IRL solutions

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THE sound of science

Dr Mark Poletti's sweet sound of commercial success

INSIDE:

INDUSTRIAL RESEARCH LIMITED
Te Tauihu Pūtaiao

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COVER IMAGE: IRL's Dr Mark Poletti, who successfully transformed academic prowess in the field of acoustics into commercial success, with the development of a system for assisted reverberation.

THIS PAGE: Three views, increasingly magnified in descending order, of IRL drug candidate BCX4208 (aka DADMe-ImmH) inhibiting the enzyme purine nucleoside phosphorylase (PNP), a key path in the buildup of excess uric acid in the blood, which can lead to the painful condition known as gout.

Scientists, take heart

It is heartening to see that despite a tight fiscal environment, the current government has prioritised science with new spending announced for the 2010 budget.

Even more heartening is the focus on encouraging companies to invest in research and development with the majority of the $225 million of new funding being targeted in this area. It is clear that the current administration understands the best way to grow a developed economy is through investment in science and technology.

By focusing on increasing private sector investment in R&D, the government acknowledges that while New Zealand's public sector R&D investment is low, our private sector investment is even lower when compared with the OECD average. For a country whose prosperity is underpinned by world-leading science and technology, this is something that must change.

I hope that a significant number of New Zealand companies, buoyed by the recovery of the world economy, think seriously about applying for some of this new funding and that it helps them develop new and innovative products and services to sell to the world.

I also hope the government's effort to implement the recommendations of the Crown Research Institute Taskforce enables the CRIs to better deliver on national priorities and respond better to the needs of industry and business.

At IRL we put a considerable emphasis on encouraging our scientists to familiarise themselves with the practices and principles of business to enable them to apply their knowledge in a commercial context. Having said this, it is important to note that science excellence is the foundation of everything we do. The work of Prime Minister's Science Prize winners Drs Bob Buckley and Jeff Tallon is a great example of how science for its own sake should not be shied away from.

It was academic curiosity more than 20 years ago that piqued the pair's interest in high-temperature superconductivity, a phenomenon whereby some materials conduct electricity without resistance. Today they are two of the world's foremost experts in what is predicted to be a multibillion-dollar industry in coming decades and, thanks largely to their efforts, New Zealand is positioned to capture a significant part of it.

Their story, from initial blue-skies research to the emergence of a new global industry, is told on page 12. Another of our researchers who found commercial success is Dr Mark Poletti who, after publishing several papers in high-profile, peer-reviewed journals, designed an electronic sound reproduction system that can transform a venue with less-than-perfect acoustics into a world-class concert hall. The system was eventually licensed to US-based Meyer Sound, who sold it to venues around the world.

Again, it was Dr Poletti's academic curiosity that gave him a fundamental understanding of the science of assisted reverberation, and by becoming a leader in his field he became well-placed to apply his knowledge in a commercial context. Dr Poletti's thirst for knowledge is not limited to these achievements. As a keen guitarist he even designed his own electronic guitar effects and amplifier. Read his story on page 6.

IRL's passion for new knowledge has helped cement a reputation as a valuable repository of scientific expertise that companies have sought out. Leading New Zealand marine electronics company Electronic Navigation Ltd is a good example: after utilising IRL's services to develop a unique seafloor mapping system called the Wide Angle Sonar Seafloor Profiler ten years ago, it is again looking to utilise IRL's research capabilities (see page 8).

Another important string to the IRL bow is the work of the Measurements Standards Laboratory (MSL), which ensures New Zealand's units of measurement are consistent with the international system of units. MSL plays a key role in ensuring international recognition of New Zealand's National Measurement System, which is essential for New Zealand's ongoing international trade.

A problem within measurement standards relates to the kilogram, which is measured against a prototype cylinder of platinum-iridium alloy kept in a vault in Paris. Since the prototype kilogram was declared as the standard for this weight in 1889, it is thought it may have picked up infinitesimal amounts of mass during cleaning and will eventually degrade and lose mass. To find out how MSL scientists are collaborating with peers around the world to find a new, more reliable definition for the kilogram, turn to page 14.

