CSIRO submission 08/297

Inquiry into Research Training and Research Workforce Issues in Australian Universities

House of Representatives Standing Committee on Industry, Science and Innovation

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Executive Summary

There are skills shortages across the Australian economy and the underlying growth in demand for trained people is a reflection of both the growing application and sophistication of technology and the economic growth this produces. Moreover, an effective innovation system encourages and facilitates the movement of people between sectors, across boundaries and into different disciplines so that researchers may move from research to other occupations, increasing the demand for additional research training.

CSIRO's governing legislation, the *Science and Industry Act 1949*, gives CSIRO specific responsibilities for training researchers and developing research capability for the benefit of Australia. Our quadrennial funding agreement, commencing in 2007, also makes specific mention of CSIRO's role and commitment to research training.

The war for talent has meant that CSIRO and other agencies are finding it increasingly difficult to recruit skilled researchers in a number of science disciplines as well as interdisciplinary skills areas critical to effective multidisciplinary science. The situation is of considerable concern because research needs and expectations are becoming more complex, multi-disciplinary, and of greater significance to Australia's sustainability. While there are many possible short term responses to the war for talent, a strategic response has to start with increasing supply. This means starting with the education system – from primary school to tertiary education and postgraduate training. CSIRO views the following as crucial issues in this regard:

- Increasing the attractiveness of mathematics, science, technology, and engineering to students.
- Developing an understanding of the complex interactions between science and society.
- Emphasising the relevance of the knowledge and skills developed through a scientific education to the widest possible range of professions.

CSIRO further suggests that new approaches to postgraduate training be considered such as an expanded post doctoral program that would encourage early career scientists to spend some time in publicly funded research organisation (PFRAs), providing incentives where critical skill shortages exist, and a greater integration with industry.

In response to the increasingly competitive labour market for leading-edge researchers, CSIRO has implemented a number of programs aimed specifically at maintaining high quality research and scientific capability including the building of a pipeline of research leaders, developing an integrated "career program", a significantly expanded and specialised PhD and Post-doc programs, more positions for early career scientists, and establishing fellowship programs designed to support researchers who have taken career breaks to care for family.

CSIRO's contribution to the training of researchers complements the role of the universities. Only through cooperation however, can CSIRO and top universities leverage their reputations to attract and retain the brightest and best in the global talent 'war'.

1. Introduction

CSIRO makes a significant contribution to the innovation system in Australia. It conducts and applies the results of large scale multidisciplinary research to advance Australia's national and international objectives and, specifically, the economic competitiveness of Australian industry (Science and Industry Research Act 1949). Our purpose is to deliver innovative solutions for industry, society and the environment.

CSIRO is a major consumer of trained researchers. In order to fulfil our purpose we rely on the people in our organisation to innovate and solve complex problems. We employ over 6,300 skilled staff, of whom 60 percent hold degrees (2000 doctorates and 470 masters degrees). Our staff provide ideas for change – for doing things better or doing different things. As the demand for innovation increases, so does the demand for highly skilled people. CSIRO is largely dependent on Australian universities to provide the next generation of researchers and it is clear Australia is working near capacity, so that recruitment across key parts of the National Innovation System is problematic.

CSIRO is also a supplier of research training. This reflects a specific legislated responsibility, as well as a response to a need. Our governing legislation, the *Science and Industry Act 1949*, articulates CSIRO's role in training researchers and developing research capability for the benefit of the nation. Our quadrennial funding agreement, commencing in 2007, makes specific mention of CSIRO's role and commitment to research training. Since its inception, CSIRO has contributed to the training and development of postgraduate students and continues to do so. Our staff supervise, co-supervise and/or sponsor over 700 postgraduate students including more than 130 supervised in collaboration with Cooperative Research Centres. CSIRO has reviewed its contribution to postgraduate training and as a result we have revitalised our approach by introducing CSIRO's talent ladder initiative, described later in this submission.

Australian postgraduate training is well regarded nationally and internationally. However, there is an increasing demand for skilled workers, especially well-educated innovative researchers, right across the economy and globally. Furthermore, the issue is not just one of trained researchers. It is equally about skilled support staff such as technicians. Above all, the expectations in the workplace are that researchers and their support staff are able to solve complex problems of national significance with strong leadership, sound planning and effective management. Such increased expectations require a new approach to postgraduate training.

