Overview of the Project

The Royal Australian Chemical Institute (RACI) undertook the following study into the Future of Chemistry as part of its leadership role for the chemistry profession in Australia. It arose from concerns of an emerging disconnect between the strengthening demand for graduate chemists and a decline in their numbers and quality.

The project was carried out under the guidance of a Steering Committee comprising the following members: Dr Graeme L Blackman (Chairman and Managing Director of the Institute of Drug Technology Australia Ltd); Professor Allan Canty (Chair of the National Committee for Chemistry of the Australian Academy of Science, and Head of the School of Chemistry at the University of Tasmania); Ms Deborah Crossing (Executive Director Australian Science Teachers Association until July 2005, currently with Engineers Australia); Mr David Edmonds (PepTech Pty Ltd, Past President of the RACI); Professor John Hill (Pro-Vice Chancellor, Albury-Wodonga campus, La Trobe University); Ms Janine Pickering (Janine Pickering Consulting); Professor Tom Spurling (Dean of the Faculty of Engineering and Industrial Sciences at Swinburne University of Technology); Dr Greg Simpson (President of the RACI, and Deputy Chief, CSIRO Molecular and Health Technologies); and Dr Elizabeth Gibson (Executive Director, RACI, and Chair of the Steering Committee). The Interim Report and Final Report were written by Felicity Jenz, Samantha Carroll and Elizabeth Gibson.

Chemistry supports a broad range of existing industry sectors including pharmaceuticals, automotive, mining, chemicals and plastics, petroleum, energy, food and agriculture. It is also crucial in the development of the new industries of biotechnology and nanotechnology. If Australia wishes to support this vibrant scientific community, then an understanding of the current and future needs of industry is required, in order to best prepare future generations of chemists. The project explored the pathway to a graduate chemist by analysing the areas of primary and secondary school teaching, universities, graduate outcomes, and industry. While the RACI acknowledges the significant contribution that the TAFE sector contributes to the training of chemists, the analysis of this sector was outside the scope of this project. The project also undertook a desktop scan of chemistry internationally, in order to contextualise the state of chemistry within Australia.

Information was collected from numerous sources including:

- 150 interviews
- 2 State Chief Scientists
- 1,196 responses to a student questionnaire
- 20 responses to a university questionnaire by Heads of Chemistry Schools
- Overview of data from 7,552 RACI members
- 14 Industry Associations
- Participation in an OECD Science Workshop
- 140 employers of chemists (representing 4,000 chemists)
- 7 focus groups of university students undertaking chemistry
- Representatives from Federal and State Governments
- Government, Education and Industry reports
- Desk-top scan of Australian and international situation of the chemical industries.

This abridged version of the report provides the reader with an overview of the project, a brief analysis of the areas examined and a summary of the issues. A CD-ROM containing a PDF copy of the complete Final Report can be found in a sleeve on the last page of this publication, and is also available on the RACI website (www.raci.org.au). You will need Adobe Acrobat to view the PDF. Information about this program can be found on www.adobe.com.

Comments or queries about the Future of Chemistry Study should be forwarded to future@raci.org.au.
Within Australian schools, the teaching of science, including chemistry, has two broad aims. One is to create a scientifically literate society and the other is to prepare school students for university level chemistry courses. The definition of scientific literacy cited in this report is as follows: Scientific literacy is a high priority for all citizens. Scientifically literate people are interested in and understand the world around them; engage in the discourses of and about science; are sceptical and questioning of claims made by others about scientific matters; are able to identify questions, investigate and draw evidence-based conclusions; and make informed decisions about the environment and their own health and well-being.1

These aims can only be achieved if our primary and secondary school teachers are inspired and capable of teaching science and our students can see the opportunities a career in science can provide. However, within the current situation there are many challenges for chemistry.

