CAREER VIEW

CELL AND MOLECULAR BIOSCIENCE
BIOMEDICAL SCIENCE

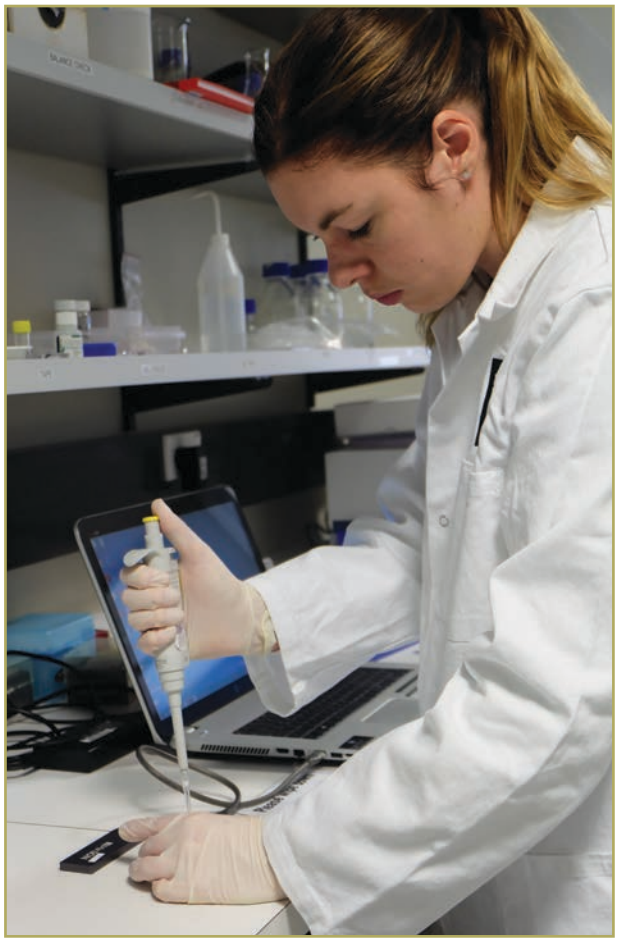
Are you curious about why and how life works, right down at the cellular level? Do you want to be a part of solving the big challenges and questions that face us as living organisms? Imagine being part of the research that improves treatment for, or prevents, cancer, multiple sclerosis, drug addiction and other complex disorders. Developments that would have been impossible 20 years ago are now happening, thanks to initiatives such as the Human Genome Project, and advances in analytical and computing technology. It has also meant the emergence of biomedical science as a fast-growing discipline.

WHAT IS CELL AND MOLECULAR BIOSCIENCE?

Studies in ***cell and molecular bioscience*** build an understanding of how life works from the molecular level upwards. It is a wide-reaching area of scientific research that includes the study of genetics, immunology, pathology, biological and medicinal chemistry, physiology and environmental health. Cell and molecular bioscientists work at a microscopic and molecular level to discover the intricacies of how the living world functions. As digital technologies increase the amount of data available to cell and molecular bioscience, computational approaches are giving rise to new fields of work such as bioinformatics.

Biomedical science has emerged as a speciality of cell and molecular bioscience that investigates the relationship between health and disease in humans. Disease and other medical conditions are caused by such things as viruses and micro-organisms, environmental and/or genetic factors. By understanding how these conditions occur, biomedical science gives us new tools for diagnosis and treatment. Within biomedical science, there are several areas of study.

Genetics is the study of individual genes, their inheritance and their evolution, which began when Gregor Mendel, a 19th century monk, studied inheritance of traits in pea plants. In the 20th century, genetics was used to identify the cause of diseases such as cystic fibrosis, haemophilia and Huntington's disease. Genomics is the study of whole genomes (all the genetic information in a person), and how



