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WHO'S WHO

Speakers at the *Europe needs more scientists!* conference, Brussels, 2 April 2004, an event organised to present the preliminary findings of the High Level Group (HLG) on Human Resources in Science and Technology:

☐ Philippe Busquin (Research Commissioner): Closing remarks
☐ Hugh Richardson (Deputy Director-General, Research DG): Opening address

Invited speakers:

☐ Luc Soete (Professor, University of Maastricht)
☐ Andrew Dearing (Secretary-General, ERMA)
☐ Jean Patrick Connerade (President, EuroSciences)
☐ Andrew Wyckoff (Head of Division, OECD)
☐ Yves Quéré (Director, La main à la pâte)
☐ Rosalia Vargas (Director, Ciência Viva)
☐ Martinus Veltman (Physicist, Nobel laureate)
☐ Fotis Kafatos (Director-General, EMBL)
☐ Martin C Huber (President, European Physical Society)
☐ Luciano Maiani (Professor, University of Roma)
☐ Edgar Jenkins (Professor, University of Leeds)

Members of the HLG:

☐ Chairman, José Mariano Gago (former Minister for Science and Technology, Portugal)
☐ Paul Caro (Honorary Director of Research, CNRS)
☐ Costas Constantinou (Assistant Professor, University of Cyprus)
☐ Graham Davies (Professor, University of Birmingham)
☐ Ilka Parchmann (Professor, IPN University of Kiel)
☐ Miia Rannikmae (Scientist, ICASE European representative)
☐ Svein Sjøberg (Professor, University of Oslo)
☐ John Ziman (Emeritus Professor of Physics, University of Bristol)

INTRODUCTION

Background

Four years have passed since European leaders set themselves the mission in Lisbon of becoming the world's knowledge powerhouse by 2010. Are we any closer to this target today than we were then? What is being done to stimulate the number of scientists in Europe when 500 000 more researchers are needed? Is the objective of the Barcelona Summit – that EU states must spend 3% of GDP on research and development – going to be met, judging by the current trends?

The special conference on the importance of human resources in science and technology (S&T) gave stakeholders the opportunity to discuss these questions and to review the preliminary findings of a High Level Group (HLG) appointed by the European Commission to examine this issue.

Prof. José Mariano Gago, the former Portuguese minister for S&T and chairperson of the Group, presented his team's preliminary findings in a 193-page report entitled 'Europe needs more scientists: provisional findings of the HLG'.

Principally, Prof. Gago and his seven-strong panel of experts addressed what European leaders should do, in practical terms, to help the Union live up to its Lisbon and Barcelona declarations. They took a critical look at the underlying trends and identified specific actions to boost the number of researchers in Europe.

First impressions count

The conference gave the 250 delegates, from science organisations across Europe and beyond, a unique opportunity to discuss the Group's findings and to raise key questions. Introducing the full programme, Prof. Gago outlined the process of wide consultation that contributed to the report and highlighted the urgency of the situation facing science-related human resources in Europe: there is an urgent need for an additional half a million researchers.

Throughout the conference a number of specific recommendations were made which will be considered for immediate implementation through EU research programmes and are hoped to influence both national and European policy. The final version of the report will integrate feedback from the audience attending the event and will include a full exposition of the whole range of recommendations.

As Hugh Richardson, the Commission representative presiding over the morning's proceedings, put it: "The report's findings and recommendations feed into an extensive policy exercise, leading to actions which inform our Sixth Framework Programme (FP6) for research, as well as our Science and Society activities… and establishes the broad lines of the Commission's thinking on research, including the next Framework Programme, FP7, and how associated and candidate countries fit into this."

FOREWORD

Research Commissioner Philippe Busquin

Last year, I set the wheels in motion for the HLG on Human Resources for Science and Technology in Europe to investigate the serious shortcomings in Europe's scientific labour market. I asked them to study what European governments can do to promote scientific careers and help scientists develop their skills.

For Europe to become the world's most dynamic knowledge-based economy, the Union must, no doubt, address this shortage of scientific talent. But, as shown by Prof. Gago, we are far from reaching our objectives in terms of the numbers of scientists needed. The combined effects of the brain drain and lower university intakes in science and engineering classes are making the challenge ahead of us harder.

