European Research Advisory Board (EURAB)

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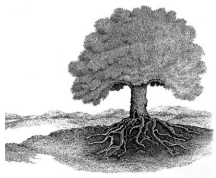
EUROPEAN UNION RESEARCH ADVISORY BOARD –

WORKING GROUP ON INCREASING THE ATTRACTIVENESS OF SCIENCE, ENGINEERING & TECHNOLOGY CAREERS

Background Document, September 2002



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1 INTRODUCTION

The importance of science and technology in European social, medical, environmental and economic development is well recognised. Yet, all Member States express concern as to the adequacy of their scientific, engineering and technological resources, particularly human resources, to ensure future development. Central is the fear that there will be insufficient scientifically trained people – researchers, engineers, technologists, technicians, knowledge workers at all levels - to meet the demands of European society. Falling student numbers and the perceived unattractiveness of science, engineering and technology careers are the main concerns.

In 2002, as one of its first actions, EURAB set up a Working Group to review the position of science, engineering and technology careers and how their attractiveness, at all levels, might be increased, paying particular attention to the European dimension.

The Current Position

Despite differences across Member States, there are two general concerns: 1) Europe's changing demographics. Europe's labour force will decline – *assuming* constant activity and migration rates.(IPTS 2000). Europe's science, engineering and technology research population is aging and facing increasing occupational replacement rates – at the same time as the potential replacement numbers decline. (Barré 2001). 2) A younger European generation is perceived to be turning away from science, with a fall in the proportion of students undertaking the traditional "hard" sciences.

But the picture is more complex. Despite weak and, at times, negative media coverage, and the high profile, sometimes justified, protests of activist groups, Europeans still see science and technology in a positive light, and when it comes to undertaking new research they are very supportive – over 80% support research for new knowledge. Even the image and status attributed to scientists and engineers are strong, and much is expected of them is solving society's problems. Medicine and environmental activities are particularly well supported. So, it is rather difficult to argue that there is any deep, overall crisis in Europe's view of science and technology. This, of course, does not mean all is well[1].

When Europeans are asked specifically about the falling interest of young people in science studies and science careers, again, the negative image of science does not figure strongly – only 10% give this as the main reason. Rather people indicate that young people are not interested in working in science and that careers and salaries are not attractive. And in schools, science lessons are not interesting enough, and are too

[1] As the main recommendations of the Benchmarking Group on Public Understanding of Science (2002) point out, there is a need for a stronger and more coherent lead by the government of Member States, a consitent engagement and communication with the external world by the Scientific Comunity, earlier introduction of science and technology subjects into junior schools, stronger partnerships with science centres and museumes as well as mechnaisms to improve dissemination through the various media.and finally an strong effort by industry.

difficult. But people believe authorities should remedy this situation – and top of the list, 71% believe, "More should be done to encourage girls and young women to pursue scientific studies and careers". (European Commission 2001a Eurobarometer).

These findings suggest we rethink two key issues

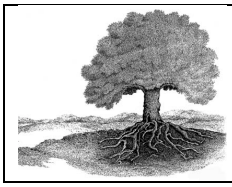
- the current image of and approach to "scientific careers", and
- how we deal with science in schools.

A New Paradigm for Scientific Careers

The dominant model and language in scientific careers is that of "The Pipeline": ensuring that the pipeline is well filled at one end, and evincing concern for "the leakages" of potential scientists and engineers at each joint in the pipe. Those who leave tend to be considered as having fallen from grace and may even have wasted resources in taking up a scientific education in the first place. The Pipeline is, of course, the horizontal version of the Ivory Tower.

Many research funding agencies have expressed deep concern at the implications of the Pipeline model, and have suggested (Wiesel 2002) a move of image and language which would provide a truer metaphor of scientific and technological careers in our society: The Tree[2]. Rooted deeply in our culture, with a trunk of more formalised education and training, students then branch out into a wide variety of useful, legitimate and valued scientific, engineering and technological associated activities, with research creating outward and upward growth. Indeed, one could even argue for the tree as a symbol of overall scientific and technological activity. It is a potent and powerful symbol of wisdom and knowledge in so many cultures - not just the Christian Tree of Knowledge, but the Norse Yggdrasil with roots to into wisdom, Bodhi-Gaya - the tree of Wisdom where Buddha received Enlightenment. The tree is a near global symbol of the development of human knowledge.

