts.
- In Japan, MEXT has inaugurated an overall reform of education that is changing traditional approach to teaching at all levels from pre-school through the university revising the curriculum, providing additional resources to classrooms and establishing of super-science high schools.

At the university level recent efforts have been put into place to ensure that entering students obtain the right skills, before moving into doctoral training. Undergraduate science education is being reformed in North America, Europe and Japan.

- In the US Physics and Chemistry course work have recently undergone significant reforms in introductory curricula to ensure retention of students and to provide them with the skills they will need to perform research⁵ The NSF has provided support in 225 departments.

⁵ *Science* 293:1624-26

- In Japan, the MEXT is modifying secondary and university degree requirements to create greater flexibility at the initial stages of the student's university experience in order to stimulate creativity and innovation.
- The EU, host to many outstanding universities, is working to harmonise higher education degrees across the continent through implementation of the Bologna Agreement. The Socrates Programme, particularly through Erasmus provides increased opportunities for mobility for students at all levels.

The two figures below are illustrative of such changes.

Figure 4 The Bologna Agreement

In June 1999 Ministers of Education from 29 European countries convened in Bologna and agreed to construct a "European Higher Education Area" to ensure that higher education and research in Europe adapt to the changing needs of society and advances in scientific knowledge.

The following should be in place by 2010:

- adoption of a common framework of comparable degrees;
- adopting two main cycles: undergraduate and graduate with the latter leading to masters or doctorate;
- establish a system of academic credits (European Credit Transfer System) to promote student mobility and improve access for students to training opportunities;
- establish a system of quality assurance across Europe with comparable criteria and methods;
- eliminate obstacles to the mobility of students and researchers.

In 2001 member countries had examined current status of compliance with the agreement. Most were already well on the way to achieving the goal such as France, which is replacing their current system with the Bachelor's and masters equivalents.

Figure 5 The HHMI & Undergraduate Education

The impact of HHMI US biomedical science has been extraordinary. It's success lies in its ability to strengthen the existing scientific infrastructure rather than creating a parallel one. HHMI "hires" the best scientists in the life sciences and leaves them *in situ*, thus strengthening the research universities. HHMI also plays a significant role in the US science pipeline by participating in curriculum reform and strengthening undergraduate research experience. Since 1988 HHMI has provided 476 million USD for undergraduate education that has enabled

- 40,000 students to do undergraduate research;
- participation of 52,000 precollege teachers and 140,000 elementary and secondary school student in science outreach programmes;
- development of 6,7000 new science courses;
- appointment of over 270 new faculty;

and broadened access to science for women and minorities.

Issues

- Which school/K12 and predoctoral programmes have been effective in attracting good students into science and scientific research?
- What are the characteristics of programmes that help develop scientific "creativity"? Are there characteristics that prepare for "interdisciplinarity" How can international undergraduate mobility be used to foster creativity and interdisciplinarity?
- Are there ways in which the Funding Agencies, government and the private sector can work together to support the development of such school and undergraduate reform?

3.2 DOCTORAL STUDENTS: TRAINEE OR RESEARCH WORKER?

The European Commission applies the term “Training through Research” to its Research Training Networks and Marie Curie Fellowships, thus, implying that doing first class research is first class research training: that the two are identical. The varying needs may create conflicting priorities:

- **At the Student level:** There may be a wish to complete the PhD – which could be considered a “piece” of research - as quickly as possible. Training – more courses, more lectures, more research placements, - means a longer period on the low finances of a PhD student.
- **At the Supervisor level:** There may be a similar wish to “get on with the research” on which the laboratory reputation, indeed the next grant, may be based. Training can mean more of the student’s time away from the bench and slower research in a competitive environment. Training can also mean more of the supervisor’s time – especially if students are going to be rotated through the laboratory as three month “Tourists”.
- **At the Department / University level:** With the rise of research universities, PhD training means additional rooms, staff resources and more administration. University administrators will recognise that costs are higher than people imagine.
- **At the Funder / Government level.** On the one hand there may be pressure on investigators to “do research” as research outcomes may be the measures of success rather than the training outcomes. Most research funding is “project based” not “researcher-based” and certainly not “Doctoral student based”. The research costs are funded and, rarely, if ever, are there strong requirements on human resources development. On the other hand, other parts of Funding Agencies may be providing funding to support *research training* at doctoral or postdoctoral levels. But it is the project-based funding which has caused the explosion in PhDs and postdocs. – not training related fellowships. The case study of the NIH illustrates many of the difficulties – and solutions are proposed⁶.

Solid training structures for doctoral students have made much progress over the last 20 years in the developments in Graduate Schools, formalised year-one training courses, experience of a number of laboratories before commitment to a research topic, improved supervision and support structures. Students trained in such environments are better equipped to develop into creative, confident and highly motivated researchers. They are also more likely to have the broader skills to cope with changing research requirements – both technical and managerial - as well an ability to pursue careers outside the academic milieu, or even out of research if necessary.

Even though formal, monitored, well-structured programmes of training grants account for the minority of research training, they provide a structure from which all students training in these departments profit. In addition, Funding Agencies are increasingly recognising the need for a new generation of scientists who are versed in several disciplines. As such, they are funding more and more interdisciplinary programmes. These programmes are both 1) changing the culture of graduate training, 2) drawing together a greater proportion of university departments and research activities, and 3) serving in some instances to link institutions outside the academic sector with pre- and postdoctoral training. But there are still many universities, even national research systems in which training structures are weak. The lone doctoral student in the thrall of an insouciant supervisor is still a reality.

⁶ An evaluation of the NIH-NRSA-predocutorial training program (appendix) showed that individuals enrolled in these programs *as well as students in the same university but not on the program* outperformed comparison groups in all categories including: time to completion of Ph.D., career progression and professional appointments, success at obtaining grant support and publications and citation levels.

Figure 6 Structuring Training Grants:

The changing landscape of science requires that training structures be responsive to the challenges faced by the new generation of students. New programmes have been developed in Germany through the DFG, and MPG; in the US through the NSF and NIH; and in the European Commission Research Directorate through support to institutional development of training of doctoral students.

The best of these programmes all share common characteristics:

- though the overall goal or research training has been outlined by national Funding Agencies the actual structure of the sites has been defined by the investigators/trainers through competitive procedures;
- training programmes go beyond a single department or even institution by bringing together excellent scientists who within a more or less general focus, provide an interdisciplinary environment for graduate formation;
- opportunities for mobility either within the institution, between countries, or between different economic sectors are encouraged;
- the structure of these institutions or networks encourages collaboration across disciplinary line both for students and the faculty associated with the training schemes;
- the programmes encourage the inclusion of women and under-represented minorities and foster mobility.

Though not fitting into the above group, the EMBL provides an outstanding example of a research-training site.

Some Issues:

- Are conflicts between “Project-based” funding and “Researcher-based” funding of real importance? Should Funding Agencies have strong research training policies in **all** research funding programmes? Could such policies be monitored and enforced?
- With the increase in interdisciplinarity and opportunities for mobility can single, individual institutions – even some of the larger ones - provide adequate training for their research students? Should Funding Agencies provide greater support for inter-institutional linkages? How should such linkages be structured and funded?
- To what degree should mobility among predoctoral students be encouraged as part of their normal experience?

3.3 DOES WHERE YOU DID YOUR DOCTORATE AFFECT CAREER DECISIONS?

While in many countries universities have a monopoly in awarding PhDs, the actual research location (university, industry, government laboratory) in which the doctorate is undertaken can vary. This can have a major bearing on the subsequent PhD's career path and employment prospects. Some, even a small amount of industrial experience, can make an industrial career much more likely. Experience as an assistant teacher makes it more likely that the PhD will stay in academia.

New programmes for expanding predoctoral training experience to include exposure to non-academic research training sites have appeared within the past few years in the USA. The NSF Integrative Graduate Education and Research Traineeship (IGERT) Programme grants require institutions receiving training support to institute opportunities for internships outside of the academic environment as part of the graduate experience.

Case Study 1 France: Career Paths of French PhDs

Martinelli found that the destination of French PhD graduates is influenced by

- 1) the funding source of the thesis – receiving a research grant seems to channel PhDs towards HE – half of the science PhDs who received research grants went into Higher Education;
- 2) the institution of study;
- 3) the experiences gained during the studies – for example teaching while undertaking the thesis made it easier to move into HE – one-third of science PhDs worked as “graduate assistants”. These then had relatively little problem in finding employment in HE and research;
- 4) any PhD who had had experience of working in industry was much more likely to find employment in that sector - and to have few problems in rapidly finding secure employment;
- 5) the small sample of non-French PhDs surveyed showed much higher levels of insecure employment and unemployment.

Martinelli (1999) also found that

- the CIFRE (Industrial Agreement on Training through Research) Programme produced the most employable and financially rewarded PhDs. These are students, pre-recruited by industry and undertaking research most often on an industry-related topic. These PhDs are the top earners, probably due to their propensity to seek industrial rather than academic or government employment – 70% of CIFRE PhDs are engineers in firms. 37% of CIFRE PhDs completed their PhD mostly in a firm. 82% carried out at least some of their research in a firm. They also outperformed the Grande Ecole graduates in terms of salary – of course many of these PhDs are also graduates of a Grande Ecole;
- within the Sciences, the “hard” sciences (maths, physics, IT) found employment more easily, had less job insecurity and unemployment than the life sciences (chemistry, biology, earth sciences,). Engineers found employment most easily of all. Even within the CIFRE PhD with their low exposure to unemployment and insecure employment, there was a marked difference between engineers and non-engineers – the latter suffering the worst of the admittedly very low levels of job insecurity and unemployment.

Some Issues:

Given the labour market difficulties of some PhDs and the trends towards growth in industrial PhD employment,

- Should Funding Agencies seek 1) to broaden and 2) to “mix” the location of doctoral research? Would this lower the quality of the research or the research training? Would such measures be more costly?
- Obtaining part-time / occasional “assistant” jobs within universities seems a common financial support supplement for doctoral and even postdoctoral students, and one effective in helping to secure future university employment. Might this be extended on a more organised basis to industry and government research laboratories?

4 THE POSTDOCTORAL CAREER LADDERS OF RESEARCHERS

This section begins by following the new doctoral student through her/his academic career including:

- the support programmes, which provide a framework from new post-doc to tenured professor;
- the dilemmas and employment prospects facing most new post-docs;
- the move to becoming an independent researcher;
- four basic problems which will face researchers throughout their lives; and
- the gender issue.

The Section then moves the focus from the individual to the wider system to look at two issues which affect the careers of academic researchers:

- the tensions between tenured, employment-for-life and the need for competitive research excellence; and
- the move from teaching-led to research-led universities.

The section finishes by briefly looking at research careers in government and industry and asking about their relationships with Funding Agency policies and academic research careers.

