ScionConnections

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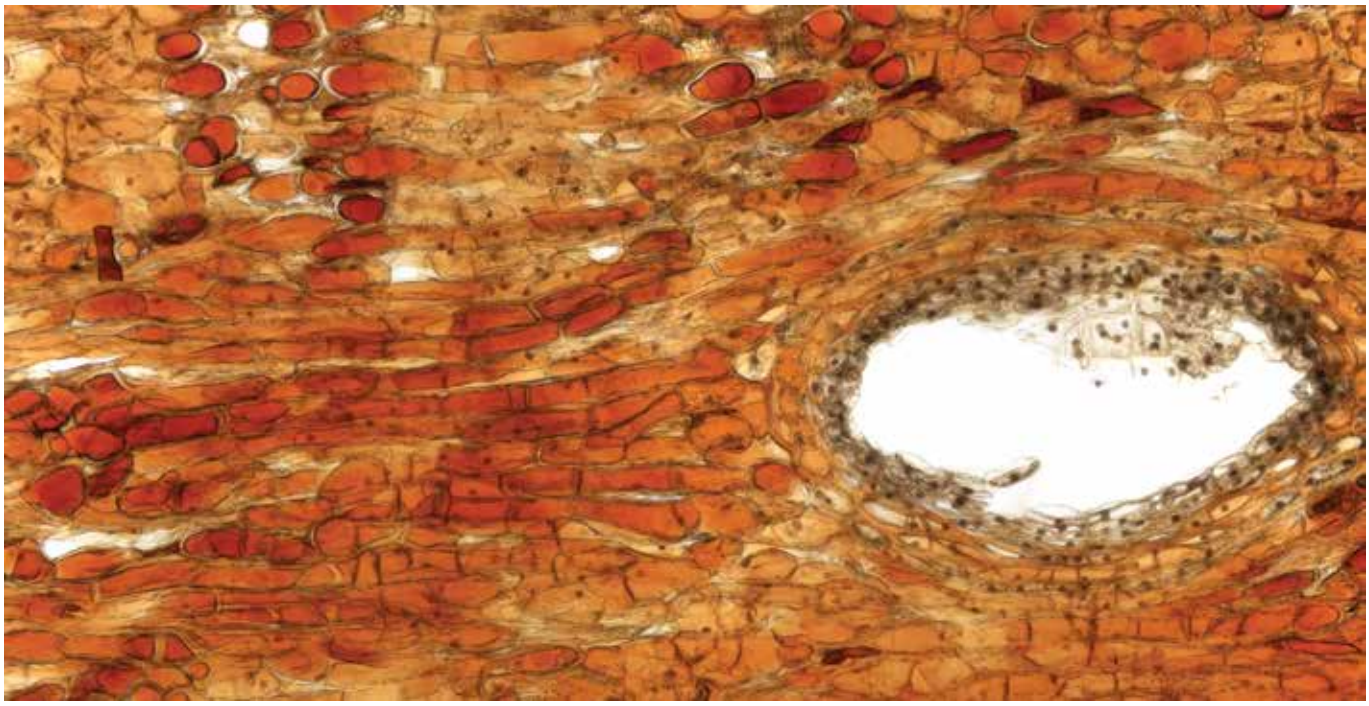

IMAGE: LLOYD DONALDSON

A thin section of radiata pine bark displayed using light microscopy. The red colour comes from tannins in the bark cells. The large hole is a resin canal, which produces chemicals that protect the tree from insects and fungal pathogens. 100x magnification.

Bark: A building block for a circular bioeconomy

As New Zealand adapts to a world living with the effects of climate change, Scion is helping to solve challenges that arise and to support the transition to a new economy focused on sustainable design and renewable resources. The 'bark biorefinery' is one piece of this much larger jigsaw.

Working with industry, international science networks and a diverse group of stakeholders, we are using advanced technology and science to create solutions for global and New Zealand problems such as our reliance on fossil fuel-based products. Biorefineries and specifically bark biorefineries will form an important part of this strategy and become a critical step in our move towards a