Of course, we have been working on reversing this trend since the Lisbon Summit in 2000: our strategy of building a European Research Area (ERA) to overcome the problem of fragmented and overlapping research in Europe underpins this. And the Sixth Framework Programme (FP6) for research is the main instrument to implement the ERA.

Europe must overcome the problem of 'intelligence fatigue', the slowing down of knowledge creation. To do this, we must bring science to life in classrooms, laboratories and the boardrooms of private and public science organisations.

From the Group's report, it appears that European universities need overhauling. They should provide the diverse skills required for modern scientific careers instead of focusing only on preparing students for a life in academia. They should also work on building more partnerships with the private sector.

That the Group singled out science teaching for particular attention is critical. The EU must not only retain and attract top-quality scientists, but also encourage young achievers to become the next generation of innovators in Europe. This means relating the way science is taught in school to students' everyday lives and experiences, making it more inquiry-oriented and socially relevant.

Through our Science and Society programme in FP6, the EU has already taken a number of concrete steps, such as the European Science Week and the Young Scientist Contest, to spark young people's interest in, and knowledge of, science and scientific careers. But clearly more needs to be done. As shown through the reporting by the HLG and Prof. Gago, European governments need to act now to address a shortage of scientists that is threatening to slow progress towards reaching the EU's ambitious Lisbon and Barcelona agendas.

Professor José Mariano Gago, Chairman of the High Level Group

As governments across Europe strive to promote science, engineering and technology (SET) careers, my Group's mandate was to see what more can be done to help the EU reach its ambitious Lisbon and Barcelona objectives. Starting in May 2003, we set out to gather comments from stakeholders on how to improve human resources in the SET fields.

Following a Europe-wide consultation process – involving nearly 200 national and European industrial organisations, universities and research laboratories, science and technology funding agencies, research councils and associations, academies, science centres and museums – we are proud to present our findings.

Our goal was not only to set out the current state of affairs in this area, but also to provide tangible action for future R&D policy in Europe. For this, involvement of the different social actors in science and technology policy was essential.

However, our efforts must be seen as the first phase of what needs to be accomplished in the near future. Considerable time should be devoted to setting up a dialogue in each Member State on the issue of human resources for SET, helping policy-makers understand what is required, and building bridges between national and European actors. Dialogue between industrial and academic organisations in Europe should also be pursued. National and European statistical bodies – as well as the OECD – need to address the conflicting and flawed data in this area.

EXECUTIVE SUMMARY

Crisis in the production of human resources for S&T

The High Level Group (HLG) on Human Resources for Science and Technology is part of the Commission's strategy to address the Lisbon EU Summit declaration of March 2000: that Europe should become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion. Since the Lisbon declaration, heads of state and government across Europe have continued to stress the need to boost substantially the number of people entering science and technology careers. Indeed, at the 2002 European Summit in Barcelona, heads of state called for an increase in the proportion of European GDP invested in research from 1.9% to 3%.

In terms of human resources, it was estimated that an extra half a million researchers (or 1.2 million research-related personnel) were needed to meet that goal and reach the minimal level of eight researchers per thousand in the workforce. However, this objective will not be reached within a reasonable time (and certainly not by 2010, the target set by the EU Summit) should the present trends continue unchanged.

There is even a risk of a future decrease in the numbers of highly qualified tertiary level graduates (PhDs) in several science, engineering and technology (SET) fields. Students entering university can react quickly to changes in the labour market by shifting to another, more promising sector, but this is not the case for graduates who are stuck with their specialisations after several years of study and may fall victim to an unfavourable economic cycle. This shows how important it is to provide countermeasures to prevent the loss of valuable human capital.

Europe would be able to catch up with the USA and Japan if employment in R&D were available to young people in Europe, if the numbers of those who choose to study SET were not allowed to diminish, if more women were involved in R&D, and if the southern and eastern European countries accelerated their SET development. In particular, achievements in education and a rapid reduction of the unacceptably high drop-out rates in many European countries could be key policy objectives to broaden the qualification pool for SET professions.