The table below provides an introduction to the very different academic career paths which have developed. It shows the very different age and tenure profiles for four EU countries: the relative “democracy” of the English career system; the professor centred nature of the German system; the importance of teaching and research associates in the Netherlands. Thus, while it is very useful to compare Funding Agency approaches across national boundaries, trends may be similar but the application of any lessons learnt have to take place within historically very different, deeply rooted national and, sometimes, even regional research structures.

Table 5 EU: General Characteristics of Academic Careers

England							
	Professor	Senior Reader	Lecturer	Lecturer	Research staff	Total	
Tenured staff (%)	92	96	90	83	6	79	
Full-time staff (%)	97	95	93	95	90	94	
Age (mean)	52	52	48	41	36	45	
Women (%)	3	6	8	22	19	15	
Doctoral degree (%)	77	88	72	66	63	70	
Toward advanced degree	1	1	7	15	30	11	

Germany							
	Professor	University lecturer	Middle rank	Assis- tant	Contracted junior staff	Research staff	Total
Tenured staff (%)	98	-	100	-	-	6	42
Full-time staff (%)	99	98	96	99	73	51	81
Age (mean)	54	39	47	35	31	33	40
Women (%)	6	14	15	22	23	24	17
Doctoral degree (%)	95	100	83	93	28	30	62
Toward advanced degree	1	40	26	83	87	77	52

Netherlands							
	Full professor	Asso- ciate prof	Assis- tant prof.	Teaching asso- ciate	Research asso- ciate	Other staff	Total
Tenured staff (%)	97	97	81	48	19	29	68
Full-time staff (%)	82	90	73	37	67	51	72
Age (mean)	52	48	42	41	34	37	42
Women (%)	7	9	19	35	38	43	22
Doctoral degree (%)	92	88	51	20	28	24	54
Toward advanced degree	1	5	30	25	43	39	25

Sweden							
	Professor	Senior lecturer	Junior fellow	Assistant lecturer	Research staff	Total	
Tenured staff (%)	91	83	17	74	52	72	
Full-time staff (%)	93	84	93	73	76	82	
Age (mean)	52	49	39	45	41	46	
Women (%)	4	25	22	38	32	26	
Doctoral degree (%)	99	90	99	22	70	74	
Toward advanced degree	1	15	39	59	46	31	

Source: Enders (1997)

4.1 PROGRAMME SUPPORT FROM DOCTORATE TO TENURE

As an individual progresses through the research career he/she has different requirements for support based not only on their own increased autonomy and independence but also on the changing opportunities in the scientific arena and in their own personal expectations. Attraction of the best minds to science and their retention requires that career opportunities at each stage of their progression be available and adequately funded.

Table 6 The Spectrum of Research support Programmes

<ul style="list-style-type: none"> • Pre-Doctoral Training • Initial Postdoctoral Training • Senior Postdoctoral Training • Independence Bridge to Group Leader • Career Development (Tenure Track Researcher) • Career Development (Tenured) <p>Crosscutting Programmes for Special Situation:</p> <ul style="list-style-type: none"> • Out-Mobility for own Researchers • In-Mobility for non-Nationals • Return-Mobility for Nationals • Re-entry to Research Workforce • Advancement of Women Researchers • Advancement of Minorities

The table above shows some of the main funding categories including funding for:

- **Initial Postdoctoral Fellowships:** It is essential that the best researchers be retained immediately after their doctoral studies. Most countries provide a variety of “basic” funding to anchor such researchers in national universities. However, as noted elsewhere, such funding, often with solid training and social welfare requirements attached, funds the minority of researchers in most countries. However, such high quality programmes are often reserved for “own nationals”
- **Senior Postdoctoral Fellowships:** While common, such programmes have come under some criticism as simply prolonging the uncertainty of “the postdoctoral dilemma”
- **Independence / Group Leader Positions:** These are recognisable break from the forms of funding above and usually act as a transition phase to tenured employment. Some Programmes’ requirements seek to ensure that such researchers do move into tenure. These positions are much sought after, and Funding Agencies seem to be devoting a greater proportion of their budget to such support.
- **Career Development Funding:** This tends to be aimed at more established researcher and seeks to support them in creative new ventures - or at least preparing for such moves. Such creative moves may be less likely to be funded by mainstream research funding. The money introduces flexibility at the higher research levels.

In addition to funding individual career progression other mechanisms address special needs that may arise at any level along the career pathway:

- **Women and Ethnic Minorities:** In addition, the pool of scientific talent needs to be broadened to include those who have not historically been part of the research enterprise. Women and ethnic minorities in many countries either do not enter the science pipeline or disproportionately populate the lower ranks.

- **International Mobility:** Opportunities for training or research collaboration at sites in other countries is recognised as having a high value. However, differences in policies regarding funding and independence of young investigators has led to disproportionate move of young scientists to the US and the UK thus the heightening concerns regarding brain drain.
- **Return Mobility:** It is becoming increasingly common for countries to offer various forms of return mobility funding to attract back its own nationals. This may take the form of 1) dedicated programmes, or 2) reforming national programmes to make them more accessible or more attractive to nationals abroad.

There are, of course, programmes which consciously fund postdoctoral research training (rather than simply research) but starting from an institutional or disciplinary (rather than individual) development viewpoint. Such programmes might include:

- cluster awards to institutions or across institutions with the objective of developing interdisciplinary research activities;
- “cross over” awards / “conversion” awards which help to bring skills into new research areas. Most funding structures emphasise historic success⁷ rather than moving skills; and
- networking awards, which bring geographically dispersed research groups together.

There is some argument that Funding Agencies might direct a greater proportion of their resources through such mechanisms since, as well as providing good training, they may be more effective in achieving institutional reform.

With the exception of doctoral students, accurate information on individuals in the postdoctoral track through to the professor is not readily available in all countries.

Some Issues

- Which type of Programme gives the best return on investment within the current research structures? For example, do programmes, which aim to develop institutional or discipline structures, provide an added value over and above individual-centred programmes?
- Is there such a thing as “ a good balance” of funding across the Programme spectrum? If so, are national Programmes well balanced? Is there a case for a marginal redistribution? From where to where?
- At what point could Funding Agencies collaborate with each other to support multinational and multidisciplinary career pathways

⁷ Even famous scientists get caught – Ken-ichi Arai - “...Up until that time I had been working mostly on bacterial systems and I wanted to move into yeast genetics or mammalian molecular biology or molecular immunology. But as long as I was applying for an NIH grant there was no opportunity to do this as I had to continue in a discipline where I had a track record. I had already received offers of a professorship from several leading universities in the USA, ...” *EMBO Reports* vol 2, no 7. 2001, pp 549-551.

4.2 FACING POSTDOCTORAL DILEMMAS

“The concept of a postdoctoral scholar in science and engineering arose about a century ago when a handful of PhD researchers were awarded small stipends for the purpose of augmenting their skills and experience. The postdoctoral population in the United States, after decades of gradual growth, leapt ahead quickly in the 1980s and now outnumbers the graduate student population at some US institutions. The total number of postdoctoral scholars, or postdocs, has grown to an estimated 52,000.

The primary purpose of the postdoctoral experience is to broaden and deepen the research and other skills that are required for a significant contribution to society and satisfying, professional employment. Ideally, this is accomplished through the guidance of an adviser in whose laboratory or department the postdoc works; the administrative and infrastructural support of the host institution; the financial support of a funding organisation; and the professional development support of a disciplinary society.

The postdoctoral experience does not always succeed in its educational purpose. In some cases, the postdoc is poorly matched with the research setting; in others, there is little opportunity for growth toward independence, guidance is poor, or a mentoring relationship fails to develop. Sometimes mentors, institutions, and funding organisations have been slow to assign postdocs the status, recognition, and compensation that are commensurate with their skills and contributions to research.”

Committee on Science, Engineering and Public Policy (2000), USA

Moving from being a doctoral student to being a post-doc is a coming-of-age process. The new PhD is faced with a variety of choices:

- **which research area:** Postdoctoral scholars can – and, indeed, possibly should be encouraged - move into a new area of research thus increasing competency and opportunity for more creative work in the future;
- **where to do the research:** It is a time of great geographical mobility and many sources of support are available to assist those deciding on a research experience abroad;
- **what type of research institution:** Large government research agencies have for a long time provided research opportunities. Large industry is now also providing increasing numbers of research positions. Academia is not the only choice.

On the other hand, for those who stay in academia.

- the sense of institutional responsibility which most / all institutions show towards doctoral students lessens dramatically. They may be seen, as one researcher put it, “guest workers”;
- certain researchers obtain post-doctoral fellowships / traineeships which may require good training structures and social welfare provisions⁸. The less fortunate - the majority in most countries - will be contracted on “project-research” where the provisions of employment may be the absolute legal minimum for contract workers (“guest workers”). Longer-term employment prospects may be poor;
- depending on the country, competition for good fellowships and tenure-track positions in most disciplines, particularly the life sciences, will be intense given the high levels of PhD production particularly in the life sciences. The chance to become an independent researcher will be slim.

Thus, the incentives to move to government or industrial research, both of which have relatively transparent research careers, are strong – as are the incentives to leave research altogether. For many the motivation to move abroad for reasons of career development is strong. This is part of the

⁸ In countries where postdoctoral fellows are identifiable and counted, there has been a growth in the number of postdoctoral fellows in temporary positions. Unfortunately, for many countries there are no country-wide statistics available to provide an indicator of the real size of this pool.

potential “brain drain” and a difficult and complex area in which a new postdoc can make or break a career.

The postdoctoral experience should be one of the most productive periods of an investigator’s professional career as he/she has few if any institutional obligations yet already has experience in research, is free to move into a new research area to broaden his/her competence and is in a period of heightened geographic mobility. The highest proportion of foreign scientists at academic research centres is in this category. Many Funding Agencies provide support for postdoctoral training not only in other institutions in their home country but, in many cases, preferably abroad. Depending on the country, the incentives to move to government or industrial research, both of which have relatively transparent research careers, are strong – as are the incentives to leave research altogether. The decision to move abroad – the potential brain drain – will be discussed in section 5.

The Case Study below shows the “casualisation” of the research workforce centring on the growth of temporary post-doc employment.

Case Study 2 US: Casualisation of the Research Work Force

The table below shows the changing distribution of the US academic biomedical workforce. Most obvious is 1) The jump in absolute numbers and 2) What labor market people call the “casualisation” of the work force: the move from permanent employment to temporary employment contracts.