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

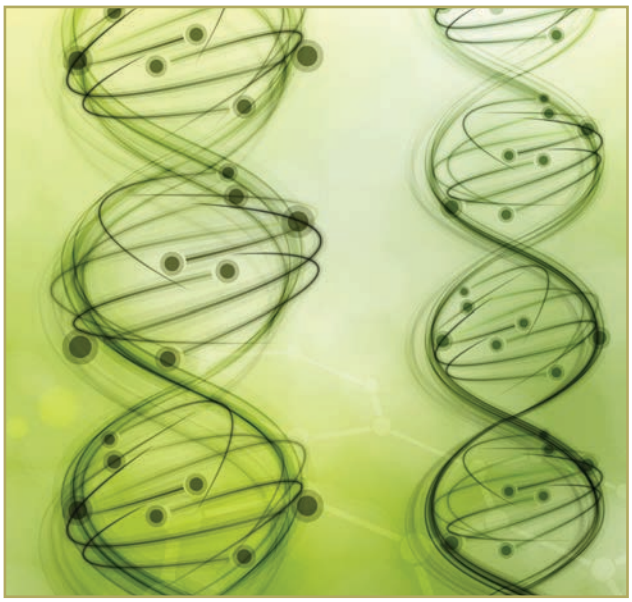
Areas covered include how degrees and courses relate to employment opportunities, to life/work planning, graduate destination information and current issues or material relevant to the employment scene. Your comments and suggestions always welcomed.

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

environmental factors can change the genome and the way cells use it. Genomics has emerged from large-scale DNA sequencing techniques developed since the beginning of the 21st century. Complex diseases and disorders such as cancer, diabetes and Alzheimer's disease are beginning to be decoded, using genetic and genomic approaches. As well as providing clues to understanding human biology, learning about the DNA sequences of nonhuman organisms can lead to an understanding of their natural capabilities. This can then be used to solve challenges in health care, agriculture, energy production, in repairing damage to the environment and developing more sustainable practices.

A recent revolution in genetic technology is genome editing, which uses a type of 'molecular scissors' to specifically cut one DNA sequence out of a genome and replace it with another. By cutting out a mutant gene and pasting in the correct version, genome editing has the potential to cure inherited genetic diseases such as muscular dystrophy, an approach that has been successful in mice.

Molecular Pathology focuses on the relationship between health and disease. Molecular pathologists work in laboratories where they investigate the biochemical and biophysical changes that occur in cells when people become ill. They also study the effects of diseases on the overall system of the human body. This includes work in clinical biochemistry, microbiology, immunology, virology and forensics. Applications are found in studies of both hereditary and acquired disorders including genetic diseases, diabetes, malignant tumours, diseases of the blood such as leukaemia and lymphomas, and infectious diseases such as AIDS, hepatitis, tuberculosis and influenzas.



Molecular pathology is a rapidly growing area of research and laboratory medicine. The development of new technologies, such as DNA sequencing techniques and associated bioinformatic analyses, continues to add layers of complexity to the field. In New Zealand molecular pathology graduates may work in hospital, medical, forensic and research laboratories, and in government and regulatory bodies.

Molecular Pharmacology and Medicinal Chemistry studies all aspects of chemistry in relation to our bodies, including modern chemical methods for the synthesis of drugs and how they are used to treat disease. Pharmacologists play a major role in human health and society. They are responsible for the discovery of hundreds of chemicals used in the treatment of disease and the relief of human and animal suffering.

The pharmaceutical and healthcare industries depend largely on pharmacology for their success. While the pharmaceutical industries are small in New Zealand, there are a few outposts of multi-national companies in the country. Stand-alone research institutes, research laboratories attached to universities and Crown Research Institutes are engaged in research that uses the skills and knowledge of molecular pharmacology and medicinal chemistry. The discovery of the marine sponge toxin called peloruside and its possible applications in the treatment of cancer is an example specific to New Zealand.

Product registration and regulation, pharmaceutical sales, patents and information science are career options for graduates specialising in pharmacology and medicinal chemistry.

Bioinformatics is the term for 'big data' analysis in biology that uses computer applications to 'mine' the massive amounts of DNA sequence, proteomic and metabolomic data that are being generated. Applications are uniquely tailored to answer unique research questions. Hence computational biology and bioinformatics is an emerging and fast-growing specialisation, which requires the combination of genetics, genomics and biological knowledge with high-level statistics and the ability to write and edit analytical code in languages such as Python.

Ethics. People working in bioscience research may need to face ethical issues on matters that have wide and far-reaching consequences for human health, other living organisms and the environment. Issues include areas of public concern such as: the role of genetic modification in relation to human health, biomedical food safety and consumer choice; environmental issues pertaining to biodiversity, bio-security and the health of ecosystems; economic issues such as the commercial

use of research, business development, primary production and exports.