Students are becoming increasingly disengaged from the sciences with four causes relating specifically to chemistry cited in a recent Victorian Government report: the poor public image of chemistry; the perception that chemistry research is not cutting edge; the lack of clear information on career options and remuneration; and the non-engaging or unexciting teaching and/or curriculum in both secondary schools and universities.2 Other research suggests that negative experiences have a significant and in some cases, decisive influence on students’ enrolment deliberations.3

Within primary schools science is often an under-resourced discipline taught by people who are not confident in the area, and find science to be a new language.4 In further work conducted by the Australian Academy of Technological Sciences and Engineering (ATSE) in this area it is suggested that: “by their own assessment, the great majority of primary teachers are ill-prepared to teach the content of the new science and technology curriculum”, and that most primary schools lack the facilities for science and technology that will allow teachers to gain the hands-on experience enabling confident demonstration to a critical audience of pupils.5 The report concludes that one of the best ways to combat this would be to equip primary schools with a Science and Technology Resource Centre or provide access to such centres. These concerns were reiterated in a 2002 report that indicated that the situation had not improved significantly since the 1998 report.6

Other challenges involve personnel. Inspiring teachers open up a world of possibilities to enquiring minds and may have a great impact on the future trajectories of their students. The RACI believes that teachers of chemistry should themselves be trained in the discipline.7 Heads of Science in secondary schools concur with this: the 2005 Australian Council of Deans of Science of Australia (ACDS) study Who’s teaching science? found that 89% of a sample of Heads of Science within schools believed that teachers of science at the senior school level should have at least a major (i.e. at least 3 years of tertiary training) in the area.8 The ACDS study found that more than a quarter of senior school chemistry teachers have two or less years of university training in the discipline, compared with 20% of biology teachers, 43% of physics teachers, and over half of geology teachers.

The study also reported on increasing recruitment difficulties for science teachers experienced by schools. It is believed that these difficulties will be further exacerbated by the aging population of science teachers and the declining uptake of science teaching as a career. The ACDS study found the current modal age of chemistry teachers was 50-54 years and the next 10 years will see many of these teachers move through to retirement. The Australian Science Teachers Association (ASTA) is concerned about the declining uptake of science teaching as a career – including chemistry teaching. ASTA notes that many graduates do not stay in science teaching beyond 5 years, a statement verified by the ACDS report.9 ASTA also believe that graduates are not adequately supported and mentored and that there is no obvious career path for them except into school administration.

There is also concern that the starting salaries for graduate teachers are not scaled to take into account the increased financial burden for graduates with science and education degrees. The potential difference in cost between a graduate teacher with a science degree and those with a humanities degree can be quite substantial – in some cases almost $13,000 more.10 Currently, state salary scales for teachers are based on time in service, not qualifications. Although this is not an issue for teachers who obtained their qualifications before the introduction of HECS in 1989, teachers who obtained their qualifications after this date, are likely to be affected by the difference in student contributions between courses.

Another challenge involves career advice. For example, if teachers themselves are informed about current developments in chemistry then they are better placed to provide students with information about potential career opportunities.

In the short term, a decline in the number of qualified and inspired teachers will lead to a decrease in the general scientific literacy in the community, with the long-term consequences impacting on Australia's scientific capability. This, in turn, will affect the Australian economy and quality of life. With this in mind, the RACI has recommended the following:

**RECOMMENDATION 1:**

That mechanisms are explored for university students undertaking chemistry to receive incentives to undertake teacher training

**RECOMMENDATION 2:**

That recognition is given to science teachers for their additional training by adjusting starting salaries accordingly

**RECOMMENDATION 3:**

That teachers of chemistry are provided with links to industry through placements in industry

**RECOMMENDATION 4:**

That evaluations are undertaken to assess the impact of State and Commonwealth programmes, including careers advice, on improving scientific literacy and increasing number of chemists.
Within the Australian tertiary sector, the number of university students studying chemistry has fallen over the last ten years. Student load data, in the form of equivalent full time student units (EFTSU), measuring the change in enrolments in chemistry courses over the last 15 years reveals a decline in chemistry student numbers from 2.3% of the total student population in 1989 down to 1.7% in 2003.

Within the cohort of science students the numbers of those studying chemistry has also fallen as a percentage of the whole. The number of students undertaking chemical sciences is now less than 20% of all science students. The EFTSU for chemistry has also decreased in whole numbers, in 2003 the EFTSU for chemistry was 6,885 down from a high of 8,633 in 1995. A continued decline in the number of students undertaking chemistry will have an effect on the number of students graduating in chemistry. As chemistry underpins many of the new and emerging sciences, a decline in the number of people exposed to chemistry will also affect the ability of people to participate in these new areas.