Table 7 US: Basic Biomedical Workforce in Academia by Employment Type

	1977		1997		Increase
Tenured Faculty	14345	48%	20326	38%	142%
Tenure Track Faculty	9170	31%	8974	17%	98%
Non-Tenure Track Faculty	1057	4%	6822	13%	645%
Academic Postdocs	3507	12%	9620	18%	274%
Other Academics (Research associates, Instructors, etc.)	1810	6%	7296	14%	403%
Total	29889	100%	53038	100%	

Committee on National Needs 2000

The period 1977 to 1997 also saw a radical change in biomedical research with a move to large research teams, which present comparatively few openings for independent researchers. The Commission (2000 p.23) notes that

- “PhDs have increasingly taken on the day-to-day work of research – tasks that command low salaries and in past years were often performed by technicians”, and
- “consequently, some believe that biomedical research has two distinct job markets: one for independent investigators for whom demand is low and one for low-paid research workers for whom demand is high”, and

that demographic analysis indicates, assuming the current trends, never mind increasing levels of PhD output, that the structure of employment is more likely to worsen for PhDs seeking permanent research employment.

The appendices also provide a first-hand review of the difficulties and dilemmas faced by a Canadian post-doc.

Some Issues

- Do Funding Agencies have a view on the causes of “the postdoctoral problem”? Do Funding Agencies view the situation as “market forces” or “exploitation”?
- If “research” is the absolute goal of Funding Agencies, does “the postdoctoral problem” have any negative impacts on research?
- Is there a geographical variation to the “postdoctoral problem”?
- What can the Funding Agencies (with Government / Universities) do to improve this system – at a minimum - those parts which might negatively affect national research potential?
- On the other hand, do the Funding Agencies have a responsibility to the researchers (doctoral, post-doctoral even temporary assistant lecturer / group leader) for their exit from such a research system – since they funded its development? Or is it up to the researcher – they are highly educated and more or less employable? Perhaps such Funding Agency concern should be limited to the exit of PhDs?

4.3 SHOULD THE POST-DOCTORAL SYSTEM BE STRENGTHENED?

While the Research Training Programmes discussed earlier can have a major direct as well as a catalytic / leverage effect in improving the postdoctoral research system, in most countries, most postdoc. researchers are not financed from such sources. They are on various forms of temporary contract associated with the “soft money” of contract research funding.

It is important that consideration be also given to the development of this, sometimes, very unclear but, certainly, very dynamic area. Of course, in some countries it is not a problem. The French legal system requires permanent contracts for such researchers, giving them the status of civil servants but then with the generally recognised problem of lack of flexibility and vitality within the system.

The UK Royal Society’s *Concordat for Research Management*, 1996, has been important in improving the employment conditions of postdocs. It has been agreed between the UK Research Councils, the Higher Education Funding Councils, the Royal Society, the British Academy and others. It provides a framework for ensuring that universities and the other higher education institutions provide proper postdoc. career management by:

- promoting the active personnel and career management of contract researchers -performance management, supervision, review and equal opportunities;
- accepting the importance of regular review and career guidance - career development and training;
- delineating clearly the different roles and responsibilities of the funding providers and the universities and colleges receiving that funding in meeting costs associated with staff management and reviewing funding levels for personal and longer-term support.

The US has recently been confronting a similar challenge in trying to improve the wider postdoc experience as seen in the case study below.

Case Study 3 US: Enhancing the Postdoctoral Experience

Guiding Principles

1. The postdoctoral experience is first and foremost a period of apprenticeship for the purpose of gaining scientific, technical, and professional skills that advance the professional career.
2. Postdocs. should receive appropriate recognition (including lead author credit) and compensation (including health insurance and other fringe benefits) for the contributions they make to the research enterprise.
3. To ensure that postdoctoral appointments are beneficial to all concerned, all parties to the appointments-the postdoc., the postdoc. adviser, the host institution, and funding organisations-should have a clear and mutually-agreed-upon understanding with regard to the nature and purpose of the appointment.

Recommendations

1. Award institutional recognition, status, and compensation commensurate with the contributions of postdocs. to the research enterprise.
2. Develop distinct policies and standards for postdocs., modelled on those available for graduate students and faculty.
3. Develop mechanisms for frequent and regular communication between postdocs. and their advisers, institutions, funding organisations, and disciplinary societies.
4. Monitor and provide formal evaluations (at least annually) of the performance of postdocs.
5. Ensure that all postdocs. have access to health insurance, regardless of funding source, and to institutional services.
6. Set limits for total time of a postdoc. appointment (of approximately five years, summing time at all institutions), with clearly described exceptions as appropriate.
7. Invite the participation of postdocs. when creating standards, definitions, and conditions for appointments.
8. Provide substantive career guidance to improve postdocs' ability to prepare for regular employment.
9. Improve the quality of data both for postdoctoral working conditions and for the population of postdocs. in relation to employment prospects in research.
10. Take steps to improve the transition of postdocs. to regular career positions.

Committee on Science, Engineering and Public Policy-COSEPUP, (2000), "Enhancing the Postdoctoral Experience for Scientists & Engineers"

Some Issues

Funding Agencies face a number of challenges in trying to develop a postdoctoral system that is attractive and equitable to researchers at the same time as producing high quality, creative research.

- There is - absolutely rightly - considerable effort to develop independent positions for the very brightest researchers. But should much better (permanent?) employment structures be developed for those of lesser ability – or should market forces simply be permitted to regulate this (relatively privileged) labour market?
- Are there any negative implications for research *per se*, from the postdoc. system as it applies in “Anglo-Saxon” countries? What can the Funding Agencies (with Government / Universities) do to improve this system, at a minimum those parts, which might negatively affect national research potential?
- Do the Funding Agencies have any responsibilities towards those in the postdoc. system, particularly in Agency-funded contract research, who will never “make it”?

4.4 INDEPENDENCE: JUNIOR GROUP LEADERS & ASSISTANT PROFESSORS

The move from the, temporary postdoctoral position to a recognised position of independent research leadership – possibly still with a temporary contact – is the goal of most researchers. The title given varies by country and institution but the reality is

- 1) budget for a substantial period, three to five years;
- 2) an annual budget which permits the employment of one or two postdocs., PhD students and a technician;
- 3) laboratory space and materials; and
- 4) independence! -your own research topic / direction.

The research leader is in her or his late 20s, if they are very lucky, or early 30s. The table below highlights some of the characteristics of such programmes.

Table 8 Dimensions of Junior Research Group Programmes

Dimensions	Characteristics / Issues
Age	<ul style="list-style-type: none"> • Usually age limit in early to mid 30s.
Qualification	<ul style="list-style-type: none"> • Usually PhD + 2 years. Could this be lowered to new PhDs?
Nationality	<ul style="list-style-type: none"> • Some limit to nationals / residents. Others open to all if they are willing to become resident.
Period covered	<ul style="list-style-type: none"> • Usually from 3 years to occasionally 6 years. What are the implications of shorter or longer times?
Research Phases	<ul style="list-style-type: none"> • Some (Canada) split support into two phases: a) research focused b) Integration of research / researcher into institution.
Funding level	<ul style="list-style-type: none"> • Substantial to researcher for postdocs/PhDs/technician • Funding to host's overheads may vary (UK v Germany) • Small equipment / consumables may be included. Large equipment may require other funding routes.
Mobility	<ul style="list-style-type: none"> • Some require researcher to move to new research centre or to have moved to new research centre since PhD.
Host Location	<ul style="list-style-type: none"> • Most restricted to university / university hospital.
Requirements of Host	<ul style="list-style-type: none"> • Unusually scientific synergy sought. • Explicit (in-kind / financial / equipment) contribution and involvement of host often required. • Often integrated researcher/host integrated research plan required. • Often opportunity to teach and host PhD students required
Additional	<ul style="list-style-type: none"> • Part-time / family friendly / childcare funding possibilities are starting to appear

The move to the first independent position is viewed as possibly the most critical step in an individual's career. It is also a critical opportunity for countries to encouraging innovation and creativity from their investigators.

- The large stay-rate in the US of foreign scientists is reported to be because the system, though highly competitive, bestows on young investigators complete independence upon obtaining an assistant professor position.
- At a time when organisations would like to encourage young scientists to obtain research experience in different disciplines, and encourage mobility, severe age limitations can either lead to investigators moving into other sectors than academic research or limit their own potential.
- New initiatives have recently been put into place such as l'Avenir at INSERM, MEXT's PREST programme in Japan, the MPG Young Group Leader positions, DFG Heisenberg fellowships, and VW Stiftung Junior Research Groups in Germany, Swiss NSF Professorships, NSF CAREER Awards, and the NWO Innovation Incentives Schemes in the Netherlands to increase and strengthen opportunities for the brightest young investigators to develop their own research programme.
- New programmes stimulating mobility and developing domestic scientific manpower are using "bridge funding" mechanisms by providing highly talented young investigators with postdoctoral experiences abroad and then with a bridge to independence upon their return home. The Canadian CIHR Senior Research Fellowship Award, the NIH International Research Scientist Development Awards as well as the German Emmy Noether Programme, all provide funds for postdoctoral experiences with research grant on award of an independent position.

HFSP and EMBO both have supported highly successful international postdoctoral fellowship programmes. In 2000, both initiated programmes for young investigators within the first few years of their first independent position. These programmes provide awardees with added opportunities to pursue their own research and build strong international and interdisciplinary ties.

- HFSP enables international teams of young investigators compete for collaborative grants for novel interdisciplinary projects. Only the principle investigators must come from either the G7 countries, the EU or Switzerland and though they must be from another country, there are no geographical restrictions on other members of the team.
- EMBO provides top-up funds over national support to new investigators in Europe and enables its grantees to utilise EMBL core facilities and encourages interactions among the awardee network.

Both programmes are highly competitive and of the 86 awardees, only 12 had not spent some period of their research training in another country.

Some Issues:

- What are the characteristics of the best independence bridge / new research group programmes? Do we need different "new research group" support strategies in areas where the trend is to larger research teams - should there be more emphasis on the group leaders' management abilities, or at a minimum, training and supporting them?
- What are the best funding approaches / systems to catalyse the universities' own systems for the generation of "new research groups"?
- How can collaborations between organisations be established to leverage support for outstanding young scientists?

4.5 FOUR FUNDAMENTAL CHALLENGES IN ACADEMIC RESEARCH CAREERS

While the career possibilities for a PhD have broadened considerably in both government and industry, academic research is still the objective of most⁹ doctoral students, despite the well-recognised problems. The table below (The Wellcome Trust (2001)), looks at these problems as they change over the lifetime of an academic researcher in the life sciences. They include:

- **initial employment insecurity** in the early stages;
- **the poor financial benefits** as a problem all through the career;
- **family (gender) issues** as a problem in the early and middle career – and associated with the huge “waste” of female research talent; and
- **poor management** is probably a career-long issue – possibly not mentioned in the early career because of the dominance of relative insecurity and penury (possibly associated with bad management?).

Table 9 UK: Academic Research Career Issues in the Life Sciences by Career Stage

Stage	Career Issues
Early	Obstacles: Job insecurity, poor career prospects. Cannot access research grant funding? Reasons for Leaving: Insufficient rewards, money status, Family Issues.
Middle	Obstacles: Family Issues. Poor management and personnel issues. Reasons for Leaving: Insufficient rewards, money status. Job insecurity, poor career prospects.
Senior	Obstacles: Insufficient rewards, money status. Reasons for Leaving: Insufficient rewards, money status. Poor management and personnel issues.

