

CHEMISTRY

Chemistry plays an absolutely vital role in the development, sustainability, and advancement of national and international economics, as it underpins every aspect of the material consumer world. It is concerned with understanding matter in all its forms, the composition and function of all living organisms and the laws of nature and the universe. Chemistry is a 'core' or 'central' science which underpins and complements many other sciences and major areas of technology, indeed most industries make use of chemicals and the products of the chemical industry. The international chemical industry is vast and highly innovative and provides the materials upon which our society is based. For example, the technique of combinatorial chemistry allows chemists to make large numbers of chemical compounds simultaneously. This technique allows thousands of compounds to be produced each year and is an integral part of drug and materials discovery. It has been used in the process of sequencing human genes. Chemistry is also fundamental to the development of new materials and products that shape our society and lifestyle, e.g. cell phones, high density data storage devices, high definition screens and displays, fibre reinforced composites, superconductors, protective clothing, electronic devices etc.

Chemistry is also concerned with the measurement and monitoring of chemicals. This may be measuring the purity of products leaving the factory or it may involve monitoring minute concentrations of substances in the environment. A large number of chemists are employed in measurement, monitoring and analysis and helping to ensure that the products which we use or consume, and the environment in which we live, are pleasant, healthy, and safe.

WHY STUDY CHEMISTRY?

The study of chemistry can lead to many careers. For science-based careers, you will need to apply and develop detailed chemical knowledge. However your scientific training will also provide you with the transferable skills, abilities, and knowledge required in a wide range of careers in commerce and industry. So although many chemists will obtain jobs in research and development, analytical chemistry, environmental research and monitoring, education and scientific management, others will make careers in information technology, government and business management.

WHAT SKILLS DOES THE STUDY OF CHEMISTRY DEVELOP?

The study of chemistry at university level has a strong practical emphasis. As well as laboratory skills it also develops theoretical knowledge, numeracy, the ability to analyse complex problems, rationality and practicality, as

well as an appreciation of the power, applications and potential of modern technology. Chemists are encouraged to be team players, develop good communication skills, and bring a logical, enquiring, and ethical approach to their work.

Analysis and Problem Solving

Problems in chemistry can be complex and their resolution requires a careful, disciplined approach. Generally, chemists seek to conceptualise problems in numerical terms, working on them theoretically before attempting to put theory into practice. Students in chemistry gain high levels of abstract reasoning, accuracy and patience.

Technological and Intellectual Competence

In addition to technical knowledge, chemistry graduates will have the capacity to readily adapt to and make use of emerging technologies, for example, nanotechnology. The process of learning a discipline like chemistry develops an intellectual 'toolkit' that can be transferred to more advanced study, other areas of study, or the acquisition of new knowledge for a range of work areas.

Topical coverage of career related issues brought to you by Victoria University Career Development and Employment.

Areas covered include how degrees and courses relate to employment opportunities, to life/work planning, graduate destination information and current issues or material relevant to the employment scene. Your comments and suggestions always welcomed.

Graduates can contribute their skills to exciting new areas of research and development and have the flexibility to adapt to rapid change in their respective fields.

Observation and Communication

Chemistry graduates have learned to pay attention to detail, observe closely and understand the effects of chemical processes. During practical laboratory sessions students learn how to explain what they intend to do in an experiment, interpret what they observe, then communicate results verbally and in writing. Complex ideas and procedures need to be conveyed in a clear and understandable fashion. All employers value people who can express complicated or detailed information in a straightforward and accurate way. Communication skills are at the top of almost every employer's 'must have' list.

Research

Chemistry graduates have been taught to retrieve information from a wide range of sources, using a variety of tools inside and outside the laboratory, including reading textbooks and current research journals, attending lectures or seminars, accessing computer data bases, and later on, attending conferences. Knowing how to find things out can be the basis of initiative and innovation in the workplace.

Numeracy

Chemists are able to translate physical problems into numerical ones in order to analyse and solve them. While needing to have a good grasp of basic mathematics, chemistry students also learn to apply their findings to real materials in experiments. The ability to think numerically, and shift from abstract numbers to concrete examples, is essential in the sciences and also has many commercial and industrial applications.