REPORT SUMMARY

Demand and supply in the SET labour market

Where will demand for SET labour most likely arise? What implications will this have on the supply side? It has been shown that the largest increases in R&D spending will have to be met by EU industry, which lags well behind the USA and Japan. And yet it is difficult to estimate exactly where, and in which sectors of the economy, the demand will be most keenly felt.

In knowledge-based economies, all industrial sectors are likely to be affected – well-established industries draw heavily on new technologies to make their business more competitive in the

global market place. Over the past few years, businesses have been forced to rely on new players to gain access to new technology worldwide. This means exploiting their supply chain, venture funds, academia, or inorganic acquisition via start-up companies. But corporate laboratories and corporately funded R&D has suffered as a result, often becoming 'integrators' rather than 'discoverers' of technology. This, in itself, has led to a new role for universities which, in partnership with industry, will become the outer 'radar' for businesses on new technology.

On the supply side, EU ambitions to increase SET personnel will not be met on current form. Change is needed to increase radically the number of women entering SET careers and decrease reliance on importing external talent. The ageing SET population, the growing shortage of teachers, and the greying of academic staff are areas that demand financial commitment both at national and EU level.

The shortage of SET workers is not felt evenly across the EU, but this could vary over time and, with increased mobility, a balance may be found. The European Research Area's success may also depend on better standards in education and qualifications. Here, the Bologna Accord is a good start but it must embrace the system of credit transfers, rather than time served, on academic courses.

Career prospects

There is a false perception that SET careers are unattractive to many young people for reasons of: pay, career structure, work environment, status and marketing. Just how do industry, academia and government match up to this perception?

Surprisingly, the research was able to show that private-sector SET careers pay very well: indeed, SET workers in industry are in the top three of professions as regards starting pay, and these high rates are sustained well into their careers. Figures for the 11 years after joining confirm this. It is also true that unemployment amongst SET graduates is very much lower than that of the population at large.

It is also shown that career diversity for people with SET backgrounds is probably more varied than for any other sector. In view of these facts, it is difficult to understand why recruitment is so low. SET careers must be 'sold' in a more effective way by industry and professional organisations, acknowledging that all sectors of the economy face employment uncertainties at one point or another.

The Commission has a major role to play in promoting these positive aspects of SET careers in industry.

Remuneration in the public sector, however, is not as good, and – despite some appealing working conditions – career structures are not conducive to attracting both the quality and quantity of qualified people required. National and European policy must address this.

The cultural context of recruitment for research careers

Europe's tendency throughout history to present science as a way to 'tame' Nature has often met with strong resistance. This feature of European culture deserves special attention today as the very image of S&T in society – and students' attitudes to science – seem to reflect this fundamental duality.

Since the 17th century, strategies have existed to popularise science, and remain very active today. They are usually supported by governments, public institutions, research organisations, scientists, museums, and science centres, using a variety of forms. They can be divided into two approaches: classical public understanding of science trying to bring more information and knowledge of science to the public and to young people; and a networking approach based on the idea that extended dialogue and direct contact between citizens and scientists is necessary in order to promote scientific culture in society, as well as help citizens better understand controversial issues in S&T.

The media are a very important intermediary between science and society – 60% of people say that they get their scientific information from television. But the media (TV, radio, movies, newspapers, magazines, etc.) have their own rules, and use S&T mainly as a source for narratives that attract people through conventional storytelling and spectacular images or situations. Nevertheless, they make science familiar, and this is a key entry point for science into society. EU data from recent surveys about S&T and knowledge highlight this.

Some economists question the effectiveness – as an eventual SET personnel recruitment tool – of programmes aimed at popularising science and improving science teaching at primary and secondary levels. They believe that emphasis should remain at the university level. The HLG firmly disagrees. It relates back to the social and cultural context of scientific development in democratic societies; the need to reinforce and widen the social fabric in order to support S&T development. All efforts to encourage students into science courses and to pursue science and technology careers are welcomed.

Women in science – filling the gender gaps in science and research

The number of women in education and in employment across Europe has increased in the past 20 years, as indeed has the number of women entering science. But, in many countries, women are still under-represented in many areas of scientific research, and face difficulties breaking through the glass ceiling in research hierarchies.