WHAT SKILLS DO CELL AND MOLECULAR BIOSCIENCE STUDENTS DEVELOP?

Undergraduate and graduate degrees in science provide excellent grounding for a range of careers. During their degree studies graduates develop both technical and generic transferable skills, attitudes and knowledge that are sought by employers.

Attention to detail: During experiments and other investigations students develop observational skills and the ability to gather and record detail to a high level of accuracy. This is crucial in work that may eventually be a matter of life or death for patients.

Analytical skills: Using analytical skills students collect and evaluate concrete and conceptual information and draw appropriate conclusions. These skills are useful in many areas of work including research, policy, and business roles at all levels of responsibility.

Scientific methodology: Scientists have to be systematic in designing, setting up and implementing experiments. Degree studies teach skills in scientific process along with a work ethic that demands rigour, safe and responsible practices, tolerance for repetition and patience.

Quantitative skills: With the emergence of bioinformatics, scientists develop the ability to understand and see patterns in large sets of data.

Lateral thinking: Scientists think outside the square, making new connections and being open to the unknown. Innovative thinking is needed in designing research questions and new methods of approach.

Planning and organising: Laboratory experiments and university assignments require planning and implementation. Learning scientific methodology gives students practical experience in managing and completing projects.

Communication and interpersonal skills: An ability to communicate scientific findings in a clear, concise way to colleagues and to clients with a non-science background is important. Students develop skills in verbal and written communication through report writing, discussion and making presentations.

Self-motivation and perseverance: Scientific exploration requires staying power and enthusiasm for the "thrill of the chase". It can require long hours of detailed repetition as well as the ability to stay tuned to the bigger picture.

WHERE DO GRADUATES FIND WORK?

Cell and molecular bioscience and biomedical graduates have the knowledge base to enter a variety of fields. Some examples are research in human genetics, genetic counselling or management, human fertility and ageing, clinical biochemistry, immunology, molecular pathology and the development of new pharmaceuticals.

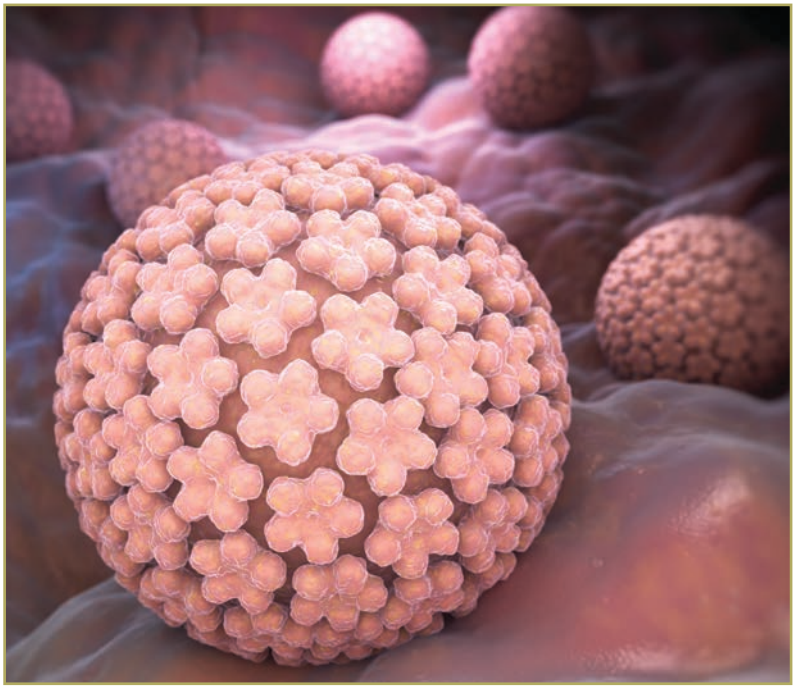
Postgraduate study is necessary to advance in research and additional qualifications are required to progress in genetic counselling and public and environmental health. Many graduates go on to complete qualifications in medical, paramedical, dental, veterinary, pharmacy or other health professions.

For employment in diagnostic medical laboratories, registration as a medical laboratory scientist or medical laboratory technician is required. This entails applying for registration with the Medical Sciences Council on completion of a relevant undergraduate or postgraduate degree.