Computing

The use of computers in chemistry, particularly for students at post-graduate level, is increasing. Some chemistry students also study computing or information systems. Many discover that because they are logical yet creative problem solvers, they develop good programming skills. Computing and information technology skills are highly transferable as they are central to almost every service and industry in the modern world.

Other Attributes

On an individual level, the study of chemistry enhances

thinking skills, rationality, persistence, goal setting and time management skills. Co-operation and teamwork are also important, however, as group projects increasingly become part of the teaching programme. Chemists are also encouraged to be enquiring, ethical people, interested in the wider economic, business, environmental or social issues relating to their field.

WHERE DO CHEMISTRY GRADUATES WORK?

Crown Research Institutes (CRIs)

In New Zealand most researchers go into applied science areas taking up positions in various research organisations, including Crown Research Institutes. As the pivotal science, chemistry links with most aspects of scientific research in one way or another. Although the focus of some of the CRIs may not be specifically 'chemical', chemists are often important members of the multi-disciplinary research teams.

Industrial Research Ltd is the largest provider of industrial scientific research and development services in New Zealand, with an emphasis on the manufacturing and natural products processing sectors. IRL also acts as an 'incubator' for spin-off companies. *B Dent Global* is a rising small company that competes successfully internationally by supplying high value specialist chemicals, for example, isotopically labeled compounds for drug testing. On a different level is *IRL Biopharm*, a company which specialises in the synthesis of pharmaceutical compounds for international clients.

The Institute of Geological and Nuclear Sciences Ltd employs chemists in a variety of areas such as geochemistry, petroleum exploration and analytical chemistry. Specific areas of activity for IGNS include environmental planning and management, development of energy, mineral and ground water resources, manufacturing and processing, and radiocarbon dating and other innovative isotope applications.

The National Institute of Water and Atmospheric Research is involved in precise monitoring of the atmosphere, oceans, lakes and rivers and provides advice to government and a range of other clients. Chemists are employed alongside other scientists in work aimed at improving the quality of our lives and the prosperity of the country.

Scion (formerly Forest Research) is involved in all aspects of research relating to forestry and the applications of wood and wood products. This includes research to enhance the key chemical and physical properties of wood using chemical processing technology which is also environmentally friendly. The economic utilisation of by-products such as bark is another important area of research. It is developing a strong focus on new biomaterials. Many of the research projects require multi-disciplinary teams of scientists in which the chemist plays a pivotal role.

Horticultural and Food Research Institute of New Zealand and the *New Zealand Institute of Crop and Food Research Ltd* are basically bio-focused companies. However, many of the development projects which these CRIs tackle require the expertise of a range of scientists from various disciplines including chemistry and biochemistry. HortResearch focuses on five interrelated areas; fruit crops, food (including natural products, nutraceuticals, and functional foods), gene technologies, bioengineering, and sustainable horticultural production and land use. Crop and Food focuses on the production and processing of most agri-food crops; vegetables, cereals, pulses, forages, ornamentals, essential oils, as well as seafoods etc.

The Institute of Environmental Science and Research (ESR) is the largest employer of chemists involved in the general area of chemical analysis and includes forensic science. *Forensic scientists* examine and analyse physical evidence that doesn't have a biological origin, such as paint chips; examine biological evidence usually by DNA profiling; identify illicit and prescription drugs in connection with crimes; analyse body tissues and organs for traces of drugs and other toxic substances, including the analysis of blood and breath for alcohol; and may visit crime scenes to collect evidence. They may also present 'expert witness' testimony to the courts. *Forensic technicians* provide technical assistance to the scientists. For both roles the minimum qualification is a BSc (Hons) in chemistry, biochemistry or molecular biology.

In addition there are several research organisations which serve specific industries. These include; *Building Research Association of New Zealand (BRANZ)*, *Canesis* (wool research, formerly WRONZ), the *Coal Research Institute*, and *Manaaki Whenua - Landcare Research New*

Zealand Ltd. These are largely funded by the industries they serve and employ chemists in research and development, and analytical roles.