Much has been achieved in promoting women's participation in scientific research since 1999, when the Commission launched its action plan on women and science which resulted in a number of reports and statistics devoted to this subject.

This data suggests women remain the most obvious source for increasing personnel for S&T in Europe. For this to happen, drastic changes need to be made to science, as well as to social and economic, policies.

Core issues

The one-day conference addressed five crucial themes based broadly on the areas of concern in the HLG's report. Each theme was examined during panel sessions, debates and presentations.

Under the heading, *There is a crisis: human resources for science and technology are not increasing*, HLG Chair José Mariano Gago introduced the sessions with a summary of his team's findings on this question.

Luc Soete and Andrew Wyckoff tackled the first question of the day: *Is it just a matter of excellence? Why elitist policies are not the solution.* Mr Soete gave his own "beacon vision" of the historical relationship between science and society today, evaluating the human quest for – and veneration of – excellence, looking at knowledge as a joint production and how to ensure global access to science. Mr Wyckoff explained the difference between 'elite' and 'excellence', showing OECD statistics which justified his theory that Europe needs to be less hierarchical and rigid in its approach to knowledge creation, and that 'poles of excellence' need to be more attractive to researchers.

After the break, Graham Davies, Andrew Dearing, Luciano Maiani and Martin C. Huber concentrated on the question of "demand" stressing the importance of shared private-public ownership of the human resource problem in Europe. Graham Davies said the answer to this question is dogged by a lack of uniform statistics. He cast doubt on the EU's human resources objectives being met but identified the key role that universities and effective talent clustering will play in the future, and the fact that Europe is especially good at technology acquisition. "Academia has to be industry's outer radar," he said, a European MIT offering the full package of skills, from scientists and economists to technologists. Mr Dearing said America's success in globalising R&D is mainly based on its managerial competence, something Europe could learn from. Mr Maiani of CERN said Europe can compete on the world stage and that his organisation is leading the way. He conceded that basic research faces an uphill battle to fill so many places but that industry should have the answers. Someone setting off on a career in fundamental science needs to be compensated for this career investment with a good salary, he said. This is the way to promote "the best" for the job. Mr Huber then presented some key statistics on the state of physics enrolments in universities and later employment prospects. He quoted the MAPS (Mapping Physics Students in Europe) study, published in March 2004, which indicates that the number of European physics graduates dropped by 17.1% between 1997 and 2002. This is a worrying trend, he said, as physics is a pivotal natural science, providing a framework for other scientific fields, including medicine.

Science education can make the difference was the position that Svein Sjøberg, Ilka Parchmann, Costas Constantinou and Edgar Jenkins defended. Mr Constantinou presented evidence on the correlation between funding for higher education and economic output. He also put forward an argument in favour of science teaching and learning for everyone and discussed the link between science understanding and a democratic culture. In addition, he argued that,

if the knowledge society scenario is going to be sustained, there is a need for an emphasis shift in the educational system away from the development of early expertise and more towards the promotion of flexible thinking and creativity skills. In the afternoon session, Mr Sjøberg gave a cogent account of the current state of affairs in European scientific education. He partly based his presentation on data from the ongoing comparative project ROSE – Relevance of Science Education – study that is looking into the interests, values, and perceptions of S&T among 15-year-olds. He reminded us that the main purpose of S&T in the compulsory school is not as a recruitment area for scientists, but to equip the younger generation with knowledge and skills for their future life as citizens in a democratic society. Stimulating curiosity, interests and promoting critical thinking and scientific literacy is the key to building a broader acceptance of science, he maintained. "Of course, it can help encourage careers in science, as well. But one thing must be remembered, young people do not choose SET careers because it's good for the national economy."

Student emotions, experiences, motivation and the relevance of the subject to their lives are more important recruitment factors than economic statistics. Mrs Parchmann was equally as realistic in her presentation, saying: the PISA study shows education is a complex system made up of many actors with sometimes conflicting motivations – students and teachers, schools and classrooms, community, education systems, society, and so on.