Wellcome (2001) Extracted from Tables 4.2 & 4.3

The German Federal Government is currently examining a radical overhaul of management and employment in their own research system as may be seen in the Case Study below.

Case Study 4 Germany: Academic Management & Employment Reforms.

- “ Academic and non-academic research institutions will continue to be relieved of bureaucratic constraints and assume more responsibility of their own. This will require less detailed regulations and control by means of staffing schedules. Instead, there will be a need for greater flexibility through budgeting and master budgets... to control the research activities more via programmes and programme budgets.
- The legal regulations governing public service employees still constitute a major obstacle (and need) a reform of these legal regulations.
- The duration of degree courses will have to be reduced, and higher education institutions will have to be supported in their training function. (We will) introduce more flexible and more performance-oriented employment and pay structures in order to create incentives to increase quality and the performance of individuals - especially those involved in teaching - and to facilitate the transfer of know-how between science and industry.

⁹ In US study 65% of 1997 PhDs planned for postdoctoral work or study.

(The main recommendations of the preparatory committee were):

- Reorganising the training of young scientists and scholars (including)... the introduction of a junior professorship limited to a maximum of six years, which as a rule is the prerequisite to obtaining a university professorship (involving the right to do research and teach independently, and the right to award a doctorate), and at the same time, the abolition of the post-doctoral thesis, which is currently required to obtain a full university professorship.
- Introducing a competitive and flexible pay structure without the current seniority levels. instead, there will be a fixed minimum amount and variable salary components (so as to) .. reward outstanding achievements in research and teaching and an above-average commitment to the university.

(We believe that)

- ...(The) competitiveness of Germany's higher education and research institutions is hampered by the rigid rules of collective bargaining law for public service employees. (We will).. modernise the collectively agreed employment conditions in the field of science and research by introducing a pay system that creates incentives, improves the competitiveness in the labour market, and promotes professional and geographical mobility.
- ... also calls for the introduction of collective bargaining rules that are in keeping with requirements in the field of science - in particular performance-based pay structures -, for the conversion of seniority levels into performance-linked components, as well as for a more flexible approach towards the definition of pay groups. (We intend to) remove current barriers confronting scientific staff members of academic and non-academic institutions when they switch to jobs in industry by improving their possibilities to "take along" their supplementary benefits.

Source: BMBF, (2001), "Report of the Federal Government on Research 2000", Bonn.

Some Issues:

Looking at the four fundamental "personnel issues", Funding Agencies alone certainly cannot resolve such questions but how might they help?

- **On Strengthening Management** – What "carrots and sticks" are available and which are effective? The Volkswagen Foundation's "Efficiency Through Autonomy" Programme funds German universities to develop university management and decision making structures as organisational and administrative preconditions for successful research. [Krull (2000)].
- **On Family & Gender.** Are there structural changes in university research systems which could lead to better use of females –or, at least, less wastage? Or do we have to continually rely on additional "Advancement" Programmes? Or, in time, will they just "take over", as they have done at undergraduate level and in school leaving examinations?
- **On Improving Employment Conditions.** Can Funding Agencies work with Universities to develop better employment conditions, particularly for those on "project" research? Can academic centres, such as CERN or the EMBL, be developed as alternative or complementary employment routes? Can more formal structuring and mentoring approaches be developed?
- **On Improving Pay Structures.** Academic research pay scales and contract rates are generally poor in most countries. Should Funding Agencies move to performance-related pay scales and pay differentials to mirror the private sector?

4.6 MAINSTREAMING GENDER EQUALITY

“Mainstreaming is a long-term strategy. It focuses on transforming systems, structures and cultures, on integrating equality into policies, programmes and projects. It is a massive agenda of organisational and cultural change” (Rees, 1998). It is also of course a policy that has a long history in North America and has been signed up to by the EC and its Member States.

Historically, much emphasis has been placed on the early entry of girls into the science pipeline. Young women are awarded between 15-47% of doctorates and in most countries, with some exceptions such as Switzerland and Japan, they receive a similar proportion of the natural science degrees (See Annex).

How might a mainstreaming approach affect women in scientific careers and indeed science itself? The first step is to identify the subtle ways in which the status quo in effect is designed with men in mind, the second is then to

open systems up to accommodate men and women equally. For example, the promotion system is predicated upon a model of an uninterrupted career. It is very difficult for women who have had a career break to compete with men on an equal basis. Selection and promotion procedures need to ensure that women are not disadvantaged by career breaks. This means a more sophisticated measurement of quality and productivity than longevity of service.

Counting a candidate's number of publications may in effect be more a measure of years' service and access to unlimited time, rather

than productivity. Similarly, the differential in the size of men and women's research teams will have an impact on number of publications. The “leaky pipeline” means that women are lost to science just as they complete their education and have the most to contribute. Such data illustrate that the maxim “we only have to wait for equality, because there is now a better gender balance among first degree students” holds no water. More dramatic measures are needed.” *From Osbourn, Rees et al (2000)*

Many countries have already moved strongly. Sweden and in Switzerland set targets for appointing women, based on the proportion of women present in the pool of recruitment, that is, the next level down on the academic ladder. In Germany, the HSP II (started in 1991) and III (started in 1996) programmes are designed to address both the demographic problem of a large number of retirements and to increase the proportion of women professors. Current German policy is illustrated in the Case Study below.

Table 10 World: Women professors

(Percentage of Faculty that are Women)
(Different ranks, all disciplines)

Country	Year	A (Full)	B (Assoc)	C (Assist)
Turkey	1996/17	21.5	30.7	28.0
Finland	1998	18.4		
Portugal	1997	17.0	36.0	44.0
France	1997/18	13.8	34.2	
Spain	1995/16	13.2	34.9	30.9
Norway	1997	11.7	27.7	37.6
Sweden	1997/18	11.0	22.0	45.0
Italy	1997	11.0	27.0	40.0
Greece	1997/18	9.5	20.3	30.6
UK	1996/17	8.5	18.4	33.3
Iceland	1996	8.0	22.0	45.0
Israel	1996	7.8	16.0	30.8
Belgium (Fr)	1997	7.0	7.0	18.0
Denmark	1997	7.0	19.0	32.0
Ireland	1997/8	6.8	7.5	16.3
Austria	1999	6.0	7.0	12.0
Germany	1998	5.9	1 1,3	23.8
Switzerland	1996	5.7	19,2	25.6
Belgium (Fl)	1998	5.1	10.0	13.1
Netherlands	1998	5.0	7.0	20.0
Australia	1997	14.0	23.0	40.7
USA	1998	13.8	30.0	43.1
Canada	1998	12.0		
New Zealand	1998	10.4	10.2-23.5	45.5

From Osborn, Rees et al. (2000) Table 2.1

Case Study 5 Germany: Gender Mainstreaming in Research

Educational and research policies must be consistently guided by the principle of equal opportunities for women (gender mainstreaming) - a principle that should be an integral part of all programmes and measures. This equal opportunity principle will thus be established as a performance and competition factor, and a shift in paradigm will be initiated in the policies for the promotion of women. The objective is to benefit from different perspectives and approaches of men and women in the interest of education, research, industry and society.

In view of the inadequate participation of women - in particular in leading positions in science and research - the Federal Government will launch a programme entitled Equal Opportunities for Women in Research and Teaching, which will be implemented jointly with the *Länder* governments as of 2001. A total of DM 60 million annually has been earmarked for this programme, which is 50 per cent higher than the amount that had previously been available for personalised measures designed to promote women in the field of science under the Third Special Funding Programme for Higher Education and Research. The promotion of women is no longer considered to be a special priority but an ongoing task - until such time when conditions will have changed drastically. Germany has a great deal of catching up to do in this area.

The BMBF has convinced the supervisory bodies of the Hermann von Helmholtz Association of German Research Centres (HgF) to adopt the necessary policy decision to enforce equal opportunities, to work out personnel development plans designed to achieve equal opportunity over the next five years, and to appoint equal opportunity commissioners who will report to the Association's executive board. In 1999, the Centres of HgF were authorised, through an initiative of the Federal Minister of Education and Research, to use 100 permanent employment slots systematically for women scientists, in particular to prepare them for leading positions. The purpose of this initiative is to increase the share of women in R&D staff, especially in top positions. For the year 2000, another 100 employment slots have been earmarked to be allocated primarily to centres that are actively involved in the implementation of equal opportunity.

The Anstoss zum Aufstieg (impetus for career development) programme is designed to achieve a substantial increase in the share of women in leading scientific positions in the next five years. This programme systematically supports female scientists in their careers through continuing education, coaching and mentoring. The objective is to take advantage of the change in generations so that women will fill 20 % of all professorships by the year 2005. In future, the scope of the programme will be extended to include other research institutions and junior female scientists.

In addition to creating jobs and training opportunities for women, it is indispensable to improve the general conditions for making scientific work compatible with family life. A major breakthrough was achieved in this respect in the 1999 federal budget. In 1999, the research institutions MPG, HgF, Offi and FhG, which receive institutional funding from departmental budget 30, were authorised for the first time to spend funds allocated to them -without any adverse impact on their budgets - in order to develop and maintain childcare facilities for their employees.

Source: BMBF, (2001), "Report of the Federal Government on Research 2000", Bonn.

Some Issues:

Individual, "Women's Achievement" Programmes are useful. But how have Funding Agencies ensured that

- All their Programmes (not just special target Programmes) support the development of equal opportunities for women?
- All their Programmes act inside universities and research institutions to ensure equal opportunities requirements are effective in all research related activities?

4.7 EMPLOYMENT FOR LIFE OR COMPETITION FOR LIFE?

Research systems are not just structurally different. They are philosophically different.

- The US has always had a highly competitive, highly mobile research system with funding and tenure regulations to ensure such flexibility. In the UK, over the last decade, the Research Assessment Exercise (RAE) and its associated funding structures have strengthened competition in the “research market”, increasing mobility and rewards for the best researchers and focusing research activity in a limited number of institutions. The Table below shows the pattern of UK university employment where the best research universities have the lowest percentage of permanent staff.
- The Netherlands is possibly less competitive, with more stable employment. But there seems to be a wish to move towards the US/UK competitive systems. See table below.
- France is, possibly, placed towards the opposite end of the employment security spectrum. While initial competition at and just after PhD graduation is intense, French law requires relatively rapid provision of full-time, permanent, pensionable, civil service positions for researchers – both those associated with universities and the CNRS. The “flexible”, temporary postdoc. position can only be provided to non-French citizens. The French postdoc. has greater pressures to obtain a permanent post or (as a number of French universities fear) move very quickly to a postdoc. position abroad or to industry.

