Smart Ideas Phase 1 - 2015 Science Investment Round Successful Proposals

Short Title	Organisation	Term (yr)	Total funding (excl GST)	Summary
Modular solids and nutrient extraction: A low capital cost solution for upgrading one the world's most common environmental protection systems.	Massey University	2	$693,275	Name any small town/community in New Zealand, look at what stands between its wastewater and the environment and almost every time you will find an algal waste stabilisation pond (WSP). Indeed pond treatment is used in tens of thousands of applications serving millions of people across the globe. Why have these systems grown so widespread? Because they are simple and efficient. While WSPs offer simplicity, they incorporate a host of complex and diverse mechanisms that work to treat and cleanse polluted waters before their return to our environment. These mechanisms act to oxidise organic wastes and, if configured to do so, can achieve very high levels of disinfection. But as increasing levels of environmental protection are demanded, the Achilles heel of these otherwise highly effective systems is exposed. Unfortunately ponds are poor at removing the nutrients that lead to excessive weed growth (eutrophication) of waterways. Furthermore, while growth of algae is a critical part of the cleansing process inside the treatment pond, these solids in their own right 'cloud' the effluent and contain quantities of organics and nutrients that are then discharged into our streams and rivers. Alternative processes do exist. Perhaps the most common alternative is dosing of industrial chemicals such as aluminium sulphate, ferric chloride and polymers into the pond effluent to create small 'lumps' of chemically bound waste. These solids then need settlement and extraction as a sludge and ongoing trucking to and dumping into landfills. While effective, this all adds significant cost and complexity to a previously very simple system. Another option is to abandon the ponds altogether and build new more high tech systems. But this means wasting the hundreds of $millions already invested into building ponds and raising rates to fund the construction and operation of the new systems. Most significantly our communities lose the advantage that made ponds so popular and widespread to start with – their simplicity. Operators of WSPs, such as local councils, are caught between intense pressure by environmental regulators to upgrade treatment while serving communities that struggle to fund the massive upfront capital expenditure needed for alternative treatment processes. Professor Shilton of Massey University is an expert in pond treatment technology and indeed produced what has been called the 'definitive textbook' in the field. He has conceived a novel solution that compacts key removal mechanisms for solids, phosphorus and nitrogen into a series of low cost, replaceable modules. Similar in size to large suitcases, these modules would simply slot in at the exit from existing pond systems to immediately provide markedly improved effluent quality and allow for easy recycling of the nutrients back to land. The real value of this proposition is that it is low in capital costs and most importantly maintains overall operational simplicity. "Simplicity is the ultimate sophistication." Clare Boothe Luce In this project a team is built that includes Dr Bickers of Watercare to ensure continuous 'end user' engagement as well as engaging one of New Zealand's most innovative filter manufacturers, Revolution Fibres Ltd, to keep the research on track for the next phase that would see the modules developed for production, sales and export.
Simple, automated nucleic acid extraction for point-of-care diagnostics	University of Otago	2	$999,999	Point-of-care diagnostics that rely on complex molecular tests have the potential to revolutionize healthcare. Currently complex tests, such as the Polymerase Chain Reaction (PCR), are performed in centralised laboratories. Clinical samples are transported to these laboratories where they are queued for testing. This delays the notification of results to healthcare professionals and to the patient, typically requiring a return visit before appropriate treatment can commence. This carries with it a risk of loss of the patient to follow up, particularly in low-resource settings. If health professionals are able to test patients on site and determine the correct course of treatment immediately at the first visit (i.e. at the point-of-care), there is no longer a risk of loss to follow up and health outcomes are greatly improved.