From providing accurate, standardised measurements to improving the experience of discerning concert goers, science and technology have a profound effect on our lives and our standard of living. I look forward to seeing how the new funding for science helps New Zealand businesses to grow, and the positive affects these changes will have on the living standards of New Zealanders.

Shaun Coffey
Chief Executive
Industrial Research Ltd

From providing accurate, standardised measurements to improving the experience of discerning concert goers, science and technology have a profound effect on our lives and our standard of living.

NEWS

No gout about it

Human trials of IRL drug candidate report promising early data.

A potential treatment for gout co-invented by IRL is showing promising results in human trials being conducted in the US.

BCX4208, a drug candidate discovered in a collaboration between IRL and Professor Vern Schramm, Ruth Merns Chair of Biochemistry at the Albert Einstein College of Medicine, New York, is being developed by BioCryst Pharmaceuticals Inc (www.biocryst.com) in the US. It has recently reported significant reductions in uric acid blood levels and no major safety issues after the completion of the study's first phase.

A severe and painful form of arthritis, gout is caused by deposits of uric acid in joints, particularly in the big toe, and affects tens of millions of people globally.

In the first part of the randomised, double-blind study, three different doses of BCX4208, a novel, next-generation inhibitor of the enzyme purine nucleoside phosphorylase (PNP), were administered against a placebo to gout patients once a day for 21 days. All three doses of BCX4208 demonstrated a statistically significant reduction in uric acid blood levels at day 22 compared with the placebo. The drug candidate was generally safe and well-tolerated at the doses evaluated.

"High levels of uric acid in the blood are a necessary precursor to gout," says Dr Richard Furneaux, the leader of IRL's Carbohydrate Chemistry team in which the compound was first synthesised.

"While these results are from early stages in the drug development path, and there is much more testing ahead, these results are exciting for us and particularly relevant to New Zealanders. Unfortunately New Zealand has as much gout in the population as any nation, if not more, with six percent of Kiwi men having the condition. Of particular concern is the genetic predisposition of some individuals to suffer gout, with a 14 percent incidence in Māori men."

Trial results showed reductions in peripheral blood lymphocytes in patients treated with BCX4208, but none of the treatments were stopped due to this reduction.

Overall, the frequency of adverse events in each of the BCX4208 treatment groups was comparable with that observed in the placebo group.

Part two of the study, designed to sequentially evaluate the safety and efficacy of up to three higher doses of BCX4208, is now underway.

In addition, on June 1, BioCryst announced it had initiated a Phase 2 study of BCX4208 alone and in combination with allopurinol—a drug approved for the treatment of excess uric acid in blood—in patients with gout.

"We are pleased to initiate this Phase 2 study of BCX4208, a highly potent and selective PNP inhibitor, as it will help to determine whether the inhibition of xanthine oxidase and PNP together has additive or synergistic effects in reducing uric acid levels in patients with gout," says Dr William Sheridan, Chief Medical Officer at BioCryst. "We expect to complete this study during 2010 and look forward to providing top-line data in the fourth quarter."

Dr Richard Furneaux: exciting drug-trial results.

Singing GlycoSyn's song stateside

Richard Lauricella has always had a passion for people and science—an ideal combination in his new role as US-based Business Development Manager for IRL's drug development and manufacturing group, GlycoSyn.

Holding certification in Medical Laboratory Techniques from Swinburne University of Technology and a Bachelor of Science from Royal Melbourne Institute of Technology, Richard has an extensive technical and research-based background within the biotech and pharmaceutical industries, as well as academic and government research institutes.

This background, along with his ongoing interest in applied research and development, particularly in the areas of drug discovery, vaccines, therapeutics and diagnostics development, makes his appointment a perfect fit for GlycoSyn, according to General Manager Paul Benjes.

"Richard's extensive experience has enabled him to gain entry into an array of key US companies and research institutions and successfully establish relationships essential for our long-term business success."

Lauricella moved from Australia to the United States in 1995 and now lives with his family in Raleigh, North Carolina, where he runs his own business, Global Synthesis Solutions Inc. It was in this capacity that he was first referred to GlycoSyn, leading to his role promoting the GlycoSyn brand and capabilities.