Industry

Large industrial and manufacturing enterprises employ chemists in various roles, from the research and development of new products and processes, laboratory quality control, to sales and marketing, through to the highest levels of management. Companies such as *Comalco*, *Carter Holt Harvey*, *Fletcher Challenge* and many others employ chemistry graduates. Entry level jobs for new graduates will include analytical chemistry/quality control, research and development, environmental monitoring, technical writing, process management and general management. Occasionally opportunities arise for work in specialist libraries.

Fonterra is a multinational dairy company which exports to 140 countries. It is not only the world's largest exporter of dairy products (95% of its production), its ingredients business is the largest dairy ingredient operation in the world. Chemists are part of multi-disciplinary teams which research the structural and functional properties of dairy based foods and their ingredients, with a particular focus on their commercial applications. Fonterra has a range of opportunities for graduates, including the Fonterra Graduate Technical Programme for those with scientific degrees, and the Fonterra Summer Student Programme. In addition, work experience opportunities often arise within the organisation. Check with your careers office for details of all these.

Wine and Oil Industries. The wine industry is a multimillion dollar export industry for NZ. Wine production is a delicate chemical art, demanding constant monitoring of enzymatic processes in order to produce recognisable taste qualities according to grape variety and region. HortResearch has embarked on a six-year project to determine the 'flavour specificities' of New Zealand Sauvignon Blanc. Wineries require laboratory technicians, and opportunities exist for progression to winemaker. Qualifications in Viticulture and Oenology are also desirable. Commercial cultivation of both olives and avocados has resulted in a viable oil industry for both these fruits, which extends beyond their table use. The lipid content of olives and avocados is similar and

both have applications for the food processing industry, the manufacture of hair and skin treatments and, possibly, medical uses. All these developments depend on rigorous chemical analysis, and an ongoing supply of skilled chemists.

Manufacturing Industry. Many manufacturing companies, such as *Resene Paints*, maintain laboratory facilities and employ chemistry graduates for quality assurance and product development roles. *BOC Gases* offer a Graduate Management Development Programme for those with good work experience and science/technical qualifications. *Unilever* recruit through university Graduate Recruitment Programmes for management trainee roles, as well as employing chemistry graduates at their laboratory in Petone.

Industry and the larger scientific organisations often demand employees who are qualified in management, as well as a scientific or technical area. If you are interested in positions of this type you may wish to consider the conjoint Bachelor of Science/Bachelor of Commerce and Administration degree (BSc/BCA) or the postgraduate Master of Management Studies (MMS).

Education

The key to New Zealand's economic prosperity is a well educated and innovative work force. A prerequisite for this is an education system staffed with motivated teachers who are themselves appropriately trained. In the future, education for many will involve more than the traditional school plus tertiary study. The pace of change in modern industry and commerce suggests that there will be an increasing demand for re-training and up-dating programmes to help maintain flexibility in the workforce. Learning will become life-long rather than episodic for many of us. This will create employment opportunities for educators and trainers, not only in schools, colleges, polytechnics and universities but also in private training organisations. As a key science, chemistry will be a major discipline within the education system of the future and there will always be good career opportunities for qualified teachers of chemistry. The qualifications required to teach chemistry will depend on the sector of education worked in. For secondary education a bachelors or honours degree together with a teaching qualification is usually required. Alternatively a conjoint Bachelor of Teaching/Bachelor of

Science (BTeach/BSc) is an efficient and versatile route into teaching. To teach chemistry in a university or polytechnic a PhD is standard with research experience necessary to secure a permanent position.

Government

Government requires expert advice to draft policy and provide ministers and parliament with timely and accurate information. Government departments such as the *Ministry of Research, Science and Technology* recruit science graduates, including chemists. There are also government funded organisations such as the *Foundation for Research, Science and Technology* and *Technology New Zealand* which run government research programmes and are managed by expert teams which include science graduates.