				It is now possible to perform complex molecular tests at the point-of-care. New technologies are available, like the Freedom4 PCR device from Ubiquitome Ltd, that deliver high-quality results in the field. However, sample preparation, that is purification of nucleic acid (DNA or RNA) from the patient tissue, is challenging. This step is critical for high quality diagnostic data to be produced from PCR devices in non-laboratory settings. PCR works by detecting specific sequences of DNA. Techniques for purifying nucleic acid are complex and not easily performed outside of a laboratory. This is a constraint for the use of portable PCR devices for point-of-care diagnosis, restricting their use to highly trained specialists. This is a serious barrier that limits the potential of point-of-care diagnostics. Our Smart Idea is designed to overcome this barrier. We have conceived a small battery powered device that collects a sample, purifies the nucleic acid and delivers it to the point-of-care device for testing. Our Smart Idea consists of only two parts: a disposable Extractor Tube that contains all of the reaction components for nucleic acid purification, and an automated Nucleic Acid Extraction Device that incubates the sample preparation mix and delivers the purified nucleic acid to a collection vessel. The automated Nucleic Acid Extraction Device has no moving parts and reduces potential cross contamination of samples making it robust and very simple to use. Our Smart Idea has the potential for significant benefits for New Zealand. The demand for point-of-care diagnostics for infectious disease is a rapidly growing market, with an estimated value of $1.8 billion dollars by 2017. Our Smart Idea could be used by all point-of-care devices that use nucleic acid, providing us a substantial potential market for the invention. We can further exploit this by developing a product and consumables stream that adds to this exciting economic opportunity for New Zealand. In addition, enabling effective point-of-care diagnostics will have a flow on effect by reducing healthcare costs through early and appropriate treatment interventions and enabling greater participation in screening programmes, like HPV screening for cancer prevention, in remote and low-resource settings. Our Smart Idea reaches beyond healthcare into all sectors of agriculture, environmental monitoring, border security, and disease surveillance, to name a few. Once it is possible to simply and reliably purify nucleic acid from samples in-field and with limited operator skills, and point-of-care complex diagnostics will become a much more accessible and cost-effective reality.
Parasite strippas: Tricking infective parasite larvae to exsheath on pasture.	AgResearch Limited	2	$978,662	This smart idea represents a quantum change in approach to controlling and managing internal parasites – the biggest animal health issue for most New Zealand pastoral farmers. By using lessons from the emerging field of biomimicry, we intend to develop a solution that will neither involve treating animals nor require changes in pasture and grazing management strategies. It will have a superior impact on parasite load without detrimental effects on pasture, livestock or other free-living, beneficial invertebrates in the environment. It will result in many fewer parasite larvae on pasture, a significantly reduced risk of infections and markedly increased growth rates in grazing livestock. Our smart idea is deceptively and intuitively straight-forward, and - based on scientific literature and patent searches – completely novel. Internal parasites are a major issue for all livestock farmers in New Zealand, costing the New Zealand economy more than $700M p.a. Losses include reduced health and productivity of parasite-infected animals and the cost of treating animals to reduce parasite burdens. Currently, the majority of farmers rely almost exclusively on treating the animals with anthelmintic drugs, but increasingly the effectiveness of these is threatened by the resistance of parasites to them. While some new drug classes have recently come to market, these are much more expensive, and resistance to one of these is already present in New Zealand. This problem is an issue for livestock farming worldwide. Thus, benefits will not only accrue to the sustained productivity of New Zealand pastoral farmers, but to export revenue for New Zealand businesses manufacturing and marketing this solution to livestock farmers overseas.
Chemical camouflage to protect vulnerable native prey from introduced predators	Landcare Research New Zealand Ltd	2	$984,300	Introduced mammalian predators have wrought havoc on New Zealand's native animals. Many of our birds have evolved behaviours that defend them from native avian predators, which hunt mostly by vision, but not from introduced mammals, which hunt mostly by smell. This has created a behavioural mismatch between the predators and vulnerable native species, and the results have been devastating. We will test the idea that vulnerable birds can be protected by using odours that smell similar to them to reduce the hunting success of mammalian predators (cats, mustelids, hedgehogs, rats). For example, before birds settle in an area to breed, we will deploy a readily-available generic bird odour, like chicken or quail odour. Predators will investigate the odour but receive no food reward. After several weeks, predators will lose interest in investigating the odour, and we will have deceived them into thinking that bird odours are no longer a profitable cue for food. When birds begin nesting, predators will have a reduced interest in investigating the cue. Naturally, predators will 're-learn' that bird odour can sometimes result in a reward, so the idea is to give birds a 'window-of-opportunity' to breed successfully

				before re-learning begins. Additional use of generic bird odour during the bird breeding season will reinforce for predators that bird odour is not always associated with food, by creating a confusing surfeit of real and similar bird odour. If some predators continue to forage near nests, they will be unable to focus on cues that would lead them to nests, allowing birds to breed more successfully for a short period. This form of 'chemical camouflage' is a novel technique for protecting valued fauna from scent-hunting predators, and should be particularly applicable to threats to native species from introduced mammalian predators, a problem faced not just in New Zealand but worldwide. The technique is well suited to situations where there is a need to protect vulnerable prey during critical time-periods. For instance, birds are particularly vulnerable during nesting or after translocation when they are 'settling in' to a new location.