"This is one of the reasons I wanted to become involved—GlycoSyn's world-class capabilities are largely unsung at present and I want the world to know a lot more about them," he says.

Dynamic duo

Joint effort aids assistive device's path to market.

A collaboration between IRL and its Taiwanese counterpart, the Industrial Technology Research Institute (ITRI), has resulted in the joint development of a unique product that is nearing market entry.

The handheld dynamometer, developed by IRL assistive devices researcher Marcus King, measures the amount of strength and the range of movement achieved by the joints or limbs of patients recovering from injuries such as stroke.

The accurate measurements it takes provide crucial information for physiotherapists who want to closely monitor the rehabilitation of their patients.

"We knew there was nothing on the market that performed these functions and could be held easily in the hand but the cost of manufacturing meant it would retail at a price that was very expensive," says King.

Enter the rapid prototyping division of ITRI, which took the technology and looked at different materials and methods of production aimed at reducing its price.

"We were really impressed with the work put in by the ITRI team. It led to a significant reduction in manufacturing cost to a level where mass production is feasible," says King.

The project is part of a larger agreement between IRL and ITRI to collaborate on the development of assistive devices for the disabled that was signed in 2008.

King says the rapid development of the dynamometer shows there are real synergies between the two organisations. "We definitely have complementary strengths. ITRI has really shown how it can take a good idea and help turn it into a feasible product for global markets."

The IRL project team is presently seeking business partners in New Zealand to commercialise the technology.

The handheld dynamometer measures the amount of strength and the range of movement in the joints or limbs of patients recovering from injuries such as stroke.

Island's elemental efficiency

Wellington Harbour's Matiu/Somes Island will soon be a step closer to becoming a showcase for sustainable energy, with IRL playing a key role in the project.

Tenders were recently announced for the supply and installation of a renewable energy system on the island.

The project, which will see diesel generation replaced with a system harnessing energy from wind, water and the sun, is a partnership between the Department of Conservation (DOC), the Port Nicholson Block Settlement Trust, the Energy Efficiency and Conservation Authority (EECA) and IRL. It is being led by the kaitiaki (governance board) for Matiu/Somes.

"This project will significantly reduce our diesel requirements and corresponding costs, freeing up resources for delivering more conservation work on the ground," says DOC's Poneke Area Manager Rob Stone.

Stone says a renewable power supply, which could include solar panels and a small wind turbine, would complement the measures already underway to reduce energy requirements on the island.

The project will include groundbreaking technology designed by IRL in the form of the HyLink distributed hydrogen energy system. The system works by capturing renewable energy from a wind turbine or photovoltaic solar cells. This energy then powers an electrolyser that extracts hydrogen from water by separating it into hydrogen and oxygen molecules.

The low-pressure hydrogen fuel gas is delivered by pipeline to a fuel cell to produce electricity. As well as transporting the energy, the system also stores hydrogen in the pipeline so that a supply of energy can be maintained even when the wind is not blowing.

IRL's distributed and hydrogen energy team manager Alister Gardiner says technological advances are making renewable energy more attractive.

"Being energy efficient and investing in renewable energy is better for the environment we live in and good value for money, as the system pays for itself over time."

Gardiner says the energy efficient and renewable energy systems to be showcased on Matiu/Somes Island are a good example of an energy solution for sites that are not connected to the electricity grid.


Dr Mark Poletti entered the field of assisted reverberation out of natural curiosity.

The sound of science

IRL researcher Dr Mark Poletti's academic achievements in the field of acoustics have reverberated all the way into the realm of commercial success.

A lifelong obsession with guitar playing, sound reproduction and acoustics led IRL scientist Dr Mark Poletti to develop a system that can transform a venue with less-than-perfect acoustics into a world-class concert hall.

A self-confessed tinkerer, Dr Poletti has always had a keen interest in electronics. In his formative years, as a keen electric guitar player, he spent much of his time designing new distortion units to change the sound of his guitar to his particular taste.

"I always look at something like a guitar effects pedal and think, 'I wonder if I could make something that does the job better,'" he says.