Table 1 Scientific Careers: A New Paradigm

	Growing Apex: Continued Research
	Branches: Careers with S&T Base / Research
	Trunk: Training UG/PG/Post Doc
	Roots: In all society, all schools

[2] Initially suggested by Geoff Montgomery of Rockefeller University.

2 SCIENCE, ENGINEERING & TECHNOLOGY EDUCATION WITHIN SOCIETY

2.1 THE ROOTS OF SCIENCE

Science helps create and is created by society: science is a profoundly social activity, even a political activity. The scientist or engineer who remains solely in the laboratory loses half the battle; the battle for resources, for influence, for future students, even for the quality and relevance of research. At the same time, others seek to draft the science agenda: government, industry, educationalists, pressure groups, the military and so on. Some have characterised science and technology as a collective experiment, a collective exploration of the human universe. We believe that it is incumbent on all scientists, engineers and technologists to take part in this experiment, not only in the laboratory but on Committees, in working with industry, in their children's schools, on political fora, but also in the local paper as well as Le Monde, on local radio as well as on the BBC. If we believe that science is important, we must engage in the debate, and encourage others to do so.

In this context, EURAB strongly supports the European Commission's "Science and Society Action Plan". Such activities should be even further strengthened and become a routinised component of *all* EU research activities – it is not sufficient that one small unit undertake the work – it should be mainstreamed.

EURAB recommends that

- In support of the EU Science and Society Action Plan, all research proposals contain a sum for appropriate dissemination of results[3].
- There is also a need for a much stronger, more direct dialogue to be developed with politicians – European and national – in these areas, and particularly in relation to "Attractiveness of Scientific Careers".

The Information and Communication Unit of DG Research is undertaking important work. Again, in the context of the Science and Society Action Plan, EURAB, along with others, would like to see the further strengthening of its role.

EURAB recommends that

- The present Framework Programme information activities should be strengthened, particularly the liaison with the European media. An analysis of the possibilities of a "European Scientific Press Agency" should be undertaken. In the

[3] For example, developing related training, workshops, conferences, hosting lab visits from colleges/schools/journalists, wide spectrum publications, media events, non-conventional presentations, etc.
[4] http://www.alphagalileo.org/

meantime, the Alphagalileo News Service should be strengthened and extended to all Member States[4].

- A coherent Framework Programme publications policy for the dissemination of the results of EU funded research projects should be drawn up[5]

[5] This policy should recognise the need for dissemination of appropriate materials to the different sectors ranging from primary and secondary schools and museums to specialist journals and the media.

2.2 SCIENCE, ENGINEERING AND TECHNOLOGY IN SCHOOLS

There is a pressing need for the revitalisation of primary and secondary science, engineering and technology education in Europe's schools not only for the simple technical functioning of a knowledge economy, but also for what some people call "the democratisation of science and technology" – the ability of European citizens to competently enter into the dialogue on setting objectives and ethical frameworks for the use of science, engineering and technology[6]. In this context, the levels of science, engineering and technology literacy developed are major barriers to Life Long Learning[7]. Similarly, there is also a need for a rethinking of the role of the science teacher, and perhaps most radically, a recognition of the *responsibilitie*s of the science, engineering and technology communities in universities, industry and government – and the European Commission – towards the school system.

Science for Younger Children

Children are natural explorers and experimenters – to a parent's never ceasing concern. Yet, by teenage years, strongly gendered opinions have been formed and choices made which presage low science, engineering and technology participation rates and a disaffection with science and engineering careers. "Give me the child until he is seven, and I will show you the man", runs the Jesuit aphorism. Many educators have come to this conclusion with respect to science, engineering and technology education – an education near totally absent from Europe's primary schools.

EURAB applauds those Member States introducing "hands on" experimental sciences into primary schools[8]. The resources necessary for modernising primary education and associated teacher education are considerable, and the time scale long, but the rewards in terms of a democratisation of science, and economic vibrancy will be worthwhile.

EURAB recommends

- The introduction of innovative, *hands-on* science education into all Europe's primary schools,
- The introduction of Creative Science Teaching modules into the formal training period of all primary school teachers.

[6] For example, to bridge the gap between today's scientific concepts and current lay notions, European citizens need to have some idea of basic principles in science in order to cope with future technological and medical developments permeating everyday's life. In clinical genetics, for instance, it has become almost impossible to translate the associated complex messages in language that can be understood by clients that have no knowledge at all of genetics.