The final panel of the day – comprising Paul Caro, Yves Quéré, Rosalia Vargas, Fotis Kafatos and Jean Patrick Connerade – dealt with the cultural aspects of science under the title, *Scientists and society in the making of scientific culture*. Mr Caro began by quoting Plato who said that knowledge and opinion are two different things, and that for knowledge to permit technical progresses in society it is necessary that it is accepted and well considered by the opinion. In this light, he approached the problem of the "deficit model" and how "science dialogue" is critical to overcoming the fear of science, especially in the light of GMOs and other life science developments. Other panel members spoke of their organisation's experiences in building scientific culture in Europe, including science education programmes in Portugal (Ciência Viva) and France (La main à la pâte), and how the EMBL's fellowship network provides a valuable service to European science.

Nobel laureate Martinus Veltman then treated the audience to *Some simple facts* drawn from his own experiences. He did not agree with the 'brain drain' theory behind Europe's problems, saying there is an overuse of buzzwords and a lack of actual scientists teaching science at higher levels. "They know how to teach it but not what it means," he chided. "The more people in science, the better – it improves society."

POLICY RECOMMENDATIONS AND ACTION

What is the problem and what can be done about it?

On current form, the EU will not be able to meet its scientific human resources (HR) goals – a minimum of eight full-time researchers per thousand in the workforce – within a reasonable time frame, and almost certainly not by the 2010 target set at the Lisbon Summit.

The major recommendations from the HLG are:

1. There is clearly a need for a common European policy in this area that goes beyond the post-Lisbon open method of coordination of national policies. Europe needs a common policy for human resources. We suggest that such a policy should be initiated in the area of science, engineering and technology resources and should integrate the economic, social and educational dimensions needed to reduce the persistently large untapped human resources in Europe.

2. We also suggest that there is a need for novel instruments to measure and monitor human resources for science and technology in Europe, either as a separate entity or as part of a broader European science and technology policy. An entity of this type could easily be created as a 'light' and non-permanent independent body. It should be given the mandate to record and analyse national and European policy measures relevant to the objective of increasing human resources for SET, and to prepare a coherent set of indicators relevant to the policy issues at stake at national as well as at European level, and report on them annually.

3. There is a need for a radical economic initiative from the EU to encourage the formation of new businesses in the knowledge-based industry sector. Without the influx of new businesses it will not be possible for the EU to meet its 3% target with its corresponding 2% commitment from industry.

4. The proportion of women in SET careers is unacceptably low in many European countries. Although considerable efforts have been devoted to the analysis of this problem and lip-service has been paid in many policy declarations, we feel that it is now time to act. Europe simply cannot reach the level of SET resources needed for its development without finding ways to remove its anachronistic science gender imbalance. It seems almost inconceivable that, at the beginning of the 21st century, European countries in need of both innovation and increasing birth rates still do not consider it a matter of social priority to provide universally available kindergartens and schools which are open all day.

This is an issue of general social policy of enormous impact in science and technology policy and requires immediate action at European as well as at national and regional levels.

5. As most of the employment opportunities for researchers are created by industry, better conditions for the development of research in and by the private sector have to be generated in Europe if the Lisbon and Barcelona goals are to be met. In addition, universities, which are the main agents for preparing researchers, need to innovate on ways of better integrating education with training and on measures to encourage more intensive collaboration with industry.

6. Once properly enumerated, the perceived skills shortage gap should be an important advertisement for new entrants into SET careers. Young people are not slow to see good opportunities. However, if the skills shortage is poorly defined in terms of sector and qualifications then there is little incentive for them to seek SET careers. The EU and industry need to better define the skills shortage likely to arise by 2010, and then sell the opportunities.

7. Perception regarding remuneration in SET careers will be key. A communication strategy needs to be put in place to dispel current perceptions. Salaries in industry remain competitive. The fact should also be celebrated that scientists and engineers have excellent career paths and can move freely into the financial and businesses sectors where their training and skills are much prized. This is not to be seen as a loss to SET but more as the value of SET to all sectors of the economy.