Patents, Law

Patent work involves assisting clients to secure effective legal protection for their innovations and developments, and advising on intellectual property rights. Intellectual property includes patents, designs, trade marks and copyright. Because inventions often involve an understanding of mechanical, electrical and optical devices as well as chemical compounds and formulations, a science qualification particularly in chemistry or physics is a valuable asset. You can often enter patent examining work with an undergraduate science degree. The *Intellectual Property Office* employs chemistry graduates as patent examiners. To become a patent attorney, a combined science and law degree (BSc/LLB) would be the ideal combination. There is a healthy demand for people skilled in patent work and the interface between technology and law is a fascinating one.

GRADUATE PROFILES

Joanna Wojnar

Worked as Scientific Advisor, Hazardous Substances, ERMA.

Currently studying for PhD in Chemistry



I am often asked why I decided to study chemistry. Well, actually, when I started university I decided to study biology, as this was the subject I liked best in school. Very quickly however, I realised that chemistry somehow made more sense for me. The ideas presented in lectures tended to click into place, and I enjoyed the fact that fundamental concepts could be used to explain even very complex reactions. I was hooked, and continued with chemistry all the way to an Honours degree.

After Honours I was lucky enough to get a job with Plastics New Zealand, a national industry group representing over 75% of the New Zealand plastics industry. They needed a chemistry graduate to work with the Environmental Risk Management Authority (ERMA) in Wellington to ensure their imported raw materials were compliant under the (then still new) Hazardous Substances and New Organisms (HSNO) Act (1996). I was given the lofty title of “Scientific Advisor, Hazardous Substances” and thrown in the deep end. Although apprehensive at first, I quickly found that my degree had prepared me well for this challenge. Obviously, I made good use of chemistry knowledge, as I was able to group chemicals the plastics industry used into broad categories based on their chemical properties. I had to use my research skills, delving for hazard information; my analytical skills, analysing hazard data for the chemicals; my writing skills, composing reports and applications. Even the dreaded oral talks we were made to do in Honours were a good practice for the presentations I had to give to the plastics manufacturers.

I enjoyed my time with PNZ and ERMA, and I also learned many new things. I had the opportunity to visit several plastics manufacturers both in Auckland and Wellington, and got to see first hand how our taken for granted milk bottles are made! I learned much about the

HSNO Act itself, how a government agency operates and what challenges it faces, often being caught between the letter of the law and environmental lobbying groups.

When my contract with PNZ expired, I realised that while I enjoyed applying my chemistry knowledge in a practical way, I missed the hands-on experimental lab work. I have therefore returned to Victoria University to do my PhD in chemistry, and am now in my second year. After my doctorate, I hope to pursue a research career either in New Zealand or overseas.

Katherine Herd

Laboratory Technician

Lion Nathan



Towards the end of school I decided that I really wanted to pursue a career in Architecture but between school and university I took a year off to save a bit of money and started to go off the idea. Knowing that I definitely wanted to go to university I still couldn't decide what to study. Eventually I realised that I would get the most out of studying something that I found interesting and had enjoyed at school. So Chemistry it was.

I found chemistry to be a very challenging and rewarding subject. The lecturers and tutors are committed to ensuring that students reach their full potential and are always willing to help. Chemistry is a very diverse subject, and the skills that I gained from my study at Victoria are just as diverse – from chemical analysis and synthesis techniques to effective literature research and professional report writing.

Towards the end of my third year I started to explore employment options and stumbled across a summer job with Fonterra. The Technology for Industry Fellowship is a programme funded by The Foundation for Research, Science & Technology on behalf of the Government. It is an excellent opportunity for industry to gain from students' fresh ideas and also for students to gain much needed experience.

For four months I worked on a project at a cheese factory in Marlborough aiming to find the source of a microbiological contamination problem and methods to control it. At the end I was required to present my findings and recommendations to the industry. I thoroughly enjoyed this experience, it was an excellent introduction into the workforce and I have no doubt it helped me land my current job.

I now work in a quality control laboratory at the Canterbury Brewery in Christchurch. The brewing industry is not something that even entered my mind when I was studying chemistry even though brewing is very much based on chemical principles. And study doesn't end when you leave university – I found myself striving for knowledge in this very exciting industry and Lion Nathan, being a company that encourages individuals to strive for personal and career progress, has helped me study to gain internationally recognised qualifications in Brewing and Packaging.