It was this natural curiosity that eventually led him into the field of assisted reverberation, using electronics to amplify and subtly modify sound, after he heard about a sub-par system that had been installed in a high-profile Auckland venue.

Dr Poletti says not all concert venues are created equally. Some may have poor acoustics, others may have good acoustics for a barbershop quartet but not for a full orchestra. Given that most modern venues are required to be multipurpose, acoustics often become a problem.

The answer? An electronic sound reproduction system that takes these imperfections into account and modifies the sound reproduction accordingly. Today, many multipurpose halls use just such a system.

With a strong background in fundamental acoustics research and having published several papers while working at Auckland University School of Architecture's Acoustics Research Centre, Dr Poletti was well prepared to enter the discipline.

"In my case, research for its own sake has really stood me in good stead. While at the Acoustics Research Centre, I was encouraged to undertake fundamental research not closely related to commercial work. This gave me a broad understanding that I was able to apply later on."

When a newly installed electro acoustic sound system at a well-known venue in Auckland received a lot of publicity because it was not performing to expectations, his interest led him to wonder if he could make something better.

After starting work at IRL, he developed a system for assisted reverberation that was licensed to a small US company (eventually bought out by Berkeley-based Meyer Sound), then embarked on a PhD in acoustics at Auckland University.

Renaming the system Constellation, Meyer Sound incorporated it into its product suite and initially installed it at the famous Zellerbach Hall on the University of California, Berkeley, campus.

Dr Poletti says while academic achievement doesn't always go hand in hand with commercial success, in his case it paved the way for the development of a commercial product.

"We had something like seven papers published on our system in some of the world's most prestigious journals. We also protected our intellectual property, as we realised we had something that was quite valuable commercially."

Dr Poletti's current research involves improving surround-sound systems and virtual acoustics, which involves making sound appear to come from any direction through the use of digital filters.

Among other things, Dr Poletti has created his own, eponymously-titled guitar amplifier. The Poletti is a solid-state amplifier that generates the particular type of distortion he prefers.

"You know what they say," he says. "If you want something done properly, do it yourself!"

"In my case, research for its own sake has really stood me in good stead. While at the Acoustics Research Centre, I was encouraged to undertake fundamental research not closely related to commercial work. This gave me a broad understanding that I was able to apply later on."

A deeper connection

IRL has teamed up with premier New Zealand-based marine electronics company ENL, with a long-term research partnership that's right in line with IRL's mission to boost New Zealand's economy through scientific R&D.

"IRL has core technology expertise that, when added to ENL's R&D engineering team, combines to produce a world-class R&D team with a proven track record of delivering innovative sonar products to our customer base."

Electronic Navigation Ltd (ENL) and Industrial Research Ltd (IRL) have signed a long-term co-funding agreement that promises to underpin next-generation innovation at New Zealand's premier marine electronics company and strengthen the country's advanced sonar systems capability.

The research partnership builds on an already fruitful ten-year collaboration and aims to deliver more successes like the Wide Angle Sonar Seafloor Profiler (WASSP), a unique seafloor mapping system now marketed in more than 20 countries.

ENL Managing Director Neil Anderson says he is confident that the agreement will significantly contribute to ENL's product development plans over the next five years.

"IRL has core technology expertise that, when added to ENL's R&D engineering team, combines to produce a world-class R&D team with a proven track record of delivering innovative sonar products to our customer base," he says.

The Advanced Sonar Technologies programme—which involves in-kind and direct co-funding from both parties—will deliver a number of new products incorporating innovations in the area of hardware design, transducers and signal processing techniques developed by both ENL and IRL teams.

"The new products will improve our customers' understanding of the marine environment—lowering their costs, improving their decision making, enhancing the marine environment through better resource use and improving vessel safety," says Anderson.

ENL first approached IRL more than ten years ago with a request to develop a sonar electronic module, after seeing a gap in the market for lower cost multiple beam sonars.

Where overseas tenders were unable to meet price and performance requirements, IRL's Electroceramics Lab was able to design a sonar transducer to comply with ENL's specification. It made the prototype and manufactured the first batch of 100 transducers, which ENL assembled, tested and further developed with the primary aim of use in the commercial fishing market.