Graduates may also find employment in related fields such as patents and intellectual property, in policy analysis, teaching, specialist library work, science writing and editing, general management and general science. There are also roles in the sales, marketing and administration of companies that manufacture and sell the tools for and products of scientific research.

Research organisations. Graduates who are passionate about a career as cell and molecular or biomedical scientists and who achieve high grades often head into research. Specialised research organisations such as the Malaghan Institute of Medical Research at Victoria University, and the

Medical Research Institute of New Zealand at Wellington Regional Hospital focus on biomedical and clinical health research. Other institutes throughout the country have their own areas of expertise. There are many exciting, cutting edge projects happening both in New Zealand and overseas. Because the economy of New Zealand is based on primary production much of the research concerns agriculture, horticulture, forestry and fishing.



Hospitals employ biomedical and cell and molecular bioscientists to carry out a range of laboratory tests that assist doctors in the diagnosis and treatment of disease. The health sector, public and private, is a major employer of lab technicians and technologists. The successful treatment of patients relies on the accuracy and efficiency of their work. They also perform a key role in preparing blood transfusions, identifying viruses and diseases and monitoring the effects of medication and other treatments. Another specialisation is cytogenetics in which prenatal and postnatal chromosome samples are processed and analysed to detect genetic abnormalities. This is also used in the diagnosis of various types of cancer.

Crown Research Institutes (CRIs) are government-owned organisations that cover particular areas of research. CRIs such as AgResearch, Plant and Food Research, the National Institute of Water and Atmospheric Research (NIWA), Scion (forestry, wood products and biomaterials) and Environmental Science and Research (ESR) employ graduates with a background in cell and molecular biology and related disciplines. Whether it is in the area of fruit genomics, detection of fish diseases, animal and human nutrition and health, reproductive technologies or forensics, there are many varied opportunities for discovery research and commercial use of scientific intellectual property.

Private research organisations and laboratories are not numerous but are found in areas as diverse as DNA testing, fertility and cancer, brewing beer, waste disposal, treatment of wounds, and the development of drugs. Some firms have links with international companies and are commercially focused. Small teams often need to be versatile so conjoint or double degrees in commerce or law can be useful.

Government agencies such as the Environmental Protection Authority (EPA), Pharmac, Medsafe, the Health Research Council and the Intellectual Property Office of New Zealand (IPONZ) employ graduates with degrees in cell and molecular bioscience and biomedical science to administrative roles that require a technical scientific background or advisory and policy roles at postgraduate level. EPA employs Bachelor's and Master's graduates to manage consent applications and PhD graduates to scientific advisory roles. IPONZ, under the Ministry of Business, Innovation and Employment (MBIE), examines patent claims for new inventions and product designs. It recruits across a range of disciplines at undergraduate and postgraduate level and provides training in the legal aspects of the job.

Education sector. Teaching at secondary school level is an important career option for graduates as biology and general science are taught in secondary schools. Further teacher training is required. Universities are key employers of cell and molecular bioscience graduates interested in a career that combines research and teaching. To fulfil these dual roles universities employ science graduates as laboratory technicians, tutors and faculty staff. Graduates considering an academic career require a PhD and a record of publication to be competitive for junior positions.

Communications. Writing and editing for science communications, journals, magazines, broadcasting and news organisations is a work option that may require further training. There is increasingly a need for people who can advocate for science. Someone in this area will be passionate about their subject, have a good understanding of cell and molecular and biomedical science, and can communicate in a clear and interesting way to a broad audience. There is also a role for

specialist science and medical writers with publishing companies and the pharmaceutical industry.

Institute of Environmental Science and Research (ESR) is the sole forensic science provider to the New Zealand Police and also provides services for other government agencies including Customs and Defence. Forensic science draws on many disciplines and involves DNA profiling and DNA database management. Much of the work relates to police investigations. On-the-job training is given, while specialist postgraduate programs are available.

Patent attorney firms employ graduates of all levels, although graduates with a Master's or PhD in science or technology are usually preferred. A law degree is an advantage but in general, is secondary to a technical qualification. For example, preparing or reviewing licences and technical agreements in a biotechnology venture is much easier if you know the science and the law. Apart from formal qualifications, patent attorneys need very good communication skills, attention to detail, business acumen and analytical skills. Patent attorneys are largely trained on the job.