Chemistry is a subject that has certainly led me on a path that I would have never foreseen and I believe that the key to my success so far was finding something that I found interesting and fun and simply sticking with it!

Rob Keyzers

Post-doctoral Research Fellow, Rhodes University, South Africa

Marine Natural Products Chemist



I am currently working as a post-doctoral research fellow (PDF) at Rhodes University, in South Africa. I initially started studying chemistry at Victoria with the aim of using my degree as an entry into the Masters of Forensic Science at Auckland University. While I was studying chemistry at Vic, however, I discovered that the job market for forensic scientists in New Zealand was rather limited. At this stage, I was enrolled as an honours student in Chemistry and my project supervisor suggested that I consider carrying on with a PhD. I took his advice and completed my PhD in 2003. The decision to

complete a PhD at Vic was the best decision I have ever made as it has given me many wonderful opportunities that I would never have dreamed of before.

I work as a Marine Natural Products Chemist. Simply put, we attempt to find new compounds from marine invertebrates (e.g. sponges, seaweed, ascidians etc) that may prove useful to the pharmaceutical industry to treat human illness. During the course of my PhD, I identified eight new compounds, five of which possess anti-inflammatory properties. Since I completed my PhD, I have been working at Rhodes University where we are trying to find new compounds to help treat oesophageal cancer, as this is the predominant form of cancer in poor rural communities of sub-Saharan Africa. So far, I have isolated four new compounds that are potentially toxic to oesophageal cancer cells. New compounds from several other organisms are currently under further investigation.

I have been lucky enough to gather many new skills during my studies. In particular, I was able to learn to dive using SCUBA in order to collect samples for my research. This in turn has allowed me to travel around New Zealand, and now South Africa, diving in many interesting and beautiful places to collect raw materials for my work. I have also been trained in the use of many instrumental techniques for both the purification and the identification of organic molecules. The skills that I have obtained throughout my research are directly applicable to careers in the pharmaceutical industry to help develop lead compounds for treatment of various illnesses, as well as to environmental labs testing for controlled substances. They are also the skills needed by forensic scientists so who knows what the future may hold...

Kathryn Jarden

Currently completing a Masters of Management Studies at Victoria University of Wellington



I decided to study chemistry at university as I believed a Science degree in Chemistry offered career opportunities

in the technology related industries. A large part of my chemistry degree involved lab work. For me this was the most interesting and fun way to learn and to get a degree. At the end of my degree I completed a student project at Fonterra. The project was an opportunity to test my analytical skills in the “real world” and to gain project work experience where I had to prepare a report and a final presentation. After graduating with a Bachelor of Science I started a Masters of Management Studies. For my thesis of my masters, I was a recipient of a Bright Future Scholarship where I tested a management methodology in operations research. Part of the scholarship was contributed by Fonterra who awarded it to me due to my achievement in the chemistry related project I had completed the previous year. The project for my thesis required a student with abilities both in science and management and my chemistry gave me a huge advantage in understanding the production process at Fonterra’s lactose business. Currently, I am completing the final proof reading of my thesis and am looking for a full-time job. I believe the analytical skills gained from my chemistry degree will be a contributing factor (and has been for my scholarship) for me to find a career in a technology related industry such as the dairy industry. There are many career opportunities with a chemistry degree, whether in research, laboratory work, production environments or just as an excellent basis for analytical skills in another career.

Elizabeth Partridge

Barrister and Solicitor of the High Court of New Zealand.

Intellectual Property Advisor-Patents

Intellectual Property Office of New Zealand, Ministry of Economic Development



Initially setting out at Victoria University with the dream of becoming a lawyer, my career path took a huge turnaround due to CHEM 113 and 114. I always had a strong interest in science during my high school years, and decided to foster this by choosing these electives to supplement my law points. My first year science papers were extremely fulfilling and this constituted the catalyst

for my realisation that a career in the sciences was where I was aimed.