[7] European report on indicators of lifelong learning make clear that scientific literacy among school children is not high enough to enable lifelong learning. *Cordis Focus* 15 July 2002, p.2.

[8] For example, Georges Charpak's work on 'La main à la pâte' project, www.inrp.fr/lamap 'hands-on' activities, with experiments, observation and interpretation as the central elements of learning. Similarly the work of the Physics on Stage www.physicsonstage.net events, as well as science communication in informal settings, such as in Science Centres.

Secondary School

Across Europe, traditional hard sciences – certainly physics and maths, often chemistry and occasionally even biology - have seen a falling proportion in the numbers of graduating secondary students. Yet, new vocational areas such as technology, engineering and information technology have expanded rapidly in most countries. France, for example, has balanced the loss of traditional science by greater numbers in vocational sciences and engineering. (Porchet 2002). In terms of imagining themselves as a scientist, biology – the science of life - is extremely positively viewed by girls and to a lesser extent boys. There is lower support for "earth sciences: space, weather, geology", "environment-pollution, clean air, clean water" and among boys "technology- computers - engineering". The hard sciences of physics and chemistry, however, hardly register. (Sjøberg 2000).

There are many excellent, creative, imaginative initiatives across Europe which seek to develop new curricula and teaching materials and supportive web sites[9]. Further afield, the Weizmann Institute[10] programmes work closely with schools and in the US the Wright Centre[11], the Howard Hughes[12], the NSF all support innovative actions in schools. However, such initiatives nearly always remain peripheral to the school system, affecting only a small proportions of students.

EURAB recommends

- Concerted efforts to mainstream science, engineering and technology curriculum and teaching innovation into secondary school systems.

Science Teachers

Science Teachers in many Member States have a high age profile with implications of imminent high replacement rates from a difficult labour market. Further, in a predominantly feminised occupation, the proportion of females fall as one moves up through the education system and into the sciences and technologies. The typical hard science teacher is male and relatively old. Along with other teachers, he tends to be relatively poorly paid, and to share in the weaker status of the teacher, rather than the high status of the scientist.

Some Member States have already moved to provide higher financial incentives for science teachers, either directly through pay scales or indirectly through training allowances. Financial reward has a powerful signalling effect not just to the labour market, but to students in the school looking towards a future career. In addition, there are many excellent initiatives networking teachers with practicing scientists, scientific organisations and science teachers abroad to compare best practices[13]. But again, there is much to be done in mainstreaming such initiatives.

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[9] For example, The Wellcome Trust http://www.wellcome.ac.uk/en/1/misedu.html
[10] Department of Science Education. http://stwww.weizmann.ac.il/menu/
[11] Wright Center for Science Education at Tufts University,
[12] The Howard Hughes Medical Institute http://www.hhmi.org/grants/
[13] The 'Physics on Stage' initiative by CERN, ESA, ESO, EAAE, EPS and the EC (soon to be expanded to become 'Science on Stage') both created a forum for exchange of best practices among European physics

EURAB recommends that
A review of innovative career and pay systems for science, engineering and technology teachers should be undertaken, with a view to supporting Member States in their moves towards developing a high-status and high-pay profession.

Support from the Science, Engineering and Technology Communities

At the same time, there is a need for a deep, systematic and structured involvement on the part of organised science, engineering and technology communities in the primary and secondary educational system. Such participation should not be seen as an additional burden, but as part of the core responsibilities of these communities towards society[14].

EURAB recommends

- All science, engineering and technology organisations – industrial, academic, professional, governmental – reassess and strengthen their commitment – at a local, national and European level - to supporting the development of school science, engineering and technology education. All such organisations should publish its policy and activities in support of school science, engineering and technology on its Web site. Regional, national and European awards might be developed for such activities.

DG Education and Culture have a major role to play in developing such activities in parallel with the development of school, teacher and student networks and activities across Europe. It is important that DG Research develops policy which supports, works with and enhances the activities of DG Education and Culture in the fulfilment of its mandate from the Stockholm and Barcelona European Council meetings.