The level of public funding per researcher in Europe is significantly below that of the USA – by almost a factor of two. It is not surprising, therefore, that the number of European researchers, notably in the public sector, does not translate into the same level of working conditions and, consequently, of results. The conditions and prospects for employment in the public sector (in universities, public research centres or other publicly funded research institutions) should be recognised as critical for the EU strategy. New human resources for SET will not be attracted to the required extent unless governments translate their own political goals into new research jobs and better career perspectives. In periods of economic slow-down, this conclusion needs to be emphasised even more strongly.

8. Reliance on importing suitably qualified workers from outside the EU is not a sustainable, long-term solution, given the global nature of the market and the dynamics at play. Despite this, we still think that European science and technology policy should be addressed as part of the European Union's broader foreign policy. The EU should compete internationally to attract qualified human resources, notably in SET areas, and combine this effort with a clearly defined promotion of its commitment to social and economic development.

9. Clearly, better coordination of national policies and the drawing up of a European policy to attract talented young scientists, with demonstrated potential for original research, from the rest of the world are necessary. At the same time, it should not be forgotten that the EU itself is a source of SET workers for other knowledge-based countries. Retention is key; the attrition, via emigration to the USA for example, undermines Europe's competitive ability. A programme should be introduced in the EU to attract young people into academic posts.

10. It is apparent that the shortage of human resources in SET is not felt across the whole of Europe, although it is argued that this in itself is not a steady state and that migration to satisfy demand will surely occur. The need for standards in educational achievement and qualifications will be necessary if the European Research Area is to succeed in the long term. The Bologna Process is designed to address such needs but it will only be successful if it fully embraces the transfer of authentic measures of scientific competence and not simply time served on academic courses.

11. Despite the risk arising from employment uncertainties – an aspect that must be true for every sector of the global economy these days – industrial careers are shown to contrast with careers in academia and the public sector in general. Remuneration in the public sector is poor and career structures are not conducive to attracting both the quality and number of researchers required. Although there are other aspects of employment that do attract people to this sector, they are not sufficient to tip the scales in favour of large numbers of people wanting to enter these professions. This is certainly an area that needs the full spotlight of national and European policy, as serious deficiencies exist that require urgent remedies.

12. There is a general hasty conclusion which suggests that the main emphasis on closing the 3% gap lies with industry, so industry needs to promote careers in a more attractive way to prospective SET employees. However, this is not a job that can be undertaken by industry alone. National governments as well as the European Commission have a significant role to play and it is only through coordinated approaches that the problem can be solved. Good, well-remunerated, attractive careers in the public sector and academia need to be put in place and marketed as such to future generations if the entire European Research Area and an underlying knowledge-based economy are to be fully realised. Science is absolutely crucial to the future prosperity and competitiveness of the European zone.

13. An important function in promoting the role of SET in European society is undertaken by education. The preparation of researchers needs to extend beyond the university in order to engage both industry and, more generally, the workplace, more extensively in integrating fundamental research, development and innovation in the researcher-training process. For some years, European initiatives and thematic networks have promoted the enculturation of doctoral students in communities of practice. There is a need for these funding programmes to

remain in place. Additional measures, such as funding for summer schools for doctoral students, could usefully contribute added value by encouraging the exchange of expertise with respect to methodological approaches, techniques for collecting evidence, and research design issues.

14. With the new role envisaged for universities as providers of long-term, applied research for industry, there needs to be greater incentive for industry to form partnerships with academia. Novel ways of working, for example to have university departments co-located at industrial laboratories, are also necessary to ensure and facilitate knowledge transfer. And there needs to be incentives for transfer pathways for staff between industry and academia. This should also facilitate movement in directions enhancing the career structures of both organisations as well as ensuring better knowledge transfer. This culture has to be promoted and can only be achieved by incentives to both organisations and staff.

15. The quality of SET training at universities is declining in some institutions. It is expensive and funding is inadequate in many of these institutions. For industry, practical experience is key, and for many students it is an immensely enjoyable experience. As the result of cost cutting, this is one of the first parts of the curriculum to be discontinued. Library projects, and experimental work in poorly equipped laboratories is no substitute. Industry involvement should be offered incentives to facilitate this experience for SET students.