All the while IRL continued building its expertise in sonar research and development, first under the Forward Looking Sonar (FLS) project and now under the Advanced Sonar Technologies programme (AST).

"The FLS project provided the opportunity to design and develop innovative electronic hardware, transducers and manufacturing technology solutions that are appropriate to ENL's present and future needs," says Dr Eugene Stytsenko, science leader of IRL's sonar programme. "This motivated ENL to continue collaboration with IRL in the sonar field."

In the process, ENL accumulated expertise and experience in the sonar technology field which allowed it to successfully absorb some of the results of the FLS project, says Dr Stytsenko.

The transducer manufacturing technology has now been transferred to ENL, which has set up a manufacturing facility, strengthening its position in the sonar market.

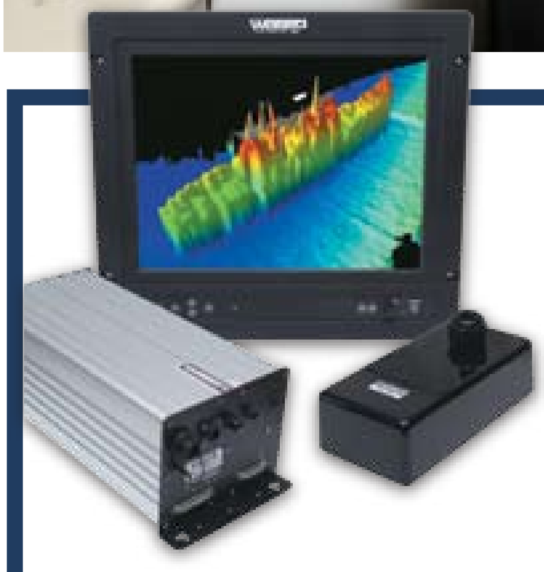
"The new agreement also provides IRL with the ideal ability to draw on ENL's knowledge of sonar market trends, current sonar technologies and market needs, and helps focus the research undertaken at IRL so that it is always commercially appropriate while simultaneously advancing our capability in the area," says Dr Stytsenko.

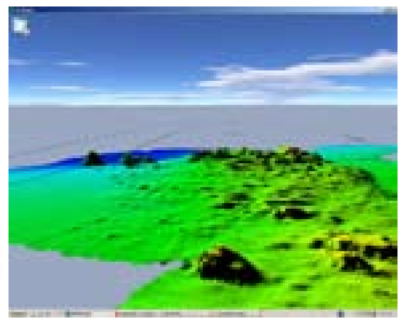
The research areas involved in advanced sonar span a number of different capabilities within IRL: electro-ceramics, acoustics, signal processing, electronic hardware, embedded firmware and software design. "This reinforces the strength of an organisation like IRL where capabilities can be combined in different ways to build a new, unique capability in a particular application area," he says.

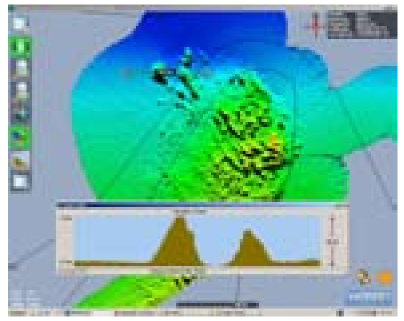
Says Dr Diana Siew, head of IRL's Engineering and Applied Physics group: "The investment from ENL means we have been able to effectively tailor a research programme for ENL and build an R&D partnership that will underpin future product innovation for the company."

WASSP Sales Manager Greg Fletcher (left) with ENL Managing Director Neil Anderson.

IRL research scientist Jeremie Barrell measures the WASSP transducer's electrical impedance in a water test tank (inset).







About WASSP

Key features of the WASSP (Wide Angle Sonar Seafloor Profiler) include a 120-degree sonar view of the water column, the ability to profile the seafloor and show where schools of fish are, and where changes in seafloor hardness occur.

SONAR GETS SMARTER

The Advanced Sonar Technologies programme applies multi-disciplinary capabilities within IRL to three main areas of sonar research: the development of new transducers, signal processing algorithms and electronic hardware.