Anti-Foul Marine Paints	The Research Trust of Victoria University of Wellington	2	$1,000,000	Biofouling is the growth of seaweed, barnacles and other sedentary organisms on marine structures and is a major problem for maritime industries. Biofouling causes economic and environmental losses, and the principal method used to combat biofouling is the use of biocides in paints. However, environmental concerns and legislative restrictions are driving technological and scientific innovations to provide solutions to this persistent problem. Fouling causes powering losses of up to 86%, so to maintain shipping speeds more fuel is consumed leading to higher greenhouse gas emissions. The dominant approach to dealing with biofouling has been to include biocides in the paint used to coat the hulls of ships. The use of tributyltin is now banned in most jurisdictions and additives such as copper are coming under similar scrutiny. These metals are toxic to the organisms that are responsible for biofouling. But they also leach into the environment and cause unintended problems to non-target organisms such as shellfish. This research project aims to produce paints which are capable of reducing or avoiding biofouling of ships' hulls. Our new paint will possess all of the benefits of existing pre-loaded paints but with none of the drawbacks associated with leaching of heavy metals into the environment.
Treating polyglutamine diseases with synthetic dendrimers - PEEs and Qs in the mind	The Research Trust of Victoria University of Wellington	2	$1,000,000	This research aims to produce a novel, safe and effective treatment for some or all of the nine known polyQ diseases which currently do not have a cure. PolyQ diseases, the most well-known of which is Huntington's, are genetically inherited rare diseases (they affect around 1 in 10,000 people worldwide) where a protein is expressed with an extended uninterrupted region of polyglutamines. Abnormal interactions of these extended polyQ regions cause neurodegeneration. Our aim is to develop a new class of dendrimer-based drugs to treat polyQ diseases. Dendrimers are synthetic tree-like macromolecules and our product will be based on our proprietary PEE-G dendrimers. These dendrimers will be designed so that they are able to pass through the blood-brain barrier, are non-toxic and effectively slow down or inhibit abnormal interactions of the polyQ regions. This New Zealand owned drug will be manufactured in this country and have health and associated economic benefits for a debilitating class of diseases in an aging population.
Agricultural plastic mulch film with nitrogen-fixing capability	Lincoln Agritech Limited	2	$1,000,000	This Smart Idea is a completely novel approach to reduce farming's reliance on mineral nitrogen fertilisation, and resultant nitrate leaching, by developing a material that catalyses nitrogen fixation directly into the soil. The new product will be a spray-on mulch functionalised with nitrogen-fixing bacteria and photocatalysts that, together, will convert atmospheric nitrogen into nitrate and ammonium available for plant growth. This will deliver to the Agritechnologies Investment Priority by developing a NZ-made novel export agri-technology, with predicted returns to NZ of US$20-50M p.a. by 2025 from the sale of materials. World-wide, farmed soils are naturally deficient in nitrogen. Farming is currently reliant on applying mineral nitrogen fertilisers – an unsustainable and costly process that also contributes to eutrophication of water bodies, and increases risks to human and animal health from elevated nitrates in vegetables and drinking water. Our new, biodegradable film will allow growers to maintain productivity, while meeting the increasingly stringent regulations being imposed globally to reduce nitrate leaching and pollution. Mulch films are commonly used over soil, on 4.5 million hectares around the world, to enhance germination and growth of crops, speed time to harvest, reduce reliance on herbicides and pesticides, and reduce water use. International market research shows a growing demand by horticulturists for mulches that can be applied through spraying: they facilitate easy application and coverage using existing spray technology, and harden in place. In addition, there is demand for biodegradable mulch so that no residual plastic remains after harvest. Our technology will provide a spray-on and biodegradable mulch with the additional benefit of in situ nitrogen fixation, while minimising the environmental impacts of applied nitrogen. Lincoln Agritech Ltd, in collaboration with the Institut des Sciences Chimiques de Rennes at Rennes University (France), University of Canterbury, and Plant and Food Research (Lincoln), will undertake the research project in collaboration with chemists from Resene.