Table 11 UK: Research Quality v Permanent Staff 2001

University	Research Assessment Permanent Staff as % of Total	
	<u>Top 5 for Research</u>	
Cambridge	6.4	27.4
LSE	6.1	44.4
Oxford	6.1	32.9
Imperial	5.4	41.5
Warwick	5.3	44.8

Table 12 Netherlands: A Typical Case for Concern

A successful Dutch career would be start with a job as an Assistant In Opleiding (AIO), a position as a postgraduate, which would permit a PhD thesis. The new doctor would then apply for a tenure track position as a Universitair Docent (UD) – assistant professor / assistenzprofessor – a tenured position unlike Germany or Switzerland. After four years, the person then becomes a Universitair Hoofdocent (UHD) – associate professor – and finally then a Professor. The problem is that 1) there are far fewer UD positions than postdoctoral researchers seeking such posts and 2) fewer UHD and Professorships than UD. In addition, the growth in Professorships has largely been in “special” (bijzonder or ausserordentliche) professors, which are financed by from external sources such as foundations or business. Unlike Germany, an Habilitation is not required, nor is there an age limit on becoming a Professor. Other problems include:

- Non-attractiveness of academic structures compared to the private sector. Solution has been to differentiate and decentralise salary issues. Those in computer science or medicine earn more than similar positions in the economic and social sciences. However, there are still ties to civil service structure and some wish to get rid of civil service status altogether.
- In addition, previous recruitment / expansion patterns of universities mean that their demographic structure makes tenured positions for postdocs. and subsequent promotion prospects quite dim – a “generation block”.

Lorenz C. (2000), “The Myth of the Dutch Middle Way”, http://www.oefg.at/oefg/text/ws_dienstrecht/Beitrag_1.html

Hull – Mid Table

3.6
62.2

Bottom 5 for Research

Wolverhampton

0.5
72.5

Bournemouth

0.4
66.1

Paisley

0.4
72.3

Thames Valley

0.3
97.9

Northampton

0.2
89.8

*Source: Times Higher Education Supplement,
18th May 2001. Taken from Casey, Mahroum,
Ducatel & Barré (2001)*

An increasing number of new research institutions are being established that provide “tenureless” funding. They are, to a large degree, initiated through private funding, including tax deductible funding in the US. They are often co-funded through grants from government and other sources. In Europe, the EMBL which serves as a beacon for both research and research training, is built around groups of young investigators on time-limited contracts. They are provided with adequate time and resources to succeed and, more importantly, with an outstanding graduate student population drawn from all of Europe. The extraordinary scientific success of these enterprises can be attributed to a general scientific focus, a strong interdisciplinary staffing, low bureaucratic requirements that enable the organisation to be flexible to new demands and opportunities.

Some Issues

- Could Funding Agencies (with Government and the Universities) develop innovative ways of making permanent positions more flexible / mobile so as to avoid the “generational block” (See Table on Netherlands above) on active young researchers at the higher level of universities? Are there good examples of how the permanent layers of university employment have been freed-up?
- Large private foundations like the HHMI and Wellcome Trust have changed (some say “saved”) research culture in their countries by providing a large infusion of funds, supporting individuals and developing new research approaches within the university system. What are the lessons of this model that could be extended to central Government Research Funding Agencies?

4.8 A GOVERNMENT RESEARCH CAREER

National and local governments as well as other groupings, for many reasons, have set up research institutes or networks of institutes such as the MPG (Max Planck Society) in Germany, CNRS in France, CNR (Consiglio Nazionale delle Ricerche in Italy) or CSIC (Consejo Superior De Investigaciones Científicas in Spain). These are independent of universities. Such institutes, while regulated by national employment law, may have different recruitment policies than those in universities. Indeed, some may have formal or informal requirements that research employees, even temporary ones, have a certain level of research experience abroad. While often co-operating with, even co-located within universities, and providing resources including the training of students, employment in such institutes usually carries no obligations to teach. The staff is full time researchers. The nature of the institute's research funding *may* also be more constant than research funding in the universities, avoiding "endless" grant applications.

Table 13 The Institutional Research Spectrum

Institution	Possible Characteristics
Teaching-led Universities	<ul style="list-style-type: none"> ▪ Possibly funding allocation by student numbers ▪ Possible reluctance to free staff from teaching for research ▪ Promotion based on seniority
Research-led Universities	<ul style="list-style-type: none"> ▪ Base funding adjustable to support developing research areas ▪ Recruitment and promotion based on research record.
University Research Institutions	<ul style="list-style-type: none"> ▪ In-university or between universities ▪ Greater flexibility in funding and recruitment ▪ Coherent research policy possible
Free-standing Research Institutions	<ul style="list-style-type: none"> ▪ Total focus on research, no teaching, less admin duties. ▪ Better possibilities of critical mass and of more stable funding. ▪ Greater freedom of recruitment.

In addition, Governments often set up more clearly identifiably / more directly controlled and funded research institutions or networks, often in more applied areas such as the TNO in the Netherlands, INRA and the CEA in France etc.

Some Issues

Clearly, major issues of coordination of research funding face Funding Agencies. How it is done affects not just the monetary input and efficiency of output of the research system. It will effect the flexibility of the research labour markets and careers at a 1) institutional, 2) occupational and 3) discipline level.

- How can coordination between funding structures be used to 1) increase rather than restrict mobility of researchers between institutions and research systems? 2) promote interdisciplinary research and research teams? 3) promote cooperative research between different research systems and different institutional groupings?

4.9 AN INDUSTRIAL RESEARCH CAREER

While research Funding Agencies tend not to directly fund private sector, for profit, research, it is well recognised that all sectors of research are becoming increasingly intertwined. The notion of “the Triple Helix” (the integrated policies for the co-development of Government, University and Industry Research) and national systems of innovation (the location of research within much broader economic and social structures if it is to operate effectively) are fairly well accepted.

Current industrial research changes:

- the percentage of industrial research funding is growing in some sectors. The speed of employment growth of postdoctoral researchers is very high, even if the numbers may still lag behind academia in many countries;
- companies are spending more money on research within universities, generating both major concerns for the traditional public service and openness of university research at the same time as providing more effective paths to commercialisation and national prosperity;
- companies are highly discerning as to the research they fund, internally and in universities –usually focusing on those areas with patenting and commercial potential. An industrial research career, or at least industrial funding support, might be expected in anaesthesia and cardiology but much less so in nursing research and ophthalmology [See Wellcome (1998)];
- while the traditional major multinational corporation (MNC) is still the totally dominant undertaker of research, small high knowledge / research based start-up companies are providing new, well-funded – if not always stable - opportunities for young top-level researchers¹⁰; and
- for the large MNCs, research is a globally dispersed and coordinated activity – although it must be said that the careers of most of their scientists (unlike their top managers) are not, [see Stein et al (1997)]. Funding Agencies are mostly national organisations.

How Funding Agencies approach interfacing their funding with industrial research activities has implications on many levels – including the possible research careers of the doctoral and postdoctoral students, which it supports.

Some Issues

Nearly all Funding Agencies have some form of higher education / industry cooperation programme, some form of industrial research mobility and exchange, some form of IPR / commercialisation programme to set its research findings. They are also paying increasing attention in research training at doctoral and postdoctoral levels leading to possible industrial employment.

- How much should Funding Agencies care about subsequent industrial employability, as opposed to guaranteeing good research – and possibly good research training? If industrial employability is a concern at the doctoral / postdoctoral level, should not industry be more strongly involved – and pay at the very least the marginal costs- most PhDs go to big MNCs with enough money to pay them.

¹⁰ Saxenian (1998) reviews the very different relationships between local labour market behaviour of employees from companies and universities and associated interactions in the Silicone Valley / Stamford as opposed to the Route 128 / MIT complex. She points to a number of issues

- the role of employee mobility between companies and with universities in accelerating technical development / research outputs;
- the role of multiple company start-ups as “multiple parallel experiments with technology”; and
- the in-migration of non-US researchers as an accelerator of technical (and economic) progress.

5 THE INTERNATIONAL MOBILITY OF RESEARCHERS

Science is by its very nature a global not a national affair. Scientists from different cultures and backgrounds pose different research questions and use different techniques to answer them. Creativity often arises at the intersection between disciplines and cultures, and many important scientific advances have resulted from young scientists open to new ideas being challenged in a new environment. The international¹¹ flow of researchers has a long history.

Coordination among Funding Agencies by creating global forums, such as the current meeting, should provide practical benefits to Funding Agencies in a number of different areas:

at the administrative level:

- establishment of a better understanding of the flow of scientist and improved ongoing data collection; and
- exchange of detailed experience on programme targeting operation and evaluations.

at the level of training policy:

- cooperation in developing postdoctoral training in cutting-edge areas where national resources may be insufficient; and
- identification of targeted areas where global research training support would be particularly beneficial - such as the development of skills in creating proteomics databases and data handling tools.

at the level of the individual researcher:

- provision of a wider choice of more structured mobility programmes.

at the national level:

- better developed and more accessible paths for less experienced research communities to participate in global research; and
- creation of forums for developing initiatives for balancing researcher flows.

at the political level

- recent political events strongly point to the necessity of establishing stable, equitable, international communities. The research community should be in the vanguard of such a movement.

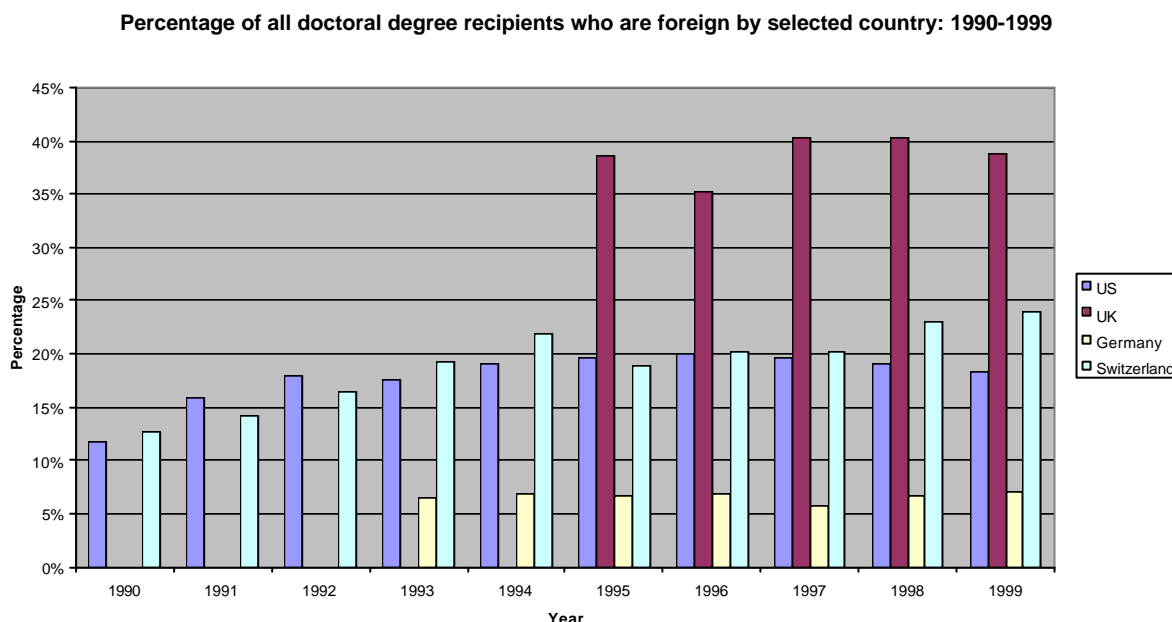
¹¹ Intra-national mobility, from one research institution to another – or the lack of it - is a major issues in some countries. It is however not discussed in this paper.