- Sonar transducers are 'piezoelectric' devices that translate electrical signals into mechanical energy in the acoustic frequency range and vice versa. Applied underwater, and by combining the individual transducer elements into novel array geometries, it is possible to configure and control the propagation and reception of these acoustic 'beams' in ways that may be manipulated for the high-resolution detection of targets such as the seafloor, fish shoals and other artefacts.
- Signal processing techniques mathematically manipulate the sonar data in ways that improve overall sonar system performance. Advanced algorithms are applied in conjunction with transducer innovations to render two- and three-dimensional, high-resolution outputs for display.
- The sonar hardware designs provide the ability to convert multiple channels of digital data into multiple channels of electrical signals or vice versa. New design approaches maximise the use of digital technologies and provide flexible, cost-effective products. Hardware designs utilise innovations developed by new signal processing algorithms and transducer arrays.

Above: IRL's 3D scene-scanning technology in use. The operator works much like a spray painter, progressively covering the scene and recording the 3D data as a computer file.

Setting the scene for a 3D revolution

The IRL scene-scanner has blockbuster potential.

There is little doubt that 3D imagery is the way of the future, a fact borne out not only by the blockbuster success of recent 3D movies, but the keen marketplace interest in the latest trials of IRL's 3D scanning technology.

The most recent developments to the IRL scene-scanner mean it now has the potential to fill a significant gap in 3D scanner technology worldwide, according to IRL project leader Dr Robert Valkenburg.

"Now that we can perform mobile photo-realistic scanning of complex or cluttered scenes over a two-metre to 40-metre range, we are targeting structures that are difficult to scan by other means—for example retrofits within the marine, aviation and baggage-handling industries, where there are many obstacles and downtime is prohibitively expensive."

IRL's handheld scanner records 3D images in real time. The operator works much like a spray painter, progressively covering the scene and recording the 3D data as a computer file that can be processed for photo-realistic fly-throughs, scene re-examinations, measurement and digital manipulation.

This can prove invaluable in applications such as online merchandising, as-built engineering surveying, heritage and archaeology recording, artistic modelling, computer games, accident and crime-scene recording—in fact, anywhere that a 3D photo-realistic record is needed.

Potential end-user clients such as Glidepath Group, Integrated Marine Group and Altitude Aerospace Interiors are anticipating that the data from these new trials, made possible by additional funding from the Foundation for Research, Science and Technology, will be converted into a useful format for their application areas.

For Alex Tung, Engineering Manager with baggage-handling company Glidepath Group, the speed and mobility of IRL's scene-scanner are major advantages. "With digital images like this we would be able to precisely engineer the equipment on site, which cuts down significantly on rework. We have projects in almost 70 countries, so time is very precious—we want to minimise site time and keep costs down.

"We envisage the scene-scanner to be compact enough to be packed into a suitcase and taken to the site by one of our managers or engineers. This will allow us to take everything back that we see and makes the scene-scanner a very powerful tool."

Mark Wightman, Managing Director of superyacht refitting company Integrated Marine Group, sees the scene-scanner as a valuable device for streamlining its refitting processes.

"Invariably the vessel will not have all the drawings we require, or the as-built vessel varies from the drawings, so to have a tool that can quickly draw complex shapes in relatively confined spaces will create significant efficiencies in so many aspects of our work."

Making complete 3D scans of complex scenes has always been a challenge. Many scans taken at different positions were required, meaning compilation of the data was a complex process. The IRL team has overcome this problem by placing numerous small LED (light-emitting diode) beacons around the site or object being scanned. This allows the mobile scanner to track its position relative to the beacons, and results in one all-encompassing data file.

With its key attributes of speed, mobility, photo-realism and non-invasiveness, IRL's 3D scanner is unique and offers innovative opportunities in 3D content creation, says Dr Valkenburg.

"Once the trials are completed, we anticipate significant interest from investors and manufacturers keen to commercialise this technology in the global market."

With its key attributes of speed, mobility, photo-realism and non-invasiveness, IRL's 3D scanner is unique and offers innovative opportunities in 3D content creation.

Dr Bob Buckley (left) and Dr Jeff Tallon: New Zealand science legends.