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Developing sustainable fish aquaculture foods from seaweed	University of Auckland	2	$990,500	Providing suitable feeds for finfish aquaculture is a growing global challenge for humanity, especially given the rising economic and environmental costs of the capture fisheries required to supply the fish meal essential for growth of cultured fish. For example, the World Bank projects a 90% increase in the price of fish meal by 2030, while food fish aquaculture production is projected to grow from 47 to 93 million tonnes. Both of these statistics are of concern for the world's food supply. Intestinal microbes are now understood to be critical for health and nutrition in all animals, including humans, and we have studied these interactions in marine fish. Our Marsden-funded work on protein nutrition in wild seaweed-eating fish, including the commercial species butterfish, has shown (a) that microbes resident in the fish gut convert atmospheric nitrogen into microbial protein in the same way that root nodules of leguminous plants fix nitrogen into soils, and (b) that these microbial proteins are taken up by the fish and provide an important source of protein in addition to dietary seaweed. Our novel idea is to develop batch cultures of the microbial communities from the gut of these fish to produce finfish aquaculture feeds from waste seaweed that we know support growth in wild fish populations. This would circumvent (a) the economic and environmental costs of feeding capture fish to cultured fish, and (b) the problems of using terrestrial protein sources that can contain compounds that may interfere with digestion, and/or lack critical nutrients for growth of cultured fish.
Hyper-loupe: A snapshot on food micro-structure	AgResearch Limited	2	$1,000,000	Production of dairy powders is critical to New Zealand dairy industry because it extends shelf life of the product, facilitates transport and enables many different uses for milk products. Investments to increase the capacity to produce powder in New Zealand since 2010 were just over $1.4b. Dairy powders represent close to $7.8b in annual exports (2012). The success of this industry is closely linked with internationally recognised quality and safety standards. In drying the milk, droplets are transformed into solid particles with characteristic surface properties and composition. The shape of powder particles, their size distribution and aggregation depend on the type of raw material, degree of heat treatment and compositional and processing parameters. The distribution of particle sizes, morphology and aggregation of particles as well as composition of the particles are factors that directly affect properties such as: flowability, rehydration (wettability, sinkability, dispersability), ability to promote gelling/whipping/foaming, and stickiness. The microstructure of particles is currently assessed with a suite of microscopic techniques, and functionality is assessed through chemical assays, both of which are too laborious for routine analysis and cannot be done in real time in the factory. Our idea represents a novel approach to obtain microstructural information of dairy products rapidly, easily and cost-effectively using a hyperspectral device. This method will replace the multiple techniques currently used and, most importantly, it can be used on the production line to get immediate results for multiple parameters simultaneously. A novel modelling approach will be used to mathematically extract microstructural information from data produced in this device and use that information to assess powder functionality, authenticity, freshness and shelf life. This approach is globally novel and the underpinning mathematical model that will be developed will be protectable. This model will be embedded in a hyperspectral device that is portable (i.e. adaptable to different industrial environments) to be used at dairy processing plants for process optimization, quality control and product development.