EURAB recommends

- Strong policy support and operational cooperation by DG Research with the activities of DG Education and Culture in fulfilling the Commission programme on "The follow-up of the Objectives of Education and Training Systems in

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teachers and marked a first attempt to link the major European Intergovernmental Science Organisations (EIROs) with the teaching world. Physics on Stage also took steps in the direction of introducing a teacher-driven market mechanism for the development of common educational materials as well as creating a possibility for teachers to air some of their professional concerns. Last, but not least it served to 'upstage' the teaching profession and to instil new self-confidence in a community, which often endures much criticism and relatively modest social esteem. Other initiatives include the Sciuence Teacher Education Development in Europe Network under the EU Erasmus Programme http://www.biol.ucl.ac.be/STEDE/ and the European Science Education Research Association http://www.summerschool.dk/esera/home.html

[14] For example, a school in northern Germany has joined forces with the Alfred Wegner Institute for Polar and Marine research in an effort to integrate science education into the day to day work of a research institute. The scheme is the first of its kind in the country and is the most ambitious of a number of recent programmes aiming to stem the decline in the number of students choosing science at school and university. *Nature* http://www.nature.com 418, 15 August 2002 p.714

[15] European Council, 20th Feb 2002. 6365/02 EDUC 27. 1) Increasing the interest in mathematics, science and technology from an early age, 2) Motivating more young people to choose studies and careers in the

Europe[15]". An Action Plan, with clear milestones, should be published and progress reported in the DG Research Annual Report.

fields of mathematics, science and technology in particular research careers and scientific disciplines where there are shortages of qualified personnel, in a short and medium term perspective, in particular through the design of strategies for educational and vocational guidance and counselling, 3) Improving gender balance among people learning mathematics, science and technology, 4) Securing a sufficient numbers of qualified teachers in mathematics and scientific and technical subjects

3 TRAINING SCIENTISTS, ENGINEERS & TECHNOLOGISTS

As with primary and secondary education systems across Europe, third level and postgraduate systems vary enormously. Most strikingly, the proportion of the age cohort receiving first science, engineering and technology degrees shows a threefold difference between the highest and lowest Member States. (Eurostat). Again, the proportion of science, engineering and technology students in overall undergraduate enrolment can vary nearly as widely between Member States (Faegri 2002). Despite such differences, two trends are common. Over the last number of years, those receiving a first degree have tended to show large percentage increases in computer related sciences and life sciences, but significant falls for traditional maths and physical sciences, and in some cases major falls in the traditional engineering subjects. There are also concerns for the falling quality of new students, particularly in declining disciplines. Member States should be encouraged to review such divergences and underlying trends. Here, EURAB is very supportive of the EU's "Benchmarking National R&D Policies" initiative. However, it could be strengthened, and an *Annual Report on the State of Europe's Human Resources Science, Engineering And Technology* would be an important element.

EURAB recommends that

- The European Commission, in conjunction with the Member States, Associate States and Candidate Countries, publish an *Annual Report on the State of Europe's Human Resources Science, Engineering And Technology* and associated policy issues.

3.1 UNDERGRADUATE STUDIES

The weak "transfer-onwards" patterns from secondary education in traditional sciences – compared with very high transfer rates in subjects such as biology and computer science – is often pointed to as an import issue in improving the flow of students in tertiary education. (Roberts 2002, Faegri 2002). Indeed, this underlines the importance of cooperation between DG Research and DG Education, and EURAB would expect to find such issues the subject of joint policy and initiatives.

While there are also concerns about the attractiveness and direction of many undergraduate programmes in the more traditional disciplines, a number of innovative solutions have been found

- Involvement in research and undergraduate research publication has been helpful in directing good students towards research careers – countering probably the greatest worry, that the best students do not go on to undertake research[16].
- Student placement programmes into "high tech" industrial research and service companies have helped to clarify scientific and engineering career choices for students.
- Modularised, open course structures – with a strong scientific base - can present students with a vision of the breath of careers open to scientists and engineers[17].

[16] For example the work of the Council on Undergraduate Research http://www.cur.org/

- Interdisciplinary, and inter-institutional courses have similarly helped both respond to the need for bringing the different bases of traditional science closer together and for showing the variety of career options.

EURAB recommends

- The European Commission, in conjunction with Member States, Associate States and Candidate Countries, through the open coordination provisions, should explore current best practices in opening up of science, engineering and technology undergraduate courses to interdisciplinary influences, to research experience, to industrial interaction, and to a clearer indication of the variety of career paths open to such students.

3.2 DOCTORAL STUDIES

Generally, the annual production of science, engineering and technology PhDs is rising across Europe. The Life Sciences, which are traditionally much more tightly tied to university based research have shown the major growth. Engineering and ICT are predominantly industrial based research disciplines, and their growth is to be seen, until recent difficulties, in the proportion of industrial turnover devoted to R&D and in the problems in filling university-based doctoral and postdoctoral research posts.