A phenomenal pairing

Winners of the inaugural Prime Minister's Science Prize Drs Bob Buckley and Jeff Tallon represent between them a significant proportion of the world's expertise in high-temperature superconductivity—a developing technology predicted to be worth billions of dollars globally in the coming decades.

The pair's research partnership has outlasted governments, restructurings, name changes and funding fashions. They've lost count of the grant applications, the reviews, the talks and the interviews ...

It's almost 25 years since Drs Bob Buckley and Jeff Tallon first heard the astonishing news that the mysterious phenomenon called superconductivity had been discovered in a ceramic at temperatures far higher than previously thought possible.

This remarkable effect, in which some materials lose all electrical resistance, had once upon a time only been observed at temperatures as cold as outer space; this new threshold however was higher than the temperature of liquid nitrogen (-196 degrees Celsius or 77 Kelvin), a cheaply available coolant. The commercial potential this opened up was breathtaking.

Then it was Drs Buckley and Tallon's turn to astonish the science world, when they won the international race to identify a new wonder ceramic that was observed to produce the same superconducting effect at the even higher temperature of -163ºC (110K). That they were also the ones to patent the formula is one of New Zealand's science legends. It was a time of intense excitement.

Since then, Dr Buckley and Dr Tallon have patiently and single-mindedly pursued the goal of complete understanding of this phenomenon of high-temperature superconductivity, and have developed an array of applications for both new and existing magnetic and electrical devices, such as MRI medical scanners and transformers. Dr Tallon is building the theory through a comprehensive experimental programme, while Dr Buckley leads the team of more than 20 at IRL Gracefield, set on solving the technological problems associated with a fundamentally different, brittle conducting material that has to be kept at the right temperature. (The 'high-temperature' descriptor is somewhat misleading — 110K is still 163ºC below the freezing point of water.)

The pair's research partnership has outlasted governments, restructurings, name changes and funding fashions. They've lost count of the grant applications, the reviews, the talks and the interviews where they must explain, yet again, just how they felt to people who cannot really understand the quantum behaviour behind the incredibly complicated electron interactions that underpin superconductivity. The Marsden Fund grant application Dr Tallon put in recently—and received—is aptly titled 'Quantum Soup'.

A number of conditions have to be satisfied at the critical temperature at which superconductivity sets in. Here, the electrons abruptly transform from a chaotic rabble, dragged along by the electromagnetic field, into orderly pairs moving coherently in the same quantum state. From rock and roll to Viennese waltz.

Although these ceramic superconductors seem to behave quite differently from traditional low-temperature superconductors, as far as the relationship between the superconducting transition temperature and other parameters are concerned, Dr Tallon's achievement has been to see that they are no different—the relationship is just disguised. However the great mystery as to why the electrons pair up remains. (In low-temperature superconductors it is understood that the pairing is prompted by vibration of the atoms.)

When asked if investors' expectations of turning the science into gold are uncomfortable at times, Dr Buckley says it has not been "a negative pressure". At each stage, they have had a clear direction and simply concentrated on the next step. The flashes of insight are interspersed by 'head down' periods of slower tempo, and some inevitable dead ends. Scientists understand and accept that the timescales for these developments are counted in decades.

Although the euphoria of cracking the structure of the 110K superconducting ceramic was a once-in-a-lifetime thrill, the formation of the company HTS-110 Ltd and sales of products such as the first dipole magnet to Brookhaven National Laboratory in New York continue to give "a terrific buzz", says Dr Tallon.

Drs Tallon (left) and Buckley receive the Prime Minister's Science Prize from John Key.

The most nerve-wracking period, apart from worrying about another team beating them to the magic HTS formula, was hanging onto the patents through repeated legal challenges. The whole undertaking, particularly the crucial business relationship with American Superconductor Corporation, was at risk. It's been a long-haul journey.

Medals they have aplenty, but the recent award of the inaugural Prime Minister's Science Prize to both Dr Buckley and Dr Tallon has been a great encouragement to them personally and to the whole team. The future of the technology looks ever brighter as concerns about energy and the environment favour these new superconductors that offer a broad range of smaller, lighter, more powerful and efficient electrical products.