Biofilm resistant materials for use in medical implants	The Research Trust of Victoria University of Wellington	2	$1,000,000	In 2015 it is estimated that 3.69 million surgeries, associated with orthopaedic implants (neck, hip, knee), will be carried out worldwide. This number is growing because of active and/or obese elderly and longer lasting implant materials therefore encouraging younger patients to have implant surgery. Although the infection rate resulting from this type of surgery is relatively low at 1-2% the cost and time (hospitalisation, revision surgery and months of antibiotic treatment) involved in treating the thousands of infections around and on artificial joints means that billions of dollars could be saved on an annual basis - the cost of treatment in the US alone is more than 3 billion USD per annum or 50,000 USD per patient per annum. Artificial hip and knee joints are engineered (surfaces roughened to improve integration into the bone) and implanted into the body (surgery) in such a way that they often "smuggle" bacteria inside patients. This can lead to the development of what are called biofilms and consequently infections which require surgery to remove and replace the implant. Biofilms are produced by bacteria to protect themselves from antibacterial attack by the patient's immune system and antibiotics, which would otherwise protect the patient from infection. Our aim is to design and build a material for artificial joint manufacture that is resistant to biofilm formation using coatings that entrap two novel classes of drug. These coated materials would revolutionise the orthopaedic implant industry and lower the incidence of infection arising from surgery. We have two novel, complementary, drug classes that prevent biofilm formation. We aim to coat titanium, used in the construction of artificial joints, with these drugs using a variety of strategies. The strategies used for coating will be ones that physically entrap the drugs on

				the titanium surface in such a way that the structure and activity of the drug is not compromised and ensures the release of the drugs at an appropriate rate into the body and around the area of surgery. We will assess the entrapment and structure of the drugs through a series of established physical methods that indirectly allow us to assess their chemical structures. We will study the bioactivity of the coated material in an idealised biofilm assay against three bacteria (Staphylococcus aureus, Staphylococcus epidermidis, and Pseudomonas aeruginosa). These bacteria are responsible for the majority of biofilms and infections . We envisage that the coating technology being investigated and the resultant materials described in this proposal will provide NZ manufacturers with a market-edge and will have significant benefits for the NZ public and the health system. For more information please contact Professor Gary Evans (gary.evans@vuw.ac.nz).
Portable NMR sensor technology for brain oxygenation monitoring	University of Otago	2	$1,000,000	The brain is exquisitely sensitive to the effects of oxygen starvation, and even brief periods of brain hypoxia can lead to death or permanent disability. The direct and indirect costs of hypoxic brain injury due to stroke and brain trauma are estimated to exceed $700 million by 2015. But when brain oxygenation is compromised, clinicians almost always rely on crude proxy measures such as blood pressure or peripheral oxygen levels to guide therapeutic interventions. Currently, any targeted measures of tissue oxygenation are invasive, need access to sophisticated and costly imaging studies, or cannot monitor deep into the brain. Our interdisciplinary team of physiologists, physicists, biomedical engineers, and critical care clinicians propose a radically different solution to these problems. We will combine technological innovation, bench top simulation, and preclinical modelling to develop nuclear magnetic resonance (NMR) sensors that can measure brain oxygenation. Our proposed technology will enable clinicians to ‘see’ regional brain oxygenation, target treatments, and reduce the high rates of morbidity and mortality associated with hypoxic brain injury. It would also be non-invasive, affordable, and portable. As recovery of brain tissue is time-critical, this is especially relevant to regional or rural hospitals serving our most disadvantaged populations. So our smart idea of bringing NMR technology to the bedside has the potential to transform clinical management of brain injuries and lead to the creation of high-value devices that could be manufactured in New Zealand and exported globally.
Modulating pathogen-host communication - new targets for antimicrobials	University of Auckland	2	$999,346	This project will develop an entirely novel strategy to treat infection based on our discovery of a new way for bacteria to interact with human cells during infection. In 2014, the World Health Organisation (WHO) reported antibiotic-resistant bacteria as a worldwide problem. Director General of the WHO, Margaret Chan, called this “...the end of modern medicine as we know it”. The WHO predicts within ten years antibiotic resistance will make routine surgery and cancer treatment life-threateningly risky. Without antibiotics, child-birth will once more become a major cause of death for women and an infection from a simple cut could be deadly. Surprisingly antibiotic research in recent years has been underwhelming. The major pharmaceutical companies have largely ignored this issue to find and develop new drugs. In some cases discovery of new targets has been considered too hard from a cost/benefit perspective for such large companies. This is slowly changing with a number of small companies now active in this space. So part of the solution is to continue to identify strong and novel new targets for anti-infective agents and enable small to medium size companies to develop them. In accord with the industry and clinical need, our Smart Idea proposal is focussed on disrupting a special type of communication occurring between the infecting bacterium and our cells. The interaction between bacteria and their host during infection is complex. A range of signals mediated by proteins, peptides and small molecules are well-recognised as mechanisms for bacterial manipulation of the host. In this Smart Idea we are proposing to develop a radically new type of antibiotic which looks to target special combinations of nucleotides similar to DNA, called small RNAs, that are released by bacteria to act as signals as they invade the host tissues. These small RNAs alter the way the host cells react to changes in their environment, like a new infection. In order to design our antibiotics we will screen the profiles of the small RNA molecules released from bacteria, looking for combinations that can alter human cells to favour bacterial infection; we call this subversion of the host cell. Our project will culminate by showing we can disrupt subversion of the host cell to favour resolution of the infection by targeting the small

				RNAs that mediate this communication. We offer two major outputs: First is a new paradigm in biology related to small RNA communication between bacteria and host that will be used to generate a series of therapeutic targets. Second, and most important, is the basis for the development and testing of a completely new class of anti-infective directed at disrupting the small RNA mediated, bacteria-to-host communication. We will use our group's expertise to develop compounds that interfere with bacterial small RNAs as a first drug approach exploiting this new biology. This project is in the hands of a team of investigators that comprises all the necessary skill sets to complete this project and includes clinicians, molecular biologists, microbiologists and bioinformaticians.