2. Key challenges

2.1 The shortage of talent

People are critical for innovation but there are limits to the supply of highly skilled people imposed by the length of the necessary training and the need to complement education with experience. As the demand for innovation increases, the demand for highly skilled people also increases.[1] This growth in demand is itself a reflection of both

[1]The 2006 SET skills audit conducted by the then Department of Education, Science and Training (http://www.dest.gov.au/sectors/science_innovation/publications_resources/profiles/science_engineering_technology_skills_audit_report.htm)concluded that Australia's future capacity will be

the growing application and sophistication of technology and the economic growth this application of technology is in part producing. Some of the fastest growing industries are the knowledge-based services such as banking and financial services, health, education, communication, security and the creative industries. With increased globalisation it has become easier for highly skilled people to move around the world and the competition for the most highly skilled people has itself become global.

It is important to understand that demand for highly skilled workers is increasingly spread right across the economy. The issue is not just one of having trained researchers able to develop and improve new technological solutions, it is equally about having skilled support staff for researchers – it is neither efficient nor an effective use of skills for research scientists to be employed in work that technicians are able to do better.

While it is easy to consider the war for talent as a competition for specialists, in fact some of the most pressing issues in innovation require the need for people to cross boundaries, to bring a business perspective to scientific issues or a scientific understanding to the analysis of start-up business plans. Competent scientists sitting on company boards can be a useful complement to industry experts providing advice to research agencies. Innovation builds on the cross fertilisation of ideas, not just through different scientific disciplines or between the physical and social scientists, but between business and science or government and research.

An effective innovation system encourages and facilitates the movement of people between sectors, across boundaries and into different disciplines; and provides the support necessary to allow people to perform when they do make such changes.[2] Among, other things, this means removing unnecessary cultural barriers between professions and sectors. Some barriers can result from the rigid silos that can exist between departments within a single university.

2.2 CSIRO's workforce requirements

While the demand for research talent is much broader than a competition for specialists, CSIRO is finding it difficult to recruit skilled researchers in a number of science disciplines as well as interdisciplinary skills areas critical to effective multidisciplinary science. Analysis of our future requirements, based on CSIRO's Broad Direction Setting and Science Investment Processes indicates current, anticipated and continuing shortages in the following areas:

- Mathematical and statistical sciences
- Computational, simulation and modelling sciences

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constrained by competition for skilled workers due to the level of international demand for SET skills; difficulties in keeping apace with growth and technological change occurring in SET industries; the availability of adequate infrastructure to support SET in universities; and concerns about support for research careers

[2] Technology transfer is often most effective when it takes place through the movement of people as this is the easiest way of transferring the tacit knowledge and understanding that can be critical to success. It is worth noting that changes to Australia's superannuation system over recent years have removed one of the most significant non-cultural barriers to the movement of people between different organizations and sectors.

[5] Science capability needs and development, CSIRO, Science Investment Process 2008.

- Quantitative systems science
- Metallurgy, surface science and advanced materials
- Petroleum, geosciences and geo-engineering
- Chemistry and chemical engineering
- Mechanical, electrical and electronic engineering
- Bioinformatics
- Molecular biologists
- Quantitative geneticists
- Molecular geneticists and advanced genomics
- Climate sciences including: atmospheric, marine , meteorological , hydrology and hydro-climatology sciences[5]

In addition to the problems of recruiting experienced research staff, a number of CSIRO Business Units face difficulty securing high quality PhD students and acknowledge that this is a broad issue as university departments cite the same issue. The declining supply and quality of PhD graduates means that the pool of future scientists able to conduct world class research is small. If not addressed, this will affect the long term viability of Australian research and the contribution to national priorities from PFRAs and universities across the national innovation system.

The situation is more concerning because research needs and expectations are becoming more complex, multi-disciplinary, and of greater significance to our sustainability. CSIRO increasingly needs people who are strong in more than one discipline, are able to work effectively in larger teams which cross traditional boundaries, communicate well, manage project teams and partner effectively with industry and government. It would seem that the environment in which students are educated will need to become more flexible and provide training from a number of sources over an extended period to ensure students can contribute effectively in this working environment.