5.1 THE CURRENT SITUATION OF SUPPORT PROGRAMMES

The table below shows the percentage of annual PhD recipients in all disciplines who are foreign in the US, UK, Germany and Switzerland over the 1990s. The table shows:

- the high dependence of the UK doctoral research system on non-UK nationals. If one looks only at science and engineering these percentages go much higher. An outsider might wonder about the long-term stability of such a system. Certainly the challenges facing Funding Agencies will be very different to those in Germany;
- the relatively autarchic nature of the German system with few foreigners entering into the doctoral system; and
- the general increase during the 1990s in numbers of non-nationals in the Switzerland and in the US. But with some tailing off in the late 1990s.

Table 14 Percentage of all Doctoral Degree Recipients who are Foreign by Selected Countries: 1990-99



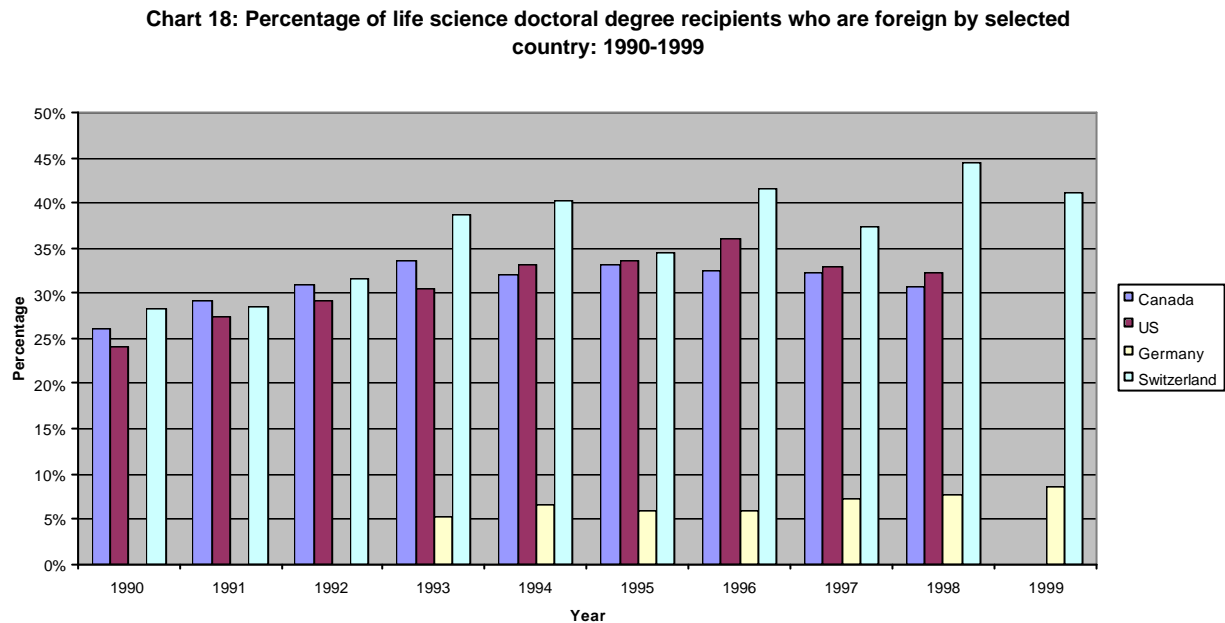
The percentage of doctoral degrees in the natural sciences awarded to women has remained constant among those countries for whom this information was available.

Table 15 Percentage of Doctorate in the Natural Sciences Awarded to Women (1992-1998)

Country	US	UK	Germany	France	Italy	Switzerland
% Awards	30-35	39-40	24-27	47-51	41-47	42-26

The table below shows the position of non-national doctoral recipients in the life sciences, but this time with Canada included instead of the UK. What is apparent, at least in looking at the US, Canada and Switzerland, is that 30% non-nationals in doctoral awards is “normal” – though one might remark that the Switzerland speaks the three native languages of three large neighbours. The autarchy of Germany remains.

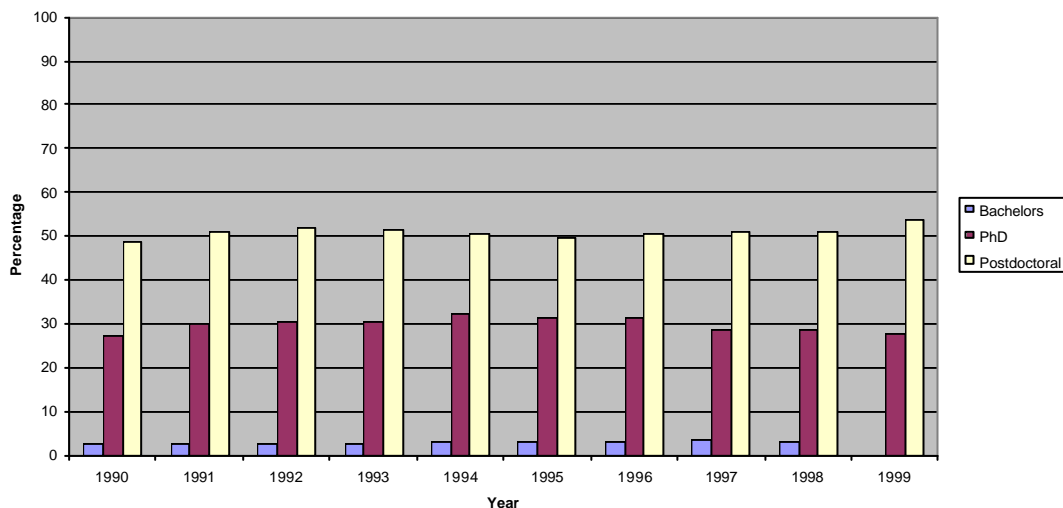
Table 16 Percentage of Life Science Doctoral Degree Recipients who are Foreign by Selected Countries: 1990-99



The table below shows that the presence of foreigners within the initial stages of the US academic career structure. It indicates that any related issues that Funding Agencies face at the doctoral level are likely to be accentuated at the postdoctoral level. Similar patterns are seen at the MPG. Many of these foreign researchers then stay in the host country.

Percentage of Foreigners at US institutions

The percentage of foreigners in the US at different education/academic career levels by year: 1990-1999



5.2 OUTWARD MOBILITY

Outward mobility provides strong attractors to both individuals and their home countries. Individuals can be exposed to cutting edge work that may not be possible to perform at home and, at the same time, they can serve as a link between the research community in their home country and that of the host. Particularly for young scientists, such scientific links serve to foster life long collaborations. For the home country it is an opportunity to obtain an added value to their investment in the training of a young scientist, providing they return, (see next section) and to link their scientific enterprise with the rest of the world.

The Table below, modified from Casey et al. (2001), outlines the factors associated with decisions to pursue research or research training in another country.

Table 17 Forces In Outward Mobility of Young Investigators¹²

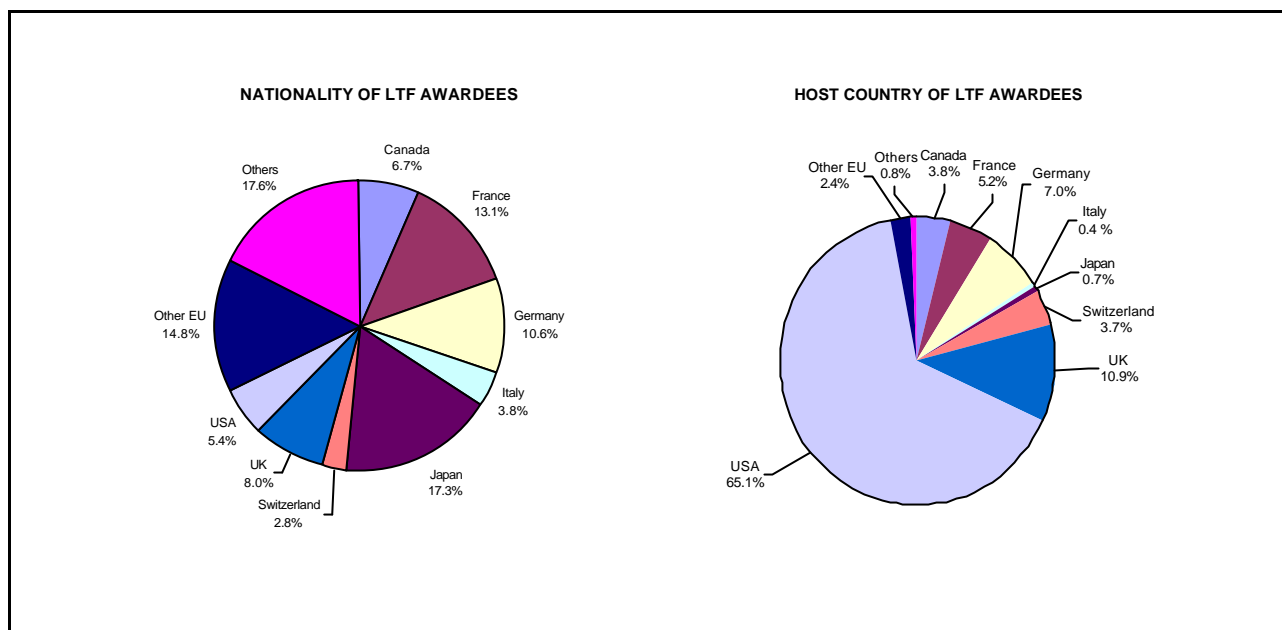
OUTWARD MOBILITY	
Attraction of Host	<ul style="list-style-type: none"> • Scientific Excellence, Facilities • Good publication prospects • Career development • Adventure and freedom
Barriers to Host	<ul style="list-style-type: none"> • Quality of Postdoc./PhD. publications • Lack of knowledge/contacts • Finance presents few problems for good Ph.D.s
Home Push	<ul style="list-style-type: none"> • Formal/informal requirements for experience abroad for tenured positions • Home institution requires skills only obtained abroad
Home Pull	<ul style="list-style-type: none"> • Need to stay close to home labs/institutes for job opening • Family/personal commitments

Postdoctoral scientists are a highly mobile population and international mobility is highly valued in Europe, Canada and Japan. In contrast, these in the US, though highly mobile within the confines of their own country, far less frequently seek training opportunities overseas. In discussing patterns of mobility the HFSP Long-term Fellowship can serve as a good model. The programme is global rather than one that is country or continent based and country choice is fellow driven¹³. Information on the nationality and host countries of 1630 fellows funded by the programme are seen in Figure below.