Evanescent Sensor for Improved Quality Control of Fruit, Vegetable and Pasture Crops	Lincoln Agritech Limited	2	$1,000,000	This programme will develop new techniques to image the fine scale structure of moisture distribution within vegetables and fruit, to give growers the ability to assess the quality and ripeness of their crop before committing to harvesting and for production line companies to improve sorting and grading of produce during processing. To do this we will develop a unique high resolution microwave system utilising a part of the electromagnetic field known as the evanescent region together with a negative refractive index lens to focus and scan agricultural produce over its entire volume to a spatial resolution of 2 mm3. Most systems using electromagnetic waves for imaging are diffraction limited, meaning that their ability to resolve detail is limited to the order of the signal wavelength. Using shorter wavelength signals to resolve smaller dimensions comes at the cost of increased absorption of its energy as it passes through the target media and thus loss of detectable signal. To avoid the use of high energy sources and overcome this energy loss we utilize the relatively unexplored part of the radiated field known as the evanescent (or near) field. This short distance field has the remarkable property of resolving well beyond the usual diffraction limit to values of spatial resolution 100 - 1000 times greater than that of the normal (far) field. We will use a 1GHz frequency (wavelength = 30 cm) evanescent field generated by a rectangular waveguide to penetrate fruit and vegetable produce up to 10 cm and with a potential spatial resolution between 0.3 - 3 mm. The resolving power will be increased by the use of a metamaterial lens (negative refractive index) that can be adjusted to enable scanning over the volume to provide a 3 dimensional moisture content and dry matter map to an accuracy of 1%. Defects in produce can also be easily resolved with this type of precision. The dimensions and operation of the probe allow for a hand held device that can be used in the field to assess dry matter content of fruit and vegetables, a critical measure of quality, to aid in harvest date decisions and limiting fruit loss, growing conditions and the detection of internal defects. A similar version will also be available to scan across processing lines providing the same information. In this case a larger version (lower operating frequency) can be constructed to increase the operating distance up to 1 metre or more. CONTACT Lincoln Agritech Ltd, PO Box 69133 Lincoln Christchurch 7640 Phone: +64 3 325 3700 Fax: +64 3 325 3725 Email: info@lincolnagritech.co.nz
A device for assessment of visual function for use with young children	University of Auckland	2	$999,986	If eye problems occur in early childhood they can affect the development of the brain areas that are responsible for sight and cause lifelong visual impairment. In addition, vision problems can affect the development of fine control over arm and hand movements and, in older children, impact on education. Many of the eye problems that affect young children can be treated effectively, however detecting these problems is challenging. Young children find it difficult to complete standard tests of vision because these tests require high levels of attention. Many tests also involve recognising shapes and letters and are therefore not suitable for young children. To address this problem we are developing a new computer-based vision test suitable for use with children as young as 2 years old. The test is simple and easy to use; carefully designed moving patterns are shown to the child that cause a reflexive, involuntary movement of the eyes if the child is able to see the pattern. At the same time we record the movement of the eyes with a video camera attached to a computer and the software we are developing will identify whether the child is able to see the pattern or not. Finally, the visibility of the pattern will be varied to measure how well the child can see.

				This MBIE funded research will enable us to develop our technology and perform clinical tests in ophthalmology and optometry clinics in New Zealand and internationally. The overall aim of this research is to produce a device that can be used to rapidly and accurately test vision in young children to allow for the early detection and treatment of vision problems. The device will be appropriate for use in eye-care clinics and school screenings as well as settings such as Plunket rooms and pre-schools.
Total over 2 years			**$13,646,068**	