16. Instead of presuming that all their undergraduate SET students are heading for academic careers, universities should cater for and celebrate the whole range of research employment opportunities, including the more industrially based jobs, that many of their graduates will actually be taking up. Significant innovation efforts are needed with respect to course structures and teaching approaches in order to safeguard sustained intellectual engagement by the majority of students rather than the few, and the preparation of all students not so much for the expertise, but for the original thinking and creative work that are required by a knowledge-based economy.

17. It can be argued that school science education policy and practice live in a world of their own. Despite the existence of established and vigorous European research into science teaching and learning, science education remains empirically grounded. Students often perceive science as too abstract because it is trying to teach fundamental ideas without sufficient experimental, observational and interpretational background, without showing sufficient understanding of their implications, and without giving them the opportunity for a

cumulative development of understanding and interest. Science curricula are often excessively factual, partly because of the explosion in scientific knowledge and the constant 'adding-on' of topics to an already extensive range of topics. More importantly, the traditionally established content-delivery model of teaching, which sustains factually oriented curricula, tends to distort student understanding of the nature of both science and knowledge by ignoring the methodological, reasoning and cultural aspects of science.

18. School science is often taught by non experts. This should not happen as a matter of policy. All teachers should be offered CPD, and substantial incentives to attend CPD courses by salary structure. Industry should be offered incentives to involve itself in education, in mentoring and ambassador schemes as well as organising and delivering master classes in practical work for teachers. Incentives could take the form of tax breaks, ranking on R&D scoreboards, etc. Newly qualified staff should be at the forefront of such schemes and perhaps it should be made a condition of employment in both the industrial and academic sectors that they become SET ambassadors.

19. Science education is an area in need of continued interdisciplinary research in relation to the European objectives. Specifically, more research is needed into mechanisms for development of innovative science curriculum materials and associated teacher professional development initiatives. Increased effort is also required into promoting science teaching and learning as a process of enquiry as well as technological thinking as a process of problem solving. Sustained initiatives are required to promote mechanisms for bridging the gap between science education research and practice. One educational level that demonstrates a particularly acute need for learning research and research-based reform are first-cycle higher education programmes. The importance of designing research-based sequences of teaching and learning activities as well as closely linked, authentic assessment mechanisms, cannot be overemphasised.

20. While students see, and may even interact with, practitioners of some S&T fields, and are familiar with the many technology products that have been developed, they lack opportunities to experience careers in industry or research institutions at first hand. Making students aware of scientific life in 'the real world', and of the ways in which industry operates, are all-important elements – but they are no substitute for the 'real thing'. School-industry and school-university partnerships are crucial in this respect, and measures for nurturing and supporting them will need to be put in place.

21. We wish to highlight the importance of science teachers. National and European programmes aimed at increasing human resources for science and technology should pay due attention to the increasing need to share these objectives with scientists, teacher educators and science teachers, as their joint efforts are required to address the challenges of science education successfully. A European dimension should be added to this issue in view of the common European objective of attaining a larger flow of human resources qualified in SET.

22. Strategies for science popularisation and for the promotion of scientific culture across society are in place in most countries. Governments, public institutions, foundations, research organisations, scientists, museums and science centres usually support such strategies, whereas the involvement of industry is too modest. The Commission should provide incentives to all these initiatives that are of European value.

23. Classical public understanding of science tries to bring more information and knowledge about science matters to young people and to the public in general. A complementary and more promising networking approach is based on the idea that extended dialogue and direct contact between citizens and scientists, schools and research organisations, is necessary in order to promote scientific culture in society and to help citizens to acquire a better understanding of the role of science and technology in society. Controversial issues related to science and technology, as well as to the science base for dealing with risk and uncertainty, are increasingly a part of these new approaches.

24. It is clear that there is a need to communicate the successes and importance of science, engineering and technology more effectively. The identification of role models, especially young role models, is important. There is a job here for industry and the EU. An active campaign needs to be put in place to identify and publicise role models, both men and women, together with their key contributions to the economy and the quality of life of Europe's citizens. Why is it that we always celebrate the names of dead scientists but very few know about living scientists? As a consequence, public engagement in science remains an issue. Scientists need to be trained in media and communication skills, not just for other scientists, but especially for non-scientists, with the emphasis on context.