Typical PhD student programs are highly academic and rarely draw on CSIRO or commercial organisations to broaden the PhD scholar's experience (particularly commercial experience). To address national priorities and industry needs scientists and research staff need to have broader capacity in a number of areas. CSIRO requires its researchers to solve significant challenges by applying multi and inter-disciplinary approaches. In those cases where joint supervision exists between CSIRO and university the graduate has broader capacities. The next generation of researchers will need to be trained in this manner.

In addition, there is broad consensus that project leadership and research management skills are in high demand, and that young researchers should receive appropriate training and support in these areas. A major requirement for researchers is the ability to conduct science in 'Mode II' (i.e. working with the intended beneficiaries/users of research from the inception of projects, rather than seeing applications as an 'add-on'). Industry partnering capability has also been identified as a complementary skill needed within the research and development sector.

3. New approaches to postgraduate training

While there are many possible short term responses to the increasing demand for talent, a strategic response has to start with increasing supply. This means starting with the education system – from primary school to tertiary education and postgraduate training. Among other things, this will require increasing:

- the attractiveness of mathematics, science, technology, and engineering to students; exposing students studying these subjects at all levels to a broader curriculum to broaden the students' understanding of the relevance of science and associated subjects to business, the economy, society and day to day living;
- developing an understanding of the complex interactions between science and society and the ways in which this can influence the impact of science; and
- emphasising the relevance of the knowledge and skills developed through a scientific education to the widest possible range of professions. The view that a scientific training can lead only to employment as a scientist or teacher is dangerously misleading.

3.1 Postgraduate and postdoctoral training

To address the anticipated shortages in supply and the increasing expectations of researchers by employers, including CSIRO, it is suggested that new approaches to postgraduate and postdoctoral training be considered including:

- **an expanded post doctoral program** to encourage early career scientists to spend some time in the PFRAs, particularly in strategic research programs or in national facilities and/or collections.
- **incentives** where critical skill shortages exist – A targeted approach to incentives to increase the intake of students in research areas experiencing skill shortages including the areas listed under section 2.1, "CSIRO's workforce requirement." Incentives could include reduced universities fees and increased access to scholarships.
- **integration with industry** - Integration of industry based experience as part of postgraduate and postdoctoral studies to better prepare students for the complexity of undertaking research in global research community. There is opportunity to integrate much more industry-based experience as part of post-graduate or post-doctoral work. Examples include:
    - For more than 30 years, the UK has linked graduate and post-graduate academic training to the broader experience provided in the workplace (industry, government and PFRAs).
    - Similarly the Cooperative Award in Science and Engineering (CASE) PhD Studentship Scheme, links university and industry investments focusing high quality (precompetitive) research on the particular strategic need of a company. Once again the Scheme provides post-graduates with the opportunity to train to high academic standards while experiencing the demands of outcome orientated research and the team dynamics of the commercial workplace. Post-doctoral fellowships, in particular, could be

offered as joint appointments in business and CSIRO, in the same way that CSIRO and universities can, and do, share appointments. Such appointments may be particularly valuable to SMEs and start-ups who cannot otherwise afford to invest in R&D. It is noteworthy that Singapore is now planning joint science/business initiatives, as part of teaching of innovation, down to primary school level.

- **addressing cultural barriers** - A cultural barrier internal to science is that the training and work ethic of science tends to promote a degree of individualism, despite the increasing proportion of large scale projects that are collaborative operating across traditional research boundaries. The training of scientists should place greater emphasis on the importance of team work, the significance of the contributions made by non-scientists to the overall innovation process and to developing a stronger understanding of the innovation process – including of the risks, costs and constraints that can operate in different parts of the system and the value added at different stages. This requires changes in postgraduate teaching methodology to better prepare students to contribute to research on a large scale and scope, to collaborate effectively and to partner with industry and government.
- **increasing mobility**
    - This could include encouraging mobility of teaching staff between industry, universities and PFRAs through, for example, using existing university sabbatical policies to broaden their experience base. Such exchanges would develop people having broad experience and a deep understanding of the issues faced by different players across the innovation system. It also – and equally importantly - facilitates the transfer of tacit knowledge: "technology travels on two legs."
    - The introduction of targeted schemes of fellowship and/or joint appointments designed to deliberately enhance mobility between universities and PFRAs, e.g. a visiting fellow scheme by which university-based researchers spend periods of residency in PFRAs. (CSIRO would enthusiastically endorse such a scheme and tangibly support it through specific project and overhead support.) A complementary scheme to help fund PFRA researchers to take up short term fellowships in universities would be another possibility
    - A PFRA-university collaborative scheme modelled on the ARC linkage scheme with industry may be considered.