The combination of a Bachelor of Science (Chem) and a Bachelor of Laws is ideal for my current position as an Intellectual Property Advisor in the Patents team at the Intellectual Property Office of New Zealand (IPONZ). I examine technical chemical and biochemical patent specifications from NZ and abroad and determine whether they comply with the requirements of NZ law. A patent protects an invention so that financial gain can materialise in order to reward the hard work of individuals, often years of intense research, and to encourage further research and development.

It is not essential to have a legal background, most of my colleagues are specialists in various scientific areas. However, as a significant proportion of the job involves interpretation of the law, it can be advantageous, and a few IPONZ employees are studying law papers. Next year I intend to commence my studies toward becoming a registered Patent Attorney. This is usually completed in three years while working and covers all areas of IP law: Trade Marks, Patents, Plant Variety Rights, Designs and Copyright.

The opportunities deriving from a career in IP are extensive, including working within IPONZ, law and IP firms, and in-house for science research institutes. It is a stimulating and challenging area to be involved in - being exposed to the cutting edge of technology and innovation – and as NZ is full of innovative people, it is exciting to see what new products and processes are being devised. For a successful career it is necessary to have strong analytical skills and the ability to pay close attention to detail. People skills, both verbal and written communication skills, and the ability to work in a team are also fundamental. Research skills are important in this line of work as examination of specifications includes investigating whether the claims are original and inventive.

I thoroughly enjoyed my years in the School of Chemical and Physical Sciences. The professors are encouraging as well as being approachable and always willing to answer questions. Small class sizes make it possible to get to know all your classmates, and the experience of working collectively in lab groups fosters important team work skills. Undertaking research projects gave me a strong

understanding on using databases and how to locate and extract the information required. Further, writing up detailed lab reports and even taking care over my grammar and English in exams (as one professor was picky about this!!) gave me a sound grasp of the skills I now need in my career in IP.

CHEMISTRY AT VICTORIA

Chemistry is an integral component along with Physics and Technology in the School of Chemical and Physical Sciences. Chemistry can be taken as a major subject in either a Bachelor of Science (BSc) or a Bachelor of Arts (BA) degree. Students can then undertake an Honours degree or PhD, particularly if they wish to pursue a career in research. As chemists often move into management roles, courses with a business management component are also offered. The study of commerce and science can be covered by a conjoint BCA/BSc with a major in Chemistry and a commerce subject such as Management or Marketing. The study of law and science covered by a conjoint BSc/LLB can lead to patent work.

The Bachelor of Science and Technology degree (BScTech) is a four-year programme being offered by the Faculty of Science. The degree is targeted at students who have a background in science and wish to progress to a career in a science-based industry, either in research and development or in management. The new degree differs significantly from existing BSc degrees in that it has a clear emphasis on applied science and technology skills and includes a three-month work placement as part of the programme.

The BScTech degree is initially offered with three majors: electronics and instrumentation, advanced materials, and chemical products and processes. There is a core of

technology courses, and students will achieve a high level of laboratory and practical skill in their specialist areas. Students with good honours in the final year of the BScTech can then proceed to a PhD degree if they wish to pursue a research-based career.

The Bachelor of Biomedical Science degree (BBmedSc) is a three-year degree offering a specialisation in molecular pharmacology and medicinal chemistry which focuses on chemical methods for the synthesis of drugs in the treatment of disease, public and environmental health.

The conjoint teaching programme combining a Bachelor of Teaching with a Bachelor of Science (BSc/BTeach) takes four years of full-time study to complete and provides a deep understanding of classroom practice, specific training for primary and/or secondary teaching and specialised knowledge in two teaching subjects.

The Master of Management Studies is a popular post-graduate degree for students with a scientific or technological background who wish to acquire managerial skills and knowledge. The degree takes up 4 trimesters or up to 4 years part-time study and consists of course work and a thesis or research project. The programme also includes workshops which investigate specific topics in-depth or concentrate on the acquisition and development of managerial and interpersonal skills.

The School of Chemical and Physical Sciences has a high national and international profile in research concerned particularly with the development and understanding of new materials and bioactive molecules. Teaching is research-led and graduate students work with staff members in enthusiastic and collegial research groups. The School is well equipped with modern sophisticated instruments which support the teaching and research programmes. Students are given experience on these instruments.

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