Genetic counselling practice. Genetic counsellors talk through issues with people who have or are at risk of having, a genetic disease, or passing it on to their children. They provide specialist information ordering, interpreting and explaining test results to clients, and supporting them through their decision-making process. Training and certification as a genetic counsellor is undertaken through the Human Genetics Society of Australasia.

JOB TITLES

These include titles relevant to undergraduate through to graduates with double or conjoint degrees, postdoctoral degrees and specialisations.

Biological chemist • biomedical technician • biomedical scientist • cell biologist • cellular biochemist • data analyst • geneticist • genetics associate • genetic counsellor • haematologist • immunopathologist • industrial research chemist • laboratory technician • microbiologist • medical laboratory scientist • medical science technician • molecular biochemist • patent attorney • pathologist – anatomical; clinical; forensic • policy analyst • research analyst • research assistant/technician • research coordinator • research scientist • science communicator • science journalist • teacher • university lecturer.

GRADUATE PROFILES

Sarah Cordiner

Research Associate
Plant & Food Research

I enjoyed biology and chemistry at high school and knew I wanted to study them further at tertiary level. However I also wanted my studies to have a healthcare focus. When I read the description for the Molecular Pharmacology and Medicinal Chemistry (MPMC) major in the Victoria prospectus it was an almost word-perfect description of what I wanted to learn. I feel the biomedical sciences degree really helps comprehension of how chemicals interact with biological systems and how biological systems have their own inherent chemistry.

I enjoyed the lab courses, as they were good places to see the concepts you'd learnt in the lectures working in practice (or in some cases how theory doesn't always work in practice and therefore provide a good lesson in trouble-shooting experiments). As good as these teaching labs were, however, I definitely learned the most about lab techniques, planning experiments, and problem-solving from working in the research lab for my Master's project.

I am currently employed as a research associate in the phytochemistry team at Plant & Food Research, one of New Zealand's Crown Research Institutes. In general, our research investigates compounds present in fruit and vegetables which have or may have a positive health impact on people or otherwise add value to the product. This role combines my biology, chemistry, and health interests.

For anyone planning to study biomedical science I would say, while the course is fairly prescribed, try and fit in some electives where you can. It always helps to have some knowledge from different fields. Once you've embarked on your studies, talk to your demonstrators about their projects and supervisors. This will give you an idea of the range and diversity of research that goes on in the university. Try and get summer studentships or volunteer work in some of the research labs – this is a very different environment to the teaching labs and will help you decide if this is the type of career you want. It will also help when trying to decide on a lab/supervisor should you decide to do postgraduate study. On that note – be prepared to do postgraduate study. Most employers will be looking for at least an Honours degree for research roles.

Nicole Moore

Research Assistant
ESR Virus Hunters

I knew I wanted to study science at university, although initially I was unsure about which course to choose. I eventually settled on a biomedical science degree. The biology focus combined with human health, pathology, physiology, microbiology and genetics was an interesting and exciting combination.

I enjoyed my classes right from the start, especially in the human genetics elective courses. I broadened out into a double major in Molecular Pathology and Human Genetics as these major subjects complemented each other well. The lecturers were all experts in their own fields and shared their knowledge and passion for their work which made me want to work hard to gain that for myself.

The self-directed learning, research and project of the Honours year was a new challenge and lot of work. Towards the end of that year I was torn between continuing the natural progression into a Master's or PhD, as most of my classmates were planning on doing, or taking a break from study and trying to find a job. I was lucky enough to get a job at ESR as a research assistant on a pathogen discovery research project. The main aim of this project was to find pathogens, normally viruses, causing unsolved cases of disease in humans or animals. The work has been hugely rewarding.

The knowledge from my undergraduate study on human health and pathogens and the research and analysis skills from my postgraduate study have been very relevant and helpful. The skills I have learnt allow me to easily adapt to the constant changes and developments in this area of science. Technological and scientific advances have meant my role at ESR has progressed since I started. I have learnt to run different DNA sequencing devices and the early stages of sequence analysis (bioinformatics).

My advice for current and future students would be to gain as much lab experience as you can, especially during your undergraduate years. Whether that be lab demonstrating or volunteering in a lab with PhD students. The experience of volunteering in a lab for over a year allowed me to gain a better understanding of lab techniques in practice and refine my technical skills and a more realistic view of what working in a lab every day might be like.