The declining number of chemistry students has caused much change in the way that chemistry is delivered in our universities. In Australia, there are 44 self-accrediting higher education institutions, of which 33 have courses accredited by the RACI. Of this latter group only one third now has a discrete Department or School of Chemistry. The remainder deliver chemistry through multidisciplinary faculties comprised of schools of science, engineering, medicine etc.

Heads of Chemistry Departments/Sections throughout Australia were sent a questionnaire as part of this study. The RACI received 20 responses, although not every question was answered by each respondent. The majority of Chemistry Heads (n=13/19) indicated that their chemistry courses had recently undergone significant and in some cases innovative changes in response to a range of internal and external factors. Generally they believed that these changes had been beneficial and would continue. Changes included the introduction of new and diversified subject areas to appeal to students, more service teaching and the introduction of specialist degrees to enable more vocational outcomes.

The opinion of university students of chemistry was gathered through a survey of all university chemistry departments. The questionnaire contained a number of sections, including issues affecting student engagement, future career aspirations and expectations of the workforce. In relation to the non-academic aspects of their studies, 10 per cent or less of the 1,196 responding students stated that lack of future career prospects, outside work commitments, personal issues, or current financial constraints would affect their ability to continue their chemistry studies. A larger proportion (27.6%) of students suggested that they were only studying chemistry because it was required of them. However, some students within the focus groups suggested that although they were required to undertake chemistry at first year level, they really enjoyed it due to the engaging nature of their first year lecturers. With regard to lecturers, 80% of responding student agreed with the statement ‘Having an approachable lecturer is important to me’. This result emphasises the importance of building relationships with students particularly in the early years of their degree, as this may be the time that they make decisions about future areas of study.

If the decline in chemistry student numbers is to be stemmed then students need to understand the career pathways for chemists as well as being supported through their studies by highly qualified staff. They also need access to quality materials, equipment and physical facilities that will allow them to become highly skilled graduates. The state of chemistry laboratories is deemed by some of the respondents as being quite poor, with first year laboratories often being most in need of upgrading. It is not only the state of the laboratories, but also, in some cases lack available funding in order to purchase state of the art equipment, which hampers the ability of universities to train students to the highest possible level.

The current chemistry curriculum also poses its own unique challenges with many industry voices requesting ‘work ready’ students. Achieving a balance between academic and work skills without impinging on the teaching of core skills in chemistry is no easy task, but one which many universities are working towards. The RACI accredits university chemistry courses to ensure that students are appropriately trained in chemistry. Considering the breadth of chemistry courses available to undergraduate students it is important that the accreditation process continues.

Within many departments, there has also been a concerted effort to create strong links to industry in order to promote careers for students, as well as create an atmosphere in which industry and universities can conduct collaborative research. Industry links were in place in 70% of respondent universities including formal and informal programmes, performed both on and off campus and as internal or external activities. Responding Heads deemed the programmes for undergraduate students to be highly beneficial, indicating that such programmes often inspired students to continue with the study of chemistry. Two-thirds of the responding universities also had programmes in place to link postgraduate students with industry. As with the undergraduate links, these programmes were deemed to be very beneficial to the students.

There are several implications for the reduction in the number of students studying chemistry, the most obvious of which is a decline in the number of chemistry graduates available to work within the Australian chemical and related industries, which in turn will have costly consequences for the industry. The scientific and R&D capacity of Australia will also be severely compromised if the numbers of chemistry graduates, and specifically PhD graduates is reduced. As many chemistry graduates are desired by employers for their strong analytical skills, a continued decrease in students studying chemistry will impact on many other sectors, as well as stifling the scientific literacy levels of Australia. In order to ensure that chemistry remains a vibrant science at university level, the RACI recommends the following:

**RECOMMENDATION 5:**

That there is access to quality materials, equipment and physical facilities for students and university staff.

**RECOMMENDATION 6:**

That every second year there is an accreditation of university chemistry courses with a focus on international best practice

**RECOMMENDATION 7:**

That more formal linkages are created between universities and industry

**RECOMMENDATION 8:**

That students undertaking chemistry have access to adequate information pertaining to potential careers in chemistry.