- **common standards across the NIS for student IP-** One of CSIRO's principle objectives is to carry out scientific research for the benefit of Australia and to encourage or facilitate the utilisation of the results of such research. Intellectual property (IP) is one of the tools used to achieve this objective. Intellectual property requires proper management to ensure it is identified, protected and its value realised. There is opportunity for IP management to be streamlined and based on common expectations and understandings particularly among players within the government sector or among those receiving government funding. CSIRO recognises that there are some fundamental issues that are of importance to students (and their university).Common standards across the NIS and where PFRAs and students are involved will facilitate greater mobility between universities, PFRAs and industry which CSIRO considers critical to the

development of researchers who can effectively contribute to large scale multidisciplinary research.

- **scientists in schools-** Lecturers and senior lecturers could be instrumental in increasing the attractiveness of mathematics, science, technology, and engineering to students**. Encouraging participation of young teaching staff** with schools through the "Scientists in Schools Programs" could increase understanding and relevance of science and associated subjects to business, the economy, society and day to day living.

4. Role clarity in the NIS

A healthy NIS that delivers on the national goals needs to have different players each with clear and distinctive roles. Role clarity ensures that a broad range of needs are met without unnecessary duplication or inefficient use of resources. This is particularly important in a small NIS in an increasingly competitive world. The clarification of CSIRO's role in the NIS has enabled CSIRO to develop structures and processes that support its defined roles for optimal efficiency and impact

4.1 Our Act and Funding Agreement

CSIRO's functions in the NIS are laid down clearly under the Science and Industry Research Act of 1949. These are to conduct and apply the results of research for the furtherance of Australia's national and international objectives and, specifically, the economic competitiveness of the Australian industry. Over the 80 years of its existence, CSIRO has built a breadth and depth of capability that is unparalleled not only in Australia but in most other countries. It is uniquely national in both its remit and geographic spread and out of need, has now developed the leadership and management skills required to coordinate large multidisciplinary programs of the type required to deliver to national challenges and opportunities of today.

CSIRO's Quadrennial Funding Agreement explicitly states that we will provide dedicated support for early career researchers and promote career and leadership development and diversity. This includes three specific examples:

- the Science Leaders Scheme (see below)
- An activity under the 2007-11 Strategic Plan to increase collaboration across the NIS by broadening the Postdoctoral Program, attracting early career, high achieving scientists and furthering the development of CSIRO's mid-career scientists (see below)
- A further activity under the 2007-11 Strategic Plan to build excellence of our workforce through proactive recruitment and retention, career and leadership development and diversity (see below).