At this level, two general concerns seem to be common across Member States:

- The finance of doctoral studentships. Following an undergraduate course, which in a number of Member States can leave the student with a financial debt, the same student is in most Member States expected to undertake at least three years of doctoral research on what can be a very low salary. Substantial basic salary funding is needed for doctoral students.
- The quality of training needed to develop the confident, research-team leaders of tomorrow. Here, the formation of Graduate Colleges or Research Institutes have often provided for the creation of a sufficient mass of resources to provide strong training structures for doctoral students. These larger structures can also provide for the development of more consistent supervision structures, as well as for the well structured training in IPR, ethics, communication and publication skills, project management, entrepreneurial skills, etc. EURAB strongly supports such improvements in doctoral research training structures and methods across Europe.

While the focus of doctoral research training is on technical research skills, many will, naturally, branch out from academic research at the end of their studies into new knowledge-economy activities in journalism, industry, commerce and finance, teaching, research administration, etc. Many studies show the importance of contact with these future professions in easing mobility (for example Martinelli (1999) on employment of French PhDs) and creating more visible and attractive career paths. EURAB supports the creation of such “bridging mechanisms” as part of the doctoral training experience.

EURAB recommends that

[17] For example, L’Ecole polytechnique http://www.polytechnique.fr/Ens/X2000_for.html

The European Commission, in conjunction with Member States, should examine doctoral research training structures globally to develop a policy – to be operated through its research spending – to attract to and retain in Europe, the most creative and talented doctoral researchers. EU research funding, and particularly that aimed at research training, should be *explicitly* used to encourage the improvement of doctoral training structures and practices. Since the European Science Foundation (ESF) and the European Heads of Research Councils (EUROHORC) are also developing mechanisms to the same end, such as the European Young Investigators (EURYI) Awards, the European Commission and these organisations should closely co-operate on this subject.

3.3 POSTDOCTORAL RESEARCH

The increasingly common practice for researchers to undertake one or possibly two periods of postdoctoral research overlaps in some Member States with what has been called the "academic proletariat", that group of researchers, at doctoral and postdoctoral level, continuously funded by short-term research contracts, rather than high-quality fellowships[18]. Some of the work practices in this area are of area of deep concern to EURAB. An open, transparent and highly competitive postdoctoral system combined with equally transparent welfare and career provisions is fundamental to a vibrant research system.

Some national research bodies and funding agencies have moved to reform the area of postdoctoral research[19], but much needs to be done by the universities themselves in formalising and strengthening research contract structures. EURAB encourages such developments and believes that EU research spending, particularly the short-term research project funding should not encourage and perpetuate such systems. Rather that funding conditions should encourage universities and research institutes to develop regularised research labour markets. Suggestions have included limiting the number or cumulative period of short term contracts an individual can experienced, if they are to receive EU funding. Another is the limitation of funding to institutions which have good and effective human resource policies for contract researchers. Indeed, such moves would support the EU Directive on Fixed Period Working being introduced into Member States.

EURAB recommends that

- The European Commission, in conjunction with Member States, Associate States and Candidate Countries, through the open coordination provisions, should examine good employment and human resource development practices in academic doctoral and postdoctoral labour markets and develop a research funding policy for the Framework Programme / ERA which supports the regularisation of such labour markets.

[18] Short-term "bridging" or widening-of-experience contracts which are part of planned career development are not being referred to in this context.

[19] Royal Society, http://www.royalsoc.ac.uk/policy/rep_fr.htm ,
NWO http://www.nwo.nl/NWOHome.nsf/pages/ACPP_4WBGJU_Eng?OpenDocument
Cosepup, http://www7.nationalacademies.org/cosepup/COSEPUP_Publications.html
Wellcome. http://www.wellcome.ac.uk/en/1/awtpub.html

4 DEVELOPING ATTRACTIVE CAREERS IN RESEARCH

4.1 THE PRINCIPAL INVESTIGATOR

In all Member States, whether tenure comes early or late, there are substantial difficulties, financial and administrative, in becoming an independent researcher – a principal investigator, a senior researcher - with the resources to undertake substantial self-directed research. The rapid provision of such positions to outstanding young researchers is essential:

- To ensure the vitality and creativity of a research system. They seed the creation of research teams in new areas.
- To provide a bridge between the "waiting room" of postdoctoral research that exists in some Member States and the often-rare tenured position. They create a necessary stepping stone in a career structure.
- To provide the opportunity in Member States where tenure does not entail independence or seniority for young creative people to quickly become research team leaders,
- To assist in retaining the brightest researchers within the system. When a tenured position opens, it is essential to have good candidates.