- the fellow nationalities are evenly distributed, based on the size of the doctoral pool, with the exception of the US;
- the primary destination for young scholars is the US. If the Anglophone countries are taken as a group, then 80% of HFSP fellows obtain training in the US, Canada and the UK; and
- Japan, though having 19% of the fellow pool, has served as host country for less than 1% of the fellows.

¹² Taken from Casey et al, 2001

¹³ With the caveat that either the host or fellow must be from either the G7 countries, Switzerland or the European Union.

Figure 7 Distribution of Nationalities of HFSP Long-Term Fellows and their Host Countries

This choice may reflect, in addition to excellent host sites, the added value of acquiring skills in English as part of the research training experience.

- National outbound fellowships programmes such as the DFG programme German that sent 947 postdoctoral fellows abroad in 2000, and the JSPS programme in that sent 225 Japanese fellows abroad also reflect the pattern of host sites seen above.
- Within the pan-European programmes, EMBO and Marie Curie Fellowship Scheme, the UK attracts the largest group of fellows, followed by France. However, Southern European countries such as Spain and Italy send many more fellows than they receive, reflecting a North/South imbalance.

Distributions reflected in the multilateral programmes may be significantly modified by the degree of support for foreign fellows offered by national programmes. For instance, data from JSPS shows that between 1996 and 2000, 4939 foreign fellows were hosted in Japan with a regional breakdown in the following table:

Table 18 Nationalities of holder of JSPS Postdoctoral Fellowship for Foreign Researchers

Country	Asia	Europe	N America	Africa	Oceania	S America
No.	2480	1334	557	180	145	42

As can be seen 50% of the foreign postdocs. in Japan have come from other Asian countries, reflecting the increasing role that Japan is serving as a significant training site for the region. European scientists account for an additional 25% of visiting fellows. Most national agencies provide support both for their own nationals to go abroad and also to support incoming students.

- Why do fellows choose to go abroad?
 - A cohort of 535 German scientists now living in the US reported that, of their initial reason for coming to the US, 68.4% had come for a postdoctoral appointment and 15.9% for a research visit. Many of them had stayed beyond their fellowships and now held permanent positions. Only 2.8% had come initially to assume a faculty position¹⁴.
 - Holders of 1987-1993 Marie Curie Fellowships surveyed in 1997 reported that they pursued postdoctoral training in another country to enlarge their scientific knowledge (90%), and/or wanted to improve their long-term career prospects and to acquire international experience (over 70%).

Though there are significant opportunities for research support, for students from many countries, such as Central Europe, the NIS or Latin America, international Funding Agencies may be the sole source of funding for an international experience. The Alexander Von Humbolt Foundation and the Wellcome Trust, for example, provide significant support for scientists from developing countries.

Some Issues

- It is clear that there is an imbalance in the outward flow of young investigators into the US and other Anglophone countries. What are the policies overt or covert, that encourage this form of migration and are there any steps can/should be taken to redress the balance? To what degree do funding opportunities drive these choices?
- Is there a need to encourage and develop programmes for more outward mobility, particularly for US postdocs., or does the problem lie with post-postdoctoral opportunities?

5.3 RETURN MOBILITY SUPPORT PROGRAMMES

Whereas going abroad is seen as highly desirable for career progression, the return home may be fraught with obstacles. In many European countries and Japan the BTA (Been to America) is an important aspect of career development. However, if mobility is only a one-way flow, particularly based on the patterns seen in the previous section, then the outcome can lead to a brain drain rather than providing a dynamic process of networks and linkages. Thus, perhaps even more important than programmes to send the young abroad are those that will bring them back home. The chart below highlight issues associated with the return home.

¹⁴ Christoph F. Buechtemann, "German Scientists in the United States:Results of the C-R-I-S Online Survey. Center for Research on Innovation & Society

Table 19 Forces In Outward Mobility of Young Investigators¹⁵

RETURN MOBILITY	
Attraction of Home	<ul style="list-style-type: none"> • Home/family Friends • Longer term career prospects • Career development
Barriers to Home	<ul style="list-style-type: none"> • Poor contact/"Closed" research structure • Poor publications abroad/Research in inappropriate area • Few/inappropriate research opening • Poor research facilities/low salary levels • Administrative issues are important but not determinant
Host Push	<ul style="list-style-type: none"> • Poor career prospects for non-national • Too competitive/insecure research system
Host Pull	<ul style="list-style-type: none"> • Better research prospects/better pay/better facilities • New friends/new partner

An analysis of the 1990-1997 cohorts of HFSP fellows showed that overall 45% return to their home country after completing their fellowship. The next table and figure provide two different ways of viewing repatriation – from the perspective of the fellow's nationality and of the host country.

Table 20 Percentage of Repatriating HFSP Fellows based on Nationality¹⁶

Nationality	Total	Repatriated	% Repatriated
Canada	70	25	37%
USA	70	41	58%
Japan	210	122	61%
France	113	65	57%
Germany	108	36	33%
Italy	32	15	47%
UK	98	40	41%
Switzerland	25	11	44%
The Netherlands	38	17	48%
Spain	50	19	38%
Sweden	10	8	80%
Finland	5	3	60%
EU	400	160	40%

France, Japan, the US, Finland and Sweden show relatively high repatriation rates among their nationals. However, the low rates of repatriation for German, Canadian, and Spanish fellows reflect concerns about insufficient employment opportunities in the home countries as a reason for staying in the host country.

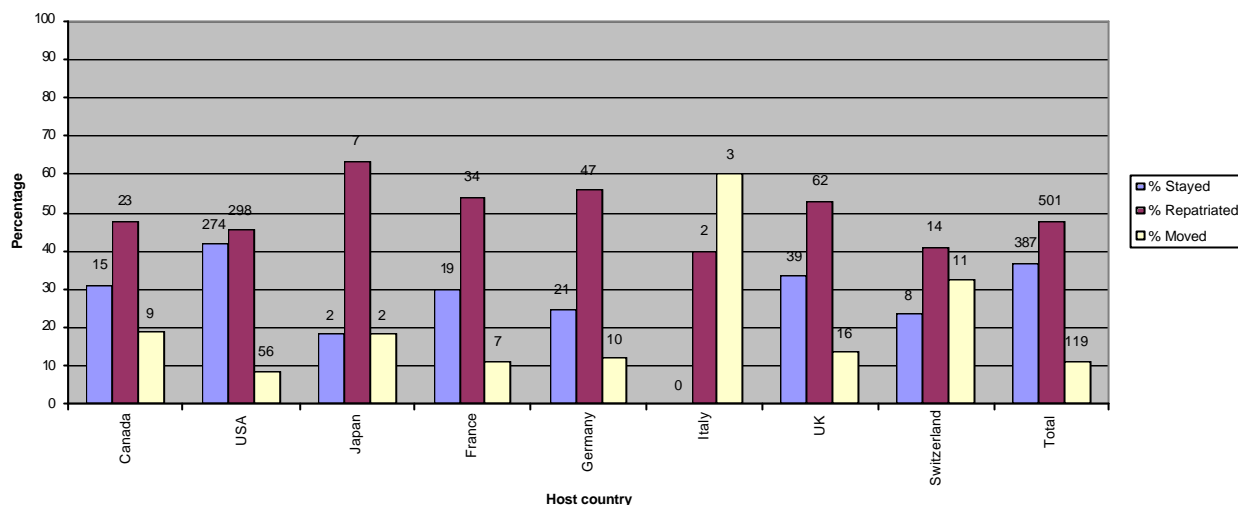
Repatriation rates based on host country are shown below.

¹⁵ Taken from Casey et al, 2001

¹⁶ Based on latest contact addresses in database as of 7/2001

Figure 8 Repatriation Rate of HFSP LT Fellows based on host country

Percentage of HFSP long-term fellows who repatriated and stayed by selected Host country (original numbers also shown): 1990-97



A number of conclusions can be drawn from the previous chart.

- In most countries movement patterns after termination of the postdoc. are similar, a higher proportion of fellows return to their home country than those that either remain in the host country or more to another country.
- Fellows often stay in the host laboratory for at least one or even two years after the end of their two-year fellowship in order to complete their work. Because of the increased complexity of contemporary life sciences, two year programmes may not provide adequate time for training abroad.
- Mobility is not binary and a minority of fellows move to a third country either for an independent position or further training
- The US, both numerically and proportionally, has the highest “stay rate”.

Data from the Marie Curie Fellowship Scheme show that the rate of repatriation among former postdoctoral fellows was strongly tied to the level of employment.

- 73% of those in advanced positions were in the home country
- 57% of those in professional positions
- 48% of those on fellowships were home while 39% were still in the home country
- 25% of those on self supported study repatriated while 50% remained in the host country.

Case Study 6 Foreign Researchers Remaining in the US

In a study of approximately 9000 foreign students earning doctoral degrees in life sciences from US institutions between 1988-1996,

- overall 77% said that they plan to remain in the country after graduation;
- among the latter, 55% reported having firm employment offers in the US. (Finn, 1998)

Levin and Stephan (1999) found that individuals making exceptional contribution to S&E (based on citation analysis) in the US are disproportionately foreign-born.

Some Issues

- Attracting talent back to the home country requires that opportunities are available to them on their return. To what degree will the development of new group leader positions actually fill this need? Should other strategies be considered?
- How can funding organisations in the host and home countries work together to support increased mobility?
- The attractiveness of the US has been attributed to the sheer size of the enterprise and the opportunities for independent research at an early stage. What approaches are needed to encourage independence in other countries?
- Repatriation is a global concern and regional balance of trained scientists is necessary for continued regional development. How can a broader distribution of scientists be ensured?

5.4 A MOBILITY MODEL

Brain circulation is a positive form of mobility involving scientists and researchers (as well as other highly skilled professionals) moving in and out of different geographical regions, and hence increasing the diffusion of knowledge. Yet, the impact of the inflows of foreign scientists/students on a country depends on its capacity to absorb these inflows. In view of growing internationalisation, several European and OECD countries have taken various steps to adjust to this new environment by putting in place new incentives, procedures, and legislations to make their participation in the international labour markets a more gainful one.

- Immigration policies of major industrialised economies have shifted towards more openness to highly skilled immigrants. In France, for example, a so-called ‘Scientific visa’ has been introduced as a fast track procedure to allow scientists from non-European Economic Area (EEA) countries to work in France. The UK is actively considering a similar scheme.
- International and major Funding Agencies and multilateral scientific programmes have recently developed new initiatives both to send researchers abroad but also to attract both national and foreign scientists to their country.