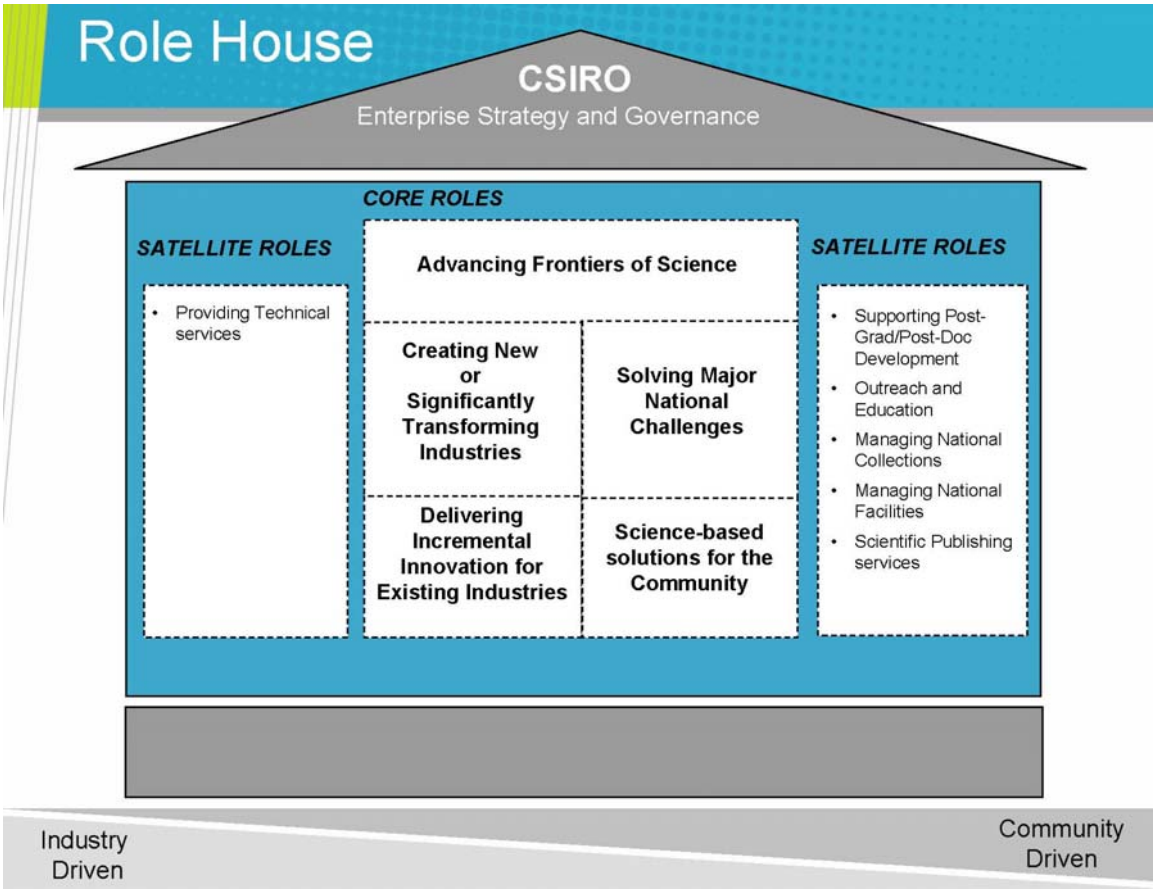
Progress against these initiatives will be reported in our annual Organisational Performance Report.

4.2 CSIRO's Role in the innovation system

CSIRO has defined its place in the innovation system around a set of core and satellite roles, figured below. CSIRO's roles can be represented via a model of a house. Each 'room' (or role) in the house describes the nature of the outcomes of our research efforts. The 'house' illustrates CSIRO's core roles at the centre of the diagram, surrounded by satellite roles. The enabling functions are represented as the 'roof' and the 'floor' of the house, highlighting the support they provide to the other roles. The house also illustrates CSIRO's continuum between industry driven activities (the left side of the house) and community driven activities (right side of the house) for the various roles.

The 'Satellite' or ancillary roles relate to the core science activities that CSIRO performs. While CSIRO performs a number of satellite roles important in delivering value to Australia, a key role from the perspective of the current inquiry is to support post-graduate and post-doctoral development.

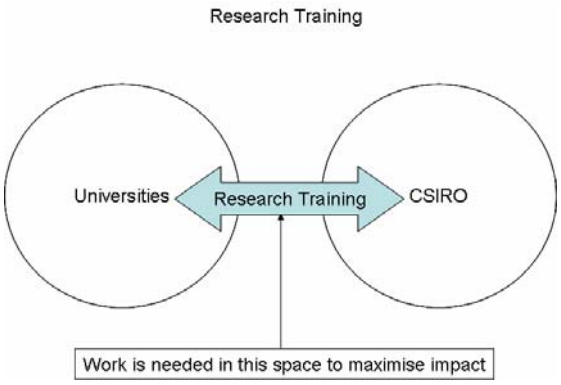
Figure 1. CSIRO Role House



5. CSIRO's contribution to postgraduate training

All players in the NIS are involved in training, either formal, or on-the-job. Universities have a key role in developing talented, well-educated people who are curious and innovative. CSIRO and universities both participate in the training of post-graduate students and post-doctoral fellows. In the case of CSIRO, we can train people with a particular mindset: to be mission-oriented; or to be industry-focused or solutions-based.

We can train people to be part of a team, and to be part of, and ultimately, to lead, large integrated projects. We also develop business-oriented people with expertise in the management of IP and its exploitation for national benefit.