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Employment Opportunities for Chemists

The future cohort of chemists is currently being trained in Australian universities. In order to understand what issues face them, including their expectations of their future work environment, the RACI conducted a survey of university students undertaking chemistry studies over different year levels. A total of 1,196 students from 15 universities covering all states and territories replied to the survey.

Within this cohort, a large proportion of students do not have an adequate understanding of what a career in chemistry entails. Only a third of students agreed with the statement ‘I know what a job in chemistry entails’ and only a third of students agreed with the statement ‘I can see myself working as a chemist’. The lack of understanding as to the role of chemists indicates that students are not obtaining adequate advice from career advisers or other avenues. When asked to select what area they would like to work in, the two most common responses were organic (20.1%) and analytical chemistry (19.3%). A number of students indicated that they wished to work in the emerging sciences, such as biotechnology (16.5%) and nanotechnology (11.0%), with over a third of students indicating that they understood what these areas were. There is obviously some work to be done in the area of educating the future generation of chemists as to what work is available in the industry.

It is reassuring to know that only a very small proportion of respondents (13.3%) suggested that they were deterred from a career in chemistry due to low earning potential. In relation to graduate starting salaries, information from the Graduate Careers Council of Australia (GCCA) indicates that the median salaries for graduate chemists have mirrored the growth of all graduates, with a slight downturn from 2003-04.

It is difficult to obtain accurate numbers of vacancies of chemists for a number of reasons including: companies do not advertise all of their vacancies but often seek candidates through informal networks and their existing agency databases; Australian Bureau of Statistics collects information at the high-level industry areas by sampling organization about their vacancies which may over or under represent vacancies for chemists; advertisements are placed in publications, media and agencies either exclusively or non exclusively and therefore may not be counted or conversely counted a number of times; and positions that require chemists may be calling for a different skill and appear more than once, fall outside the search parameters, or be labeled something else. The Final Report includes information collected from human resource professionals, recruitment agencies and analysis of advertisements. The Study reveals that there is not one shared view of the opportunities for chemists rather each employment opportunity yields a different experience, some more positive than others. In terms of chemistry graduates, they are being employed at almost the same levels as all other graduates, and are also being paid equivalent salaries. This indicates a match between supply and demand. For chemists with some experience, however, recruitment agencies have suggested that chemists are being turned away from the profession due to a lack of opportunities.

Australian Industry

The chemical industry in Australia adds significantly to the Australian economy, is a feeder to many different manufacturing areas and is very diverse in composition. Using criteria of outputs, level of innovation and research intensities the following segmentation has been developed:

1. Companies engaged in the production of bulk chemicals, eg petrochemicals, that typically have low innovation expenditures and research and development intensities
2. Companies manufacturing special-purpose chemicals, eg paints, that typically have more low-to-medium innovation expenditures and research and development intensities
3. Companies that operate in technology-intensive segments including the pharmaceutical, biotechnology and nanotechnology companies.

Each of the segments is subject to significant change and adjustment in response to an increasingly competitive global marketplace. The Traditional Chemical Industry, Pharmaceutical Industry and the emerging areas of Nanotechnology and Biotechnology have been examined in detail in the Final Report. Challenges that the industry faces include: a small domestic market; no world-scale plants; supplies of major feedstocks being remotely located; Australia being geographically removed from major markets; tariff protection levels that are still high in many countries and a widening chemical deficit (exports less imports). Despite this situation the chemical industry remains optimistic that there are opportunities for Australia across each of the sectors and that these will be best captured by moving towards a ‘knowledge’ economy centred on innovation, research and development.

For the traditional industry that covers the first two categories above this includes successfully leveraging the capacity and knowledge of the public research base in order to provide a source of innovation to the industry, niche manufacturing of high-value chemicals and attracting research and development activities of multinational organisations to Australia through being connected to the brightest parts of the ‘open innovation models’. A number of people interviewed for this report suggested that opportunities for the chemical industry exist through linkages across scientific boundaries, for example through teams of multidisciplinary scientists that include material scientists, chemists and biologists.

The pharmaceutical industry has embraced an agenda for action that requires significant investment in research and development, particularly biotechnology, to enable Australia to become world class in a global value chain and double Australia’s share of the global industry by 2012. Strategies include positioning Australia as a global pharmaceutical hub for research, development and commercialisation and as a global exporter of both products and services for the industry.