A number of research systems are tackling this difficulty by funding senior, tenure-track "packages" of equipment and support researchers over an extended period, rather than simple research posts[20]. Similarly, in France, where tenure does not imply independence, INSERM's AVENIR "young blood" programmes help young researchers move to towards autonomy[21]. EURAB welcomes such developments. Further, EURAB believes that EU research funding should consciously seek to accelerate the development of such independent, senior research positions within research systems, both to improve the quality of European research, and to improve career structures. Such developments may also be important in providing a regional development dimension to the ERA.

EURAB recommends that

- EU funding mechanisms for Integrated Projects and Networks of Excellence should recognise the needs for the development of the careers of high-level individual researchers,

[20] For example, the Dutch NWO www.nwo.nl "Veni, Vidi, Vici" Programme: **Veni** grants offer annually about 150 researchers who have only recently completed their doctorates the opportunity to develop their own research ideas over a further three years with a grant amount of 200,000 EUR; **Vidi** grants (about 75 per year) are meant for researchers who have already conducted postdoctoral research in the Netherlands or abroad for some years and who have demonstrated their ability to generate new ideas and bring these independently to fruition. These grants amount to 600,000 EUR for five years, thus providing the possibility to appoint one or more researchers to develop with the Vidi grantee a new line of research; **Vici** grants (about 25 per year) are directed at senior researchers who have proved to be able to successfully develop their own innovative lines of research and to act as good coaches for young researchers. For 1,250,000 EUR for a five years' period they are enabled to build up their own research teams

[21] http://www.inserm.fr/servcom/servcom.nsf/(Web+Startup+Page)?ReadForm&recherche

- EU funding mechanisms for individual researchers should also be developed to promote the career structures of researchers. In particular, there is a need for a number of larger "Principal Investigator" contracts to support the move of the very best young researchers towards independence.

4.2 THE TENURED RESEARCH POSITION

While the timing and conditions of tenure vary greatly across Member States, there are some fairly common concerns: 1) The age at which tenure is achieved. It may often be the first occasion for independent research and for entry into normal employment and social welfare conditions.2) Tenure may entail a surfeit of non-research administrative and teaching requirements. 3) Competition for the post may be weak, or biased towards very local candidates.

It is well recognised that research teams benefit from a diversity of experiences, cultures, and nationalities: the vitality of heterogeneity and different research backgrounds. The same is true for those holding the tenured posts. EURAB encourages universities and research institutes to strengthen their efforts to open up all tenured positions to wider competition, not only from across Europe and further afield, but also from industry where the quality of research in many disciplines often equals or surpasses university research. The development of the ERA, would also be assisted by the further opening up of tenured positions to other Member States.

More generally, we are already seeing individual Member States exploring ways of easing the access of non-EU researchers to national research training and employment positions. One of the most striking examples has been the French "Scientific Visa" system[22] . EURAB supports such a general opening up of the EU to non-EU researchers.

EURAB recommends that
The European Commission, in conjunction with Member States, Associate States and Candidate Countries, through the open coordination provisions, should examine policy and mechanisms which assist in the opening up of tenured research positions to EU and potentially global competition. Framework Programme funds should then aim to support such developments. More generally, an opening up of EU research training and employment positions to non-EU researchers is recommended and should be similarly explored.

4.3 RESEARCH CAREERS IN INDUSTRY

Despite recent difficulties in the ICT sector, industrial research is growing: currently, some 2/3 of EU research spending is industry based. While industrial research careers are

[22] http://www.recherche.gouv.fr/recherche/internat/accueil.htm "**Entrée et séjour des scientifiques étrangers (hors Union Européenne) en France**: La loi N° 98-349 du 11 mai 1998 ouvre de nouvelles perspectives en faveur de l'accueil des scientifiques étrangers dans les établissements d'enseignement supérieur et les organismes de recherche français. Les dispositions particulières facilitant la délivrance des visas et prévoyant la mise en place d'une carte de séjour temporaire spécifique, ainsi que l'attention portée au regroupement familial devraient largement simplifier les formalités d'entrée et de séjour des scientifiques dans notre pays...."

rather beyond the remit of EURAB, the need for a strong supply of well trained researchers implies close, mutually supportive relationships between the academic and industrial systems. Ease of passage between the sectors is a hall mark of the US research system and would be an important element, in Europe, in creating a strong an attractive career path for researchers. Creating research linkages from academia to industry at a graduate, doctoral, postdoctoral helps researchers see the breath and surety of research opportunities and careers. EURAP is supportive of the efforts which EU has made to bring industrial and academic research worlds closer together.