25. One of the problems of attracting and retaining people in SET is poor or non-existent careers advice. This is particularly pertinent for the 11 to 14 age group and the 16- to 18-year-olds where important choices are being made, and when SET is seen as "uncool" and peer pressure is all-important. Very often, students have little or no insight into what scientists can do to contribute to the future of society. The EU needs to address this via policy and partnership initiatives.

26. There is an urgent need for a comprehensive European strategy towards enhancing the development of scientific culture across Europe. The critical importance of this issue is clearly not proportionate to the very modest means allocated to 'science and society' in the EC budget. We urge the European Commission to address this issue.

27. Certain policy-makers doubt that actions to improve the popularisation of science and science teaching at primary and secondary levels are helpful when it comes to recruitment into science careers. They believe that the most important point, on which efforts should be concentrated in Europe, is at university level. They advocate that the creation of elite higher education institutions in Europe should be the main policy objective. We do not agree with this view which, in our opinion, disregards the social and cultural context of scientific development in democratic societies, the need to reinforce and widen the social constituency able to support scientific and technological development and, notably, the very wish to study science and pursue science and technology careers. Such approaches also tend to disregard the importance of science literacy for all in democratic decision-making as well as the role of science learning in developing critical thinking skills.

28. It would be counter-productive to see scientific and technological excellence in conflict with the need to broaden the scientific and technological human capital in Europe. We believe that scientific and technological excellence can only be achieved in Europe if there is a sharp increase in human resources for science and technology. At the same time, only the economic impact of scientific and technological excellence, innovation and its social perception will provide the jobs and the attractiveness needed to sustain the growth in the number of people who will choose either to study SET or to vote for increasing R&D budgets.

Conclusion

Scientific and technological excellence can only be achieved in Europe if there is a sharp increase in human resources for S&T: greater emphasis on the socio-economic impact of SET – how it helps create wealth which, in turn, gives it political importance – should sway policy-makers on the importance of bigger R&D budgets.

SCIENCE AND SOCIETY IN THE RESEARCH PROGRAMME

The European Union's efforts to promote science and flesh out the European Research Area concept were given a significant boost in the Sixth Framework Programme (FP6).
Through its 'Science and Society' programme, the Union supports numerous activities and prizes aimed at bringing research closer to society – promoting responsible use of scientific and technological progress, respecting fundamental ethical values, and stepping up the science-society dialogue.
Administered through the Commission's Directorate-General for Research, it achieves these goals through:

- ☐ Networks and the establishment of structural links between institutions and activities at the national, regional and European levels, in particular using information society technologies
- ☐ Exchange of experience and good practice
- ☐ Carrying out specific research
- ☐ High-profile awareness-raising initiatives, prizes and competitions (i.e. Descartes Prizes for Scientific Excellence and Communication, the Young Scientist Contest, Science Week, etc.)
- ☐ Establishing databases and carrying out studies on different themes

Science and Society activities focus on five main themes: science and governance, ethics, education and science, youth and science, and women and science.

In addition, FP6's Marie Curie actions, under the Human Resources and Mobility Programme, aim to consolidate and widen career prospects for researchers. These actions are some of the most direct and visible examples of how developing and enhancing the European dimension of scientific careers, mobility and training provides valuable impetus to human resources in the European Research Area.

More information:

Sixth Framework Programme (FP6): http://europa.eu.int/comm/research/fp6/index
Science and Society: http://europa.eu.int/comm/research/science-society/index_en.html
Marie Curie actions: http://www.europa.eu.int/mariecurie-actions
The researcher's mobility portal: http://europa.eu.int/eracareers/index_en.cfm

European Commission

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European Commissioner for Research Philippe Busquin appointed the High Level Group on Human Resources for Science and Technology in Europe – in May 2003 – chaired by José Mariano Gago, former Minister of Science and Technology, Portugal.

This brochure presents a summary of the Group's findings, first published in April 2004, on how to reinvigorate scientific careers and prospects in Europe – and of the proceedings of the conference coinciding with the launch of the report under the same title.

For more information about the High Level Group and to download a copy of the full report, visit the website:
http://europa.eu.int/comm/research/sciprof.html

Or contact the European Commission's Science and Society Programme:
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