Australia has approximately 400 biotechnology companies employing around 6,000 people, with total revenues of around $2.1 billion in 2004. These companies have high research intensity with an estimated $414 million spent on biotechnology research in 2004, including organic chemistry and biochemistry activities. It has been suggested that while the outlook for the industry holds promise there are some gaps in performance and an ongoing dependency on government support. Gaps include access to preclinical and clinical development and number of people that are skilled in the art of preclinical testing products through preclinical and clinical pathways.

The chemical industry in Australia, however, is suffering because of the high level of fragmentation. Each of the segments looks to develop strategy and policy for their own area only instead of a more comprehensive

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12 Data from the Graduate Careers Council of Australia, 1983-2004

In 2002, the European Union determined that in order for it to be competitive and ensure long term innovation, growth and employment potential, the average research and development investment level needed to increase to 3% of gross domestic product (research intensity) by 2010 from a base in 2002 of 1.9%. Further, the 3% target should comprise two-thirds private sector expenditure with the reminder from the public sector. They further postulated that if this target is to be reached, then by 2010 there will be a need for 700,000 new researchers. The benefits of reaching this target would include a further 400,000 new jobs per annum as well as an estimated 0.5% of supplementary output.

The US is also following a path of strong research and development. Reporting on the Science and Engineering Indicators 2004 the National Science Board suggested that: ‘US strength in science and technology reflects many decades of government support for the conduct of research and development, the development and maintenance of the necessary infrastructure and the education and training of scientists and engineers’. Currently the US leads the world in research and development expenditure with approximately two-thirds of the total $276 billion expended by the private sector ‘as an engine for continuing competitive strength and profit growth’.

Currently, Australia does not have targets for research intensity, with recent performance of 1.62%, comprised of 0.79% private sector and 0.83% non-business research. If Australia decided to adopt the 3% target there would need to be a significant increase in the science and engineering workforce as discussed in the Summary of Issues.

There are a number of countries within the OECD reflecting a downturn in the number of students wishing to study chemistry and a looming teacher shortage. The downturn in interest in studying science cannot match the global demand for scientific advances and technological innovations. The OECD has predicted a long-term demand for tertiary level science and technology graduates and science and technology workers in many OECD countries, especially since many of the current workers in these fields are retiring. There are, however, some countries that are experiencing a renewed support for chemistry, particularly Germany, where they are experiencing rising student numbers and increasing public support for their chemical industry. Global trends may have an effect on the Australian chemical industry, indeed some people in industry have already expressed the need to import chemists from overseas countries to fill current gaps. If the dearth of chemists is not just a problem that Australia has to face, rather an international phenomenon, then Australian industry will need to find ways in which they can compete for chemists on an international level. As the international picture of chemistry is constantly changing and as some countries already have experienced a downturn and have found ways in which to tackle this problem, the RACI recommends that:

RECOMMENDATION 13:
Australia needs to ensure that it is appropriately involved in international initiatives in chemistry.

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Australian Industry

- Approach that could make a solid contribution to industry, science, education and economic policy development.
- Fragmentation also has an impact on the profile of the science. Many people in industry are concerned that chemistry has a poor public profile, which deters students from engaging in the science. This image may be overcome through a coordinated approach to promote careers within chemistry to school level students. This in turn will ensure a flow through of students to university levels. Universities also need to be more involved with industry, with linkages that pave the way for students and new graduates to gain experience in industry of particular benefit.
- Overall, a further downturn in the supply of chemists to emerging and established industry sectors could jeopardise development and success of the overall chemical industry, the implications of which will be difficult for Australia to overcome quickly. In order to ensure that the future of the chemical industry continues to be an intrinsic and valued part of the Australian economy the RACI recommends the following:

RECOMMENDATION 9:
To bring together representatives of the chemical industry including traditional, pharmaceutical, nanotechnology and biotechnology to determine policy priorities for the discipline of chemistry.

RECOMMENDATION 10:
To provide a supportive environment to encourage more linkages between industry and universities.

RECOMMENDATION 11:
To provide ongoing opportunities for professional development of chemists to allow more mobility between areas of chemistry.

RECOMMENDATION 12:
Seek alternative mechanisms for fostering R&D intensity in Australia.