Entrepreneurship is one of the most attractive and rewarding of science, engineering and technology careers, and one which brings the benefits of research to a wide public. Universities and research institutes are rapidly changing regulations, structures, and support facilities to encourage such activities based on their own research. A strengthening of the entrepreneurial ethos and supports within Framework Programme research would improve impact.

EURAB recommends that

- The European Commission, in conjunction with Member States, Associate States and Candidate Countries, through the open coordination provisions, should examine the mechanisms Member States to encourage research mobility between academia and industry. The best practices should be grafted onto research funding within the Framework Programme.
- The Commission should highlight the entrepreneurial research careers and start-ups companies which have developed from EU research.

4.4 MAINSTREAMING GENDER EQUALITY

There is now a common concern, which EURAB shares, about the under-representation of women in certain science, engineering and technology careers, particularly at higher levels of responsibility. The recent analysis undertaken by the Commission is most valuable[23], and its main recommendations, which EURAB reiterates below, should be rapidly implemented.

EURAB recommends that

- Statistics should be consistently gender-disaggregated, along with appropriate gender monitoring and evaluation practices.
- Improving human resource management in science, engineering and technology, along with much greater transparency in recruitment and promotion processes.
- Awareness raising and equality training, along with support for gender-proofing polices and practices.
- And that these practices should be mainstreamed into all EU research activities and funding mechanisms.

[23] Osbourne, Rees et al (2000), and Rees, T., 2002, "National Policies on Women and Science in Europe" http://www.cordis.lu/improving/women/policies.htm.

5 CONCLUSIONS

Despite the relatively positive image of scientists and engineers, Europeans are unwilling to commit themselves to studying the "hard" disciplines in sciences, engineering and technology and to taking up an associated career. When asked why, they point to school science as both dull and difficult, and to the associated careers as being unattractive.

In considering this problem, EURAB starts from two argued premises – in a sense conceptual recommendations - which strongly affect our more practical recommendations:

- That science, engineering and technology studies and research training are the basis for a broad spread of careers, which naturally branch out at different periods from such studies. This is our Tree Paradigm, and we consciously move away from the purist "Leaky Pipeline" image, which seems to withhold full legitimacy and value from the careers of those whose talents and desires merge their science, engineering and technology training with other activities in industry, commerce and government.
- That science, engineering and technology as well as research are profoundly social activities, and that if those involved and their institutions – in industry, academia and government – do not take a full and active part in setting society's agenda and developing society's wider institutions, then they are not being "proper", fully effective scientists, engineers and technologists.

The recommendations, which are listed in the following section, are largely directed towards "open coordination" seeking the European Commission to act with Member States, Associate States and Candidate Countries. We believe such an approach is most supportive of the development of ERA – and in the long run most effective in improving European research . They cluster around developing three broad requirements.

Firstly, there is a need to develop the dialogue with the citizens of Europe about the activities of science, engineering and technology, and eventually about careers. We support in the strongest terms the EU's "Science and Society" programme. But we feel that some of the activities are so important that they should be mainstreamed into *all* EU funded research activities.

Secondly, school science needs a major investment of innovative human thought and resources. These are the roots which nurture science, engineering and technology careers, and we call on all with an interest in its future well-being – industrialists, academics and government agencies alike – to develop an institutional commitment to the development of school science, engineering and technology.

Thirdly, there is a need to develop a strong, transparent training and career structure in science, engineering and technology. In the area of research, upon which we concentrate, there is a pressing need to professionalise the training which is provided. Some universities and research institutes have moved ahead and provide excellent models.

Similarly, there is a need to create a proper career structure – core to which are adequate employment contracts and good human resources management for contract researchers at doctoral and postdoctoral levels. We believe that the EU research spending has a major contribution to play in both the development of sound training structures and career paths.

Finally, we request the DG Research to include a section on "Improving the Attractiveness of Science, Engineering and Technology Careers" each year in their Annual Self Assessment Report detailing progress on the implementation of EURAB's recommendations.