Repatriation vs. Brain Drain

Mobility needs not be a one-way path from one location to another. Indeed, it should not be a one-way flow if it is not to be associated with brain drain. The objective of mobility is to provide a dynamic process of networking and linkages.

- “Brain circulation”¹⁷ is a positive form of scientists’ mobility between different places.
- “Brain exchange” implies a two-way flow of expertise between a sending country and a receiving country.
- “Brain gain” or “brain drain” are used where net flow is heavily in one direction. Thus, attracting foreign talent and repatriation can be important tools for ensuring brain circulation.

Repatriation programmes can solve the so-called “re-insertion” problems that arise due to long periods abroad that cause the individual to lose contact with his/her home country. This is particularly true for nationals of countries where networking and personal contacts are key elements to success and progression (e.g. Italy & France). In some research environments, researchers going abroad risk being accused of not being competitive enough in the local scene and, thus, escaping from it. In general, concerns about re-insertion are often expressed in terms of fear of losing contact with the career structure in the home country.

In light of the re-insertion problems, national and international funding organisations have started to provide repatriation grants allowing researchers to return to their home countries and re-insert themselves in their research environments of their countries. National governments are increasingly introducing state-sponsored return grants (e.g. Spain, UK, and Finland,). However, unless repatriation programmes are embedded in a general programme of opportunities for young scientists in the home country, as discussed earlier, they will not fulfil the goal for which they have been designed.

¹⁷ Gaillard & Gaillard (1998)

Three general types of support fit into the following three categories and are listed in greater detail in the appendix:

- **Repatriation:** competitive awards to doctorates for outward mobility with funding for repatriation that include funds for salary support and some research;
- **Bridge funding:** outward funding with an independent position plus funding for research support in the home country upon completion of postdoctoral training abroad; and
- **Career development:** competitive independent junior group/young professor positions with salary, research and technical support.

Young researchers having completed a training period abroad are often faced with the choice between pursuing a career in the hosting country or returning to the country of origin. Various factors may make the return difficult:

- better work opportunities which they may find in the hosting country, especially if the latter is more technologically advanced than the region of origin;
- a barrier to reinsertion in the country of origin's labour market, due to physical distance and loss of connections; and
- a salary difference between the two countries.

These factors very often result in the permanent transfer of brilliant, highly educated scientists to more technologically and economically developed regions at the expense of the less favoured regions.

The recent study on Mobility of Academic Researchers (2001) identified issues for best practice in researcher mobility. These issues include:

- schemes for mobility should be developed within a general strategy of institutional development and reform, as the absence of career opportunities at home could actually increase the brain drain;
- opening up closed systems by emphasising competition for posts from all candidates and development of more autonomous junior group leaders positions leading to tenured positions that capitalise on the creative energy of the newly returned investigator;
- establishment of start up grants to enable investigators to set up research teams rapidly and effectively; and
- greater openness and fluidity of research systems to retain the best men and women in the system.

Case Study 7: Irish Attraction & Repatriation

Science Foundation Ireland is a major 5 Year Programme to attract the best researchers in IT and Biotechnology to work in Ireland. There are three levels currently being operationalised within this programme: 1-Principal Investigators, 2-Experienced Researchers, and 3- SFI Research Leaders. For the first category, in the first round, 10 awards have been made. Half of the Principal Researchers come from UK and US, the other half are Irish researchers. In the second category, the target is high quality postdocs. with 4 to 8 years post-doc experience. The last category, the award will be about £30 million over 5 years. It will be integrated with the provision of a dedicated building programme and will target researchers in their late 30s.

Another major initiative is by the **Health Research Board (HRB)**. The HRB in conjunction with the Wellcome Trust established the “New Blood Fellowships” directed for the most part towards Irish researchers abroad. It offered substantial funding for a period of 5 Years, after which tenured posts were to be provided by the receiving university.

Some issues:

- When is mobility driven primarily by socio-economic factors and when is it science driven?
- How can countries and institutions benefit from international mobility without falling into a brain drain/brain gain competition? What is the long-term impact of mobility on the distribution of scientists between regions?
- Since repatriation is dependent on opportunities in the home environment, what steps should national agencies take to ensure a “hospitable” environment for young investigators? What is the role of international cooperation?
- Finally, while mobility may be beneficial for the individuals, is it possible to create an economic measure of the costs/benefits of mobility to the individual, the exporting institution/country, and the host institution/country?

6 CHALLENGES: DEVELOPING SCIENTIFIC CAREERS IN AN INTERNATIONAL ARENA

This background report finishes with the challenge to the participants to identify mechanisms by which they can work cooperatively to promote scientific careers and encourage a mobility that will lead to a brain circulation that will benefit not only the countries that are represented at this meeting but also less developed regions, as well. These activities might include the following dimensions that will have their own national or regional complexion, as have been described in the previous sections:

- **The time / longitudinal dimension** – as individuals progress through their research careers, how can Funding Agencies act along, what might be termed the time-line or time phases of a research career to ensure access into, transfer out of and progression onwards in research is effectively achieved?
- **The structural dimension** – investigators are usually embedded in a variety of structures – not only their own research group but also the university and the research discipline, each with its own requirements. How can Funding Agencies act at the different structural or institutional levels at which a research career takes place to ensure coherent development and the effective and efficient use of human resources.
- **The spatial/geographical dimension** – this is highly political dimension to an individual researcher’s career. Neither politicians nor Funding Agencies can ignore “brain drains”. How can Funding Agencies act to ensure spatially stable and equitable research systems and research migration patterns?

Some Issues

While Funding Agencies have the potential to act on all of these areas, they may wish to consider:

- Which are the areas that are near **impossible** for the Funding Agency to impact or are not relevant to the Agency’s legal role? Such areas will vary from Agency to Agency.
- Are some requests for Funding Agency support or initiatives simply supporting **ineffective palliatives** (often dressed up as reform) rather than seeking deep-rooted structural change within the universities?
- Can the Funding Agency focus on the one or two pivotal issues where it can have the greatest, **sustainable, structural benefit** in terms of “research” – be it performance, training, careers, exploitation, etc?

7 BIBLIOGRAPHY

- Buechtemann**, Christoph F. "German Scientists in the United States: Results of the C-R-I-S Online Survey. Center for Research on Innovation & Society.
- BMBF**, (2001), "Report of the Federal Government on Research 2000", Bonn.
- Casey, T., Mahroum S., Ducatel K., & Barré R.**, (2001), "The Mobility of Academic Researchers: Academic Careers and Recruitment in ICT and Biotechnology", IPTS, Seville. <http://futures.jrc.es/reports/ipts-estoMobility01.pdf>
- Cervantes M.**, (1999), "Background Report: An Analysis of S&T Labour Markets in OECD Countries", DSTI/STP/TIP(99) 2/FINAL, OECD, Paris.
- Committee on Dimensions, Causes, and Implications of Recent Trends in the Careers of Life Scientists**, (1998), "Trends in the Early Careers of Life Scientists", National Academy Press, Washington DC.
- Committee on National Needs for Biomedical and Behavioural Scientists**, (2000), "Addressing the National Needs for Biomedical and Behavioural Scientists", National Academy Press, Washington DC.
- Committee on Science, Engineering and Public Policy-COSEPUP**, (2000), "Enhancing the Postdoctoral Experience for Scientists & Engineers", National Academy Press, Washington, DC.
- Elton S.**, (2001), "Scientific Careers: UK Paper", Chairmen & Secretaries of EU National Advisory Bodies for S & T, Athens 21/22 June 2001, Office of Science & Technology, London.
- Enders J.**, (1997), "The Academic Profession in Europe: A view from the Status Perspective", Occasional Paper, Centre for Economic Reform and Transformation, Herriot-Watt, Edinburgh.
- Finn**, Michael G., (1997), "*Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1995*". Oak Ridge Institute for Science and Education, Dec. 1997.
- Fox M.F. & Stephan P.E.**, (2001), "Careers of Young Scientists: Preferences, Prospects and Realities by Gender and Field", *Social Studies of Science*, 31/1, Feb 2001 pp 109-22.
- Harrap, N** (2001) "International Training and Mobility of young Investigators Report", Masters Thesis, University of Manchester.
- Gaillard, J., Gaillard, A.M.**, (1998), "The International Circulation of Scientists and Technologists: A Win-lose or Win-Win situation?" *Science Communication*, Vol. 20 No. 1, September 1998 106-115.
- Kobayashi S.**, (1999), "Changes in the S&T Labour Market and its Future: Are there too many PhD Graduates?" DSTI/STP/TIP(99) 2/FINAL, OECD, Paris.
- Krull W.**, (2001), "German Universities on the Threshold of the Twenty-First Century",
- Lanciano-Morandat C & Nohara H.**, (2000), "A Comparative Study of R&D Staff in France and Japan", Laboratoire d'Economie et de Sociologie du Travail, Aix en Provence.
- Lorenz C.** (2000), "The Myth of the Dutch Middle Way", on the web at http://www.oefg.at/oefg/text/ws_dienstrecht/Beitrag_1.html
- Maiworm, E and Teichler, U.** (1997) European Research Fellowships 1987-93. European Commission.
- Martinelli D.**, (1999), Labour Market Performance of French PhDs: A Statistical Analysis. DSTI/STP/TIP(99) 2 / FINAL. OECD, Paris.
- National Science Foundation/Science Resources Studies** (1998), Science and Engineering Indicators-1998. Arlington, VA. 43.
- NIH**, (n.d.), "Report of the NIH Working Group on New Investigators", NIH, Maryland.
- Osborn M., Rees T.**, et al., (2000), "Science Policies in the European Union: Promoting Excellence through Mainstreaming Gender Equality", Official Publications of the European Communities, Luxembourg. <http://www.cordis.lu>

- Pion, GM** (2001), "The Early Career Progress of NRSA Predoctoral Trainees and Fellows", NIH Publication 00-4900.
- Rees T.**, (1998), "Mainstreaming Equality in the European Union", Routledge, London.
- Royal Society**, (1996), "Concordat to Provide a Framework for the Career Management of Contract Research Staff in Universities & Colleges", Royal Society, London,
- Saxenian AL.**, (1998), "What Matters in this Network System is Relationships", Keynote to IT Conference, Stockholm, 9th June 1998.
- SCPR**, (1997), "Survey of the Postgraduates Funded by the Research Councils", Swindon, UK.
- Wellcome Trust**, (1998), "Mapping the Landscape: National Biomedical Research Outputs: 1988-1995", The Wellcome Trust, London.
- Wellcome Trust**, (2000), "Career Paths of a 1988-1990 Prize Student Cohort: Review of **Wellcome Trust** PhD Research Training", The Wellcome Trust, London.
- Wellcome Trust**, (2001), "Radical Thinking, Creative Solutions: Career Issues in UK Academic Research", The Wellcome Trust, London.
- Zaunberger K. & Kerner W.**, (1999), "Strategies and Policies on Research Training in Europe", DG for Science, Research & Development, EUR 18880EN, European Communities, Luxembourg.