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International Perspective
Summary of Issues

Ensuring we have a high quality stream of graduate and postgraduate chemists in adequate numbers to meet the needs of industry and society is an issue of national economic importance. Chemists are required to support a large and important part of Australian manufacturing industry, to support future chemistry-based industries, and to generate the innovation that Australian industry will need to succeed in a world of increasing global competition.

Companies in the chemicals and plastics industry, and the related pharmaceuticals industry, recorded an estimated 1,000,000 people, accounting for about 10% of total manufacturing employment, with about 3,000 enterprises operating across the full range of industry. It is also an important source of inputs, and innovation, to other sectors such as mining and mineral processing, the automotive industry, agribusiness, medical and bioprocess industries.

Moreover, it is an industry that needs well trained people as it goes through a period of change. While mainstream activities will remain important, we are witnessing the transformation of the industry worldwide, as we move to a molecular-based understanding of materials, biology and the environment. This will provide new opportunities for less asset-based, more knowledge based activities, for new companies and start-ups able to find new ‘intermediation’ roles in global supply chains, or to operate in global markets, and for companies to capture the opportunities of emerging technology areas such as biotechnology and nanotechnology that are projected to change the chemical industry’s products and processes in the future.

Finally, a steady stream of well trained researchers will be needed to generate the innovation required for Australian industries to survive global competition. The recently announced research priorities for Australia—underlining the importance of chemistry trained researchers. They are fundamental to a large number of the activities to deliver these priorities in areas as diverse as development of advanced materials or health promoting products, extraction of mineral commodities, understanding and minimising environmental impacts, and rapid threat identification techniques. Despite a number of strengths in chemical research there is a lot to be done. We will need a strong and well-connected public research base (ie publicly funded research institutions), but also entrepreneurs and companies with the agility and foresight to capture the opportunities that arise, and government policies that provide a supportive environment.

Consequently, we need to make sure we target resources and effort for chemistry education at secondary, university, and post university level to promote a scientifically literate, skilled and flexible workforce. This has implications for the teaching of chemistry and other science subjects at secondary schools, for graduate and postgraduate education at universities, and for professional development training. It may require additional government funding in some cases; in others it may be a matter of rethinking existing programmes, or for a new role for bodies such as industry associations or professional institutions such as the RACI.

There is a risk at the secondary school level that scientific literacy skills which are so important to a modern society will decrease if the number of students undertaking chemistry and other enabling sciences declines, or if the quality of chemistry teaching goes down. We face pressing issues related to the ageing of the present stock of qualified chemistry teachers, evidence of decreasing numbers of students pursuing chemistry at year 11 and 12, as well as perception issues related to chemistry and other physical sciences as potential career paths.

Finally, a steady stream of well trained researchers will be needed to generate the innovation required for Australian industries to survive global competition. The recently announced research priorities for Australia—including an environmentally sustainable Australia; promoting and maintaining good health; frontier technologies for building and transforming Australian industries; and, safeguarding Australia—underline the importance of chemistry trained researchers. They are fundamental to a large number of the activities to deliver these priorities in areas as diverse as development of advanced materials or health promoting products, extraction of mineral commodities, understanding and minimising environmental impacts, and rapid threat identification techniques. Despite a number of strengths in chemical research there is a lot to be done. We will need a strong and well-connected public research base (ie publicly funded research institutions), but also entrepreneurs and companies with the agility and foresight to capture the opportunities that arise, and government policies that provide a supportive environment.

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For university teaching the main challenge is not just excellence in particular sub-disciplines, but also to ensure that chemistry graduates have both core chemistry skills and the flexibility to move into related areas. This is likely to be increasingly important as the workforce becomes more mobile, and with the growing presence in the chemical industry of small and medium sized employers rather than a limited number of large companies with specialist needs. A basic requirement is that students have access to high quality laboratory facilities and relevant infrastructure which can be costly to maintain. On the other hand, there are also opportunities, which a number of universities are acting on, to offer students the chance to learn about issues, such as commercialisation and management of intellectual property, to prepare them for their later careers.