Super smart

About high temperature super-conductivity

Superconductivity is a phenomenon where some materials conduct electricity with no resistance or energy loss during the transmission process. While it would seem that high-temperature superconducting cables are very hot, they are in fact extremely cold and are termed high-temperature because they are comparatively much warmer than previously developed low-temperature superconducting materials, which operated at close to absolute zero—the temperature of liquid helium (-273 degrees Celsius). HTS technology operates at the relatively warmer temperatures of liquid nitrogen (-196ºC). The colder the materials are, the greater the financial cost, so the development of HTS makes superconducting technology a viable commercial proposition.

Standard measures

Researcher Jane Robinson, holding one of the Measurement Standards Laboratory's primary standard kilogram weights, which is stored under triple bell-jars to avoid it becoming contaminated. To her left is a chamber containing a high-accuracy mass comparator used to compare MSL's primary standard kilograms with other kilograms calibrated at the International Bureau of Weights and Measures in Paris and to generate part of the New Zealand mass scale. The chamber is used to thermally stabilise the mass comparator and to control the air density during weighings.

The weighting game

IRL's metrologists are taking a novel approach to bringing the kilogram—the last measurement to be based on a physical object—into the 21st century.

The Measurement Standards Laboratory of New Zealand, which operates within IRL under the authority of the Measurement Act 1992, has the vital job of ensuring the accuracy of a wide array of measurements crucial to New Zealand's competitiveness in the global economy, and that enable us to communicate technically and scientifically with the rest of the industrialised world.

Most of these measurements—known as SI units—can nowadays be defined according to fundamental constants of nature (such as the speed of light in the case of the metre).

However, one last measure based on a physical object remains: the kilogram, the base unit of mass.

This means that for MSL to calibrate its own kilogram measure, and measures derived from it, it must periodically send physical artefacts to the International Bureau of Weights and Measures (BIPM) in Paris, where the International Prototype Kilogram (IPK)—a platinum-iridium alloy artefact officially sanctioned in 1889—is stored in a triple-locked, environmentally monitored vault.

Compounding issues related to such a long calibration chain is the risk that because the kilogram is a physical object, its actual mass may be changing over time; indeed, evidence from copies around the world suggests it has done so by at least 50 micrograms over the past 100 years.

Little wonder then that scientists around the world are engaged in efforts to bring the kilogram into the fundamental fold, and find a way of redefining it according to an unchanging, natural constant.

"A key aim of this research is to have several different experiments that give results for the Planck or Avogadro constant that agree within an uncertainty of five parts in 100 million," says MSL researcher Chris Sutton, the distinguished scientist leading the New Zealand drive to find a solution to this problem. "This is quite a challenge, but the international metrology community will not move to redefine the kilogram until it is achieved."

Across the Tasman, in collaboration with institutes in Japan, the USA, Germany, Belgium and Italy, scientists are looking at ways to link mass to the Avogadro constant—defined as the number of atoms in exactly 12 grams of carbon-12—using a single, pure silicon crystal sphere. While this research is close to achieving the target uncertainty for the Avogadro constant, it is unlikely to offer a practical realisation of the kilogram. "A silicon sphere is itself an artefact," says Sutton.

At IRL, Sutton and colleagues are instead designing an apparatus—known as a Watt balance—using pressure balances as a weighing device for an experiment to measure what is known as the Planck constant, as a route to redefining the kilogram away from a physical object.

"We have chosen to follow the Watt balance approach but with some design concepts that differ radically from existing Watt balances. Through this we hope to contribute to research on improving the value for the Planck constant. Then, once the value for the Planck constant is fixed and the kilogram is redefined in terms of this fixed value, we will be able to realise the kilogram in New Zealand in terms of this new definition."

MSL researcher Chris Sutton next to a traditional beam balance, of a type used for early weighings with the international prototype kilogram.

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Joint effort

Developed by IRL, this handheld dynamometer measures the amount of strength and the range of movement achieved by the joints or limbs of patients recovering from injuries such as stroke. IRL researchers engaged the services of the Taiwanese Industrial Research Institute (ITRI) to significantly reduce the cost of production and are now seeking business partners to commercialise the technology.