Zak Murray

Account Manager
Thermo Fisher Scientific

I've always been curious and liked to see how things worked right down to the cellular level, so I was drawn to maths and the sciences.

After completing a conjoint Science and Commerce degree, I settled on a Biotechnology major for the Honours year. This included being part of a research project looking at the Nosema parasite in honeybees and the parasite's association with a phenomenon known as colony collapse disorder. It worked for me as it had both behavioural/ecology and a molecular focus, as well as direct relevance to a key industry.

Through contacts, I landed a research assistant role at ESR (the Institute of Environmental Science and Research). I was part of a project looking at unique viruses in New Zealand bats. This involved DNA sequencing of bat droppings! I then moved into a technician role in the clinical lab at ESR, this time assessing human swab samples to identify whether respiratory viruses were present and if so, which type of virus they were infected with.

While I was developing essential technical skills and knowledge, the plan for me was always to combine these skills with the business and marketing skills from my commerce degree. My current job came up and I went for it. I manage a sales territory for the lower North Island, across a variety of sectors, with a focus on research and academia. My day-to-day role involves helping scientists and technicians finding new and innovative products which can assist with their work. I work with the universities and research institutes, as well as food and beverage companies, district councils and industrial manufacturers.

What I learned from my marketing studies has really kicked in now, such as understanding the sales process and concepts and terms that are used in the commercial sector. There are practical skills, too, such as presenting ideas one to one and in groups and making complex information understandable.

My study at postgraduate level was essential in learning about the wide range of products that I now sell, their usage and building credibility with customers. The scientific sector is fast-changing and growing but it is still a competitive market. Along with technical/lab skills, my Honours year was a big year for learning key workplace skills

such as dealing with pressure, time management and developing coping mechanisms as I balanced a thesis alongside coursework. Now the pressures are meeting sales targets in a competitive market, however the coping mechanisms remain the same. My single piece of advice to students wanting to work in cell and molecular bioscience or a related field is to differentiate yourself by combining science with another useful skill set, such as commerce, law or even the arts.

Emma Dent

Analyst–Market Data
NZX

Biology was always my favourite subject at high school – it was something that made me excited to go to class and something I really enjoyed learning about. So it was a no-brainer for me to continue that into my tertiary study. I decided on a double major in Ecology and Biodiversity, and Cell and Molecular Bioscience, so I could incorporate all the areas of biology I enjoyed. Studying ecology allowed me to look at 'bigger picture' ideas, while cell and molecular biology let me explore all the finer details that had fascinated me at high school. The subject of biology always appealed to me as I loved pulling together pieces of information to get a better understanding of how a system works.

I am currently working as a market data analyst for NZX as part of their three-year graduate programme. NZX is the only registered securities exchange in New Zealand. Previously, I worked in their side business, NZX Agri, on the data team. While the technical knowledge I have from my biology studies is not directly relevant to my job at NZX, the analytical skills and the ability to pick up new ideas has been. Continuing on into postgraduate study allowed me to improve these skills and work in an independent manner. Postgraduate study has helped me immensely in my working life, and is something I would recommend to anyone studying science.

The best thing I have found after leaving university is not being limited by my degree. My job for the next two years will be around data analysis in New Zealand's capital markets – something I did not know anything about at university. However, my degree from Victoria and postgraduate study has given me skills that I can apply into vastly different career fields which I hadn't considered prior to graduating.

Haley Ataera

Senior Advisor
Ministry of Health

You wouldn't be considering a career in science if you didn't love it. When it came to career choice, for me, genetics was a given. I loved the combination of science and maths and the mystery of how endless variations of really simple building blocks leads to such a huge diversity of flora and fauna. There are so many real world applications: from talking through the implications of having a genetic anomaly with someone, to explaining why human babies are born so helpless when farm animals can stand within minutes of being born. I love being able to answer in a way that makes sense and hopefully helps to demystify science in the process.

After finishing my PhD in Biomedical Research with a focus on cancer immunotherapy, I moved to the States to do a postdoctoral fellowship. My project involved developing new immunotherapies for children with neuroblastomas by genetically modifying the patient's own T cells to be tumour specific. I realised pretty quickly that although I loved the project, I wasn't prepared to continue working long hours with tenuous job security. I also wanted to be closer to friends and family, so I moved back to New Zealand.