5.1 CSIRO's talent ladder initiative

The development and maintenance of science excellence is critical for CSIRO and Australia. In response to the increasingly competitive labour market for leading-edge researchers CSIRO has implemented a number of programs aimed specifically at maintaining high quality research and scientific capability. The outcomes of these programs have been to:

- Build a pipeline of research leaders by attracting and developing high-quality, early and mid career scientists who have the potential to become leading scientists in CSIRO and other parts of the NIS.
- Develop an integrated "career program" to continue to attract the talented individuals to science careers and to develop this talent to build capability for CSIRO and Australia's broader research sector.

Elements of this program address early, mid and experienced-career researchers:

- Significantly expanded and specialised PhD and postdoctoral programs, providing early career scientists with a mentored and differentiated experience including the development of project management, collaboration, commercialisation and research leadership skills.
- More recognition for early career scientists through the Julius Career awards. This High Achievers Program includes an emphasis on professional development of the scientists, through the funding of 3 to12 months international experience and/or experience in industry and the provisional of additional support for their individual careers.
- More recognition for senior scientists through the Newton Turner awards. This award targets exceptional senior scientists within CSIRO and contributes toward their career development strengthening their already significant scientific achievements.

5.2 Education and outreach

CSIRO facilitates and operates a range of science education initiatives to alert school children, their families and teachers to the contribution of scientific research to our community and to provide broader scientific training and opportunities. For example:

- In collaboration with university colleagues, our staff supervise, co-supervise and/or sponsor over 700 postgraduate research students, including more than 130 supervised in collaboration with CRCs
- Through this sponsorship and supervision of MSc and PhD students, our extensive postdoctoral programs, our distinguished Visiting Scientists program, the CEO's Science Leader scheme and other initiatives we are continuing to build and foster a world-class team of scientists and helping to develop the science leadership Australia needs to meet future challenges
- stories involving CSIRO science are reported in around 12 000 news or feature items every year in print, radio and television and there are approximately 30 000 articles relating to CSIRO on Australian and International web pages each year
- CSIRO media releases posted on Eurekalert (an online, global news service operated by the American Association for the Advancement of Science) are viewed by about 60 000 subscribers each year
- the number of CSIROpod podcast listeners continues to grow rapidly, with now over 400 000 downloads of CSIROpod a year
- CSIRO's nine Science Education Centres engage over 350 000 students, parents and teachers each year, including school visits in metropolitan and regional areas with the 'Lab on Legs' program.
- The Scientists in Schools program which brings working scientist into a paired relationship with working teachers enhancing real science experience and creating excitement in school science programs

6. Conclusions

Australia needs a strong and internationally competitive education system (from pre-school to post-doctoral) that produces the talent that in turn is the life blood of innovation. CSIRO is acutely aware that as part of the national innovation system, PFRAs, universities and industry must work together to create incentives, remove barriers and disadvantages in the education and training of the next generation of innovators. CSIRO's contribution to the training of researchers complements the role of the universities. CSIRO provides early career researchers opportunities to contribute to mission-oriented; industry-focused or solutions-based research. CSIRO develops researchers who can contribute to, or lead large integrated projects. CSIRO supports researchers to develop a business-orientation and expertise in the management of IP and its exploitation for national benefit.

A number of approaches have been outlined and suggestions have been made regarding strategies universities (and others) could employ. These strategies, in our view, will contribute to more effective, and future focused research training and employment.

Once again the key suggestions are:

- **Expanding the post doctoral program to include PFRA experience as a part of post doctoral training,**
- **providing incentives to increase student intake** where critical skill shortages exist
- increasing **integration with industry** including industry based experience as part of postgraduate and postdoctoral;
- **addressing cultural barriers** to ensure recognition of the significance of the contributions made by non-scientists and a stronger understanding of the innovation process
- **increasing mobility** including encouraging the mobility of teaching staff between industry, universities and PFRAs
- Introducing common **standards across the NIS for student IP**
- **Encouraging teaching staff to participate in the Scientists in School Program**

Only through cooperation, can CSIRO and top universities leverage their capacities to attract and retain the brightest and best global research talent. Of critical importance is how we combine to:

- increase our supply of skilled people who fuse traditional R&D skills with an increased focus on delivery and impact
- build knowledge and experience and/or skills development relevant to different parts of the innovation pathway
- remove barriers to mobility between sectors essential to improving the effectiveness of the NIS and attracting the best people
- Increase education and mobility to remove cultural barriers that impede effective collaboration and the achievement of synergy across the NIS.