Finally, post-university professional development courses, which could be run in conjunction with industry associations are a way of broadening the professional skills of chemists and widening their career options as well as facilitating their uptake by industry. With the diminishing importance of large chemical firms the scope for in-house on-the-job training has also been reduced. Programs to develop work related skills, for example technology transfer or specific areas of technology management, are a means of addressing this gap. These should be tailored to respond to the demands of chemical related industries and developed in consultation with them.

The supply and demand for professional chemists needs to be kept under continuing review to guard against potentially costly skills shortages. While the evidence gathered in this survey does not indicate an acute or widespread shortage of graduate and postgraduate chemists there are, nonetheless, warning signs in some areas of growing skills gaps and shortages. One such area of concern is the future supply of qualified secondary school chemistry teachers. Within industry areas such as polymer engineers, and analytical and synthetic chemists have been highlighted as potential areas of concern. The key to a timely response to these potential shortages is early awareness, and processes which provide signals to educational institutions. In some cases, enabling people to move from adjacent professional areas may stem potential shortages. In addition, the core skills and flexibility at the tertiary level mentioned above, are also a way of reducing the long term impact.

At a broader industry level, the impact of new technologies such as nanotechnology and biotechnology need to be closely monitored. While the traditional chemical industry looks forward to modest, but steady growth, there is the potential for rapid growth of activity from a small and non-traditional industry base, with demand outrunning supply and a consequent loss of foregone employment and production. One pertinent example is nanotechnology and the projection by the Victorian Department of Innovation, Industry and Regional Development (2003) that 12,000 additional skilled graduates and workers in micro and nano-enabling disciplines – chemistry, physics, mathematics, materials sciences, molecular biology and engineering - would be required over the 7 years to 2010 to sustain a new billion dollar industry. This compares with an estimated 30,000 employees currently employed in the chemicals and plastics industry in Victoria and would place heavy demands on the output of graduates in chemistry and allied disciplines. It is still early days in the field of nanotechnology but the analysis is indicative of the kind of situation that could arise.

Australian R&D expenditure currently runs at around 1.5% of GDP, and employs about 65,000 people. Assuming 30% of these operate in chemistry fields a 10% increase would require 1,950 extra research scientists and technicians, graduates and post graduates. A 100% increase to 3.0% would require an estimated 19,500 graduates and postgraduates in chemistry fields.

The situation warrants continuing government review, and consultation with people in new and existing chemical industries. If not, there is a serious risk that in rationalising our affairs, for example in closure and amalgamation of university chemistry departments, we may be closing off options for growth in new areas, with serious economic consequences in terms of foregone production, profits and employment.

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22 References: ABS 8221.0, ABS data service, Applies to ANZSIC 253, 254, 255 and 256 (ie includes 2453 pharmaceutical and medicinal products)  Cited in

23 Summary of Issues

DIVISIONS
The RACI has Divisions in the following chemistry areas:
- Analytical Chemistry
- Biomolecular Chemistry
- Cereal Chemistry
- Colloid and Surface Science
- Electrochemistry
- Environment
- Industrial Chemistry
- Inorganic Chemistry
- Organic Chemistry
- Physical Chemistry
- Polymer Chemistry
- Solid State Chemistry Division

The Divisions arrange national symposia in their own fields of interest between National Conventions. Detailed information on each of the Divisions is available on the RACI web site under the Divisions menu.

AWARDS
The RACI recognizes achievement in chemistry through a range of initiatives. Further information can be viewed on the RACI web site through the Awards menu.

AUSTRALIAN NATIONAL CHEMISTRY QUIZ
The Australian National Quiz is a key program for the RACI. The Quiz is an annual event that involves more than 100,000 students from 1,300 schools in Australia and neighbouring countries. Further information can be viewed on the RACI web site through the Events menu.

CHEMISTRY IN AUSTRALIA
Chemistry in Australia is the journal produced by the RACI for members. It contains information on the RACI, scientific development in chemistry, people working within chemistry, news, events, conferences, links to other areas and policy. More information is available on the RACI web site under the Chemistry in Australia menu.

INTERNATIONAL NETWORK
The RACI provides access into the international world of chemistry through participation in many different groups. The RACI was instrumental in forming the Federation of Asian Chemical Societies (FACS), an organization committed to the promotion of chemistry in the Asia-Pacific region. The RACI also has links into the American Chemical Society and the Royal Society of Chemistry UK.