List: EURAB Recommends that:

In the Public Uublic Understanding of Science
• In support of the EU Science and Society Action Plan, all research proposals contain a sum for appropriate dissemination of results. There is also a need for a much stronger, more direct dialogue to be developed with politicians – European and national – in these areas, and particularly in relation to "Attractiveness of Scientific Careers". • The present Framework Programme information activities should be strengthened, particularly the liaison with the European media. An analysis of the possibilities of a "European Scientific Press Agency" should be undertaken. In the meantime, the Alphagalileo News Service should be strengthened and extended to all Member States. • A coherent Framework Programme publications policy for the dissemination of the results of EU funded research projects should be drawn up
In Primary and Secondary Schools
• The introduction of innovative, *hands-on* science education into all Europe's primary schools, and the introduction of Creative Science Teaching modules into the formal training period of all primary school teachers.
• Concerted efforts to mainstream science, engineering and technology curriculum and teaching innovation into secondary school systems.
• All science, engineering and technology organisations – industrial, academic, professional, governmental – should reassess and strengthen their commitment – at a local, national and European level - to supporting the development of school science, engineering and technology education. All such organisations should publish its policy and activities in support of school science, engineering and technology on its Web site.
• Strong policy support and operational cooperation by DG Research with the activities of DG Education and Culture in fulfilling the Commission programme on "The follow-up of the Objectives of Education and Training Systems in Europe". An Action Plan, with clear milestones, should be published and progress reported in the DG Research Annual Report. Regional, national and European awards might be developed for such activities.
• A review of innovative career and pay systems for science, engineering and technology teachers should be undertaken, with a view to supporting Member States in their moves towards developing a high-status and high-pay profession.
The Training & Careers of Researchers
• The European Commission, in conjunction with the Member States, Associate States and Candidate Countries, publish an annual report on the state of Europe's science, engineering and technology human resources and associated policy issues
• The European Commission, in conjunction with Member States, Associate States and Candidate

Countries, through the open coordination provisions, should explore current best practices in opening up of science, engineering and technology undergraduate courses to interdisciplinary influences, to research experience, to industrial interaction, and to a clearer indication of the variety of career paths open to such students.
• The European Commission, in conjunction with Member States, should examine doctoral research training structures globally to develop a policy – to be operated through its research spending – to attract to and retain in Europe, the most creative and talented doctoral researchers. EU research funding, and particularly that aimed at research training should be *explicitly* used to encourage the improvement of doctoral training structures and practices. Since the European Science Foundation (ESF) and the European Heads of Research Councils (EUROHORC) are also developing mechanisms to the same end, such as the European Young Investigators (EURYI) Awards, the European Commission and these organisations should closely co-operate on this subject.
• The European Commission, in conjunction with Member States, Associate States and Candidate Countries, through the open coordination provisions, should examine good employment and human resource development practices in academic doctoral and postdoctoral labour markets and develop a research funding policy for the Framework Programme / ERA which supports the regularisation of such labour markets
• EU funding mechanisms for Integrated Projects and Networks of Excellence should recognise the needs for the development of the careers of high-level individual researchers, • EU funding mechanisms for individual researchers should also be developed to promote the career structures of researchers. In particular, there is a need for a number of larger "Principal Investigator" contracts to support the move of the very best young researchers towards independence
• The European Commission, in conjunction with Member States, Associate States and Candidate Countries, through the open coordination provisions, should examine policy and mechanisms which assist in the opening up of tenured research positions to EU and potentially global competition. Framework Programme funds should then aim to support such developments. More generally, an opening up of EU research training and employment positions to non-EU researchers is recommended and should be similarly explored.
• The European Commission, in conjunction with Member States, Associate States and Candidate Countries, through the open coordination provisions, should examine the mechanisms Member States to encourage research mobility between academia and industry. The best practices should be grafted onto research funding within the Framework Programme. • The Commission should highlight the entrepreneurial research careers and start-ups companies which have developed from EU research
The Gender Dimension
• Statistics should be consistently gender-disaggregated, along with appropriate gender monitoring and evaluation practices. • Improving human resource management in science, engineering and technology, along with much greater transparency in recruitment and promotion processes. • Awareness raising and equality training, along with support for gender-proofing polices and practices. • And that these practices should be mainstreamed into all EU research activities and funding mechanisms

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