My advice is just be smart about where you are going with your science studies. Keep an eye on local, national and international job seeker sites to see what kind of roles are available and what you need for these roles. If you have other interests that would complement your science major, for example law, management, policy, commerce or teaching, then see if you can build these into your studies.

My degree helped me land a job at the Ministry of Health as a medicines assessor with a focus on biological medicines. I have since moved on to a broader role helping to implement new or changed legislation administered by the Ministry of Health. This role uses my broader science skills. Aside from lab skills, I developed problem-solving skills, the ability to critically analyse information, confidence and comfort with public speaking, which are useful in any discipline.

I never imagined that this would be where my degree took me but I am so happy it did! Serendipity at its finest.

CELL AND MOLECULAR BIOSCIENCE AND BIOMEDICAL SCIENCE AT VICTORIA

There are two options for study in the area of molecular bioscience at Victoria, a Bachelor of Science (BSc) majoring in Cell and Molecular Bioscience, or the Biomedical Science (BBmedSc) degree. Graduates are equipped for a variety of molecular and biomedical related fields, such as genetic counselling and the biotech and pharmaceutical industries. Either degree provides an excellent base for study at medical school, or for postgraduate medical and paramedical training programmes, or you can do further study at Honours and Master's degree level.

While the science that underpins the Biomedical Science degree overlaps with the Cell and Molecular Bioscience major, the BBmedSc focuses on the science behind clinical delivery with integrated specialist majors in human genetics, molecular pathology, and molecular pharmacology & medicinal chemistry.

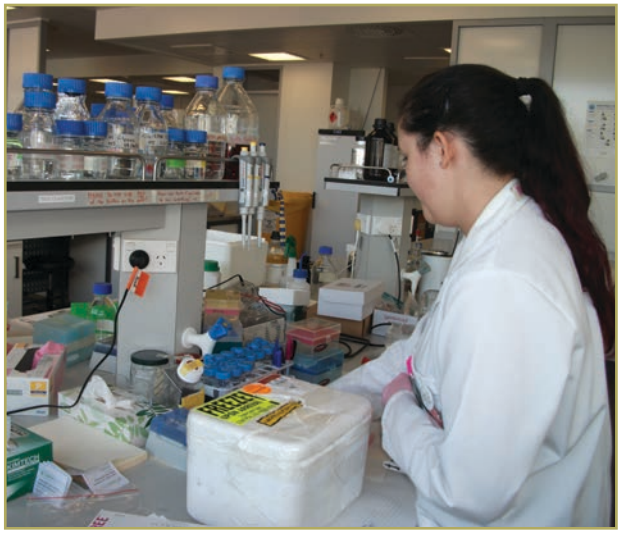
The staff who teach in Victoria's Biomedical Science programme also undertake research with organisations including the Wellington School of Medicine, the Medical Research Institute of New Zealand, the Maurice Wilkins Centre, and the on-campus Malaghan Institute of Medical Research.

Programme structure:

Cell and Molecular Bioscience. This major includes biochemistry and molecular biology, cell biology of animals, plants and bacteria, genetics, physiology and pharmacology. A BSc majoring in Cell and Molecular Bioscience has a smaller core programme that allows more flexibility in the choice of courses than the Biomedical Science degree.

Biomedical Science. The BBmedSc degree is highly structured but it is possible to include courses from any other first degree at Victoria. In the first year of your degree you study a core programme of human biology, cell biology, human diseases, chemistry, psychology and statistics. In years two and three you study courses specific to one of three specialisations:

- **Human Genetics** – covers all aspects of the science of human genetics, including the study of the human genome and the treatment of disease and illness of a genetic origin. This specialisation is for those with an interest in areas such as genetic counselling, syndromes and diseases of genetic origin, human fertility, and ageing.
- **Molecular Pathology** – an introduction to the molecular basis of disease. The emphasis is on the metabolic and other changes that occur when humans succumb to illnesses. This specialisation suits those interested in the relationship between health and disease, in clinical biochemistry, microbiology, immunology and forensics.
- **Molecular Pharmacology and Medicinal Chemistry** – a focus on all aspects of chemistry in relation to our bodies, including modern chemical methods for the synthesis of drugs and how they are used to treat disease. This specialisation is appropriate for students interested in both organic chemistry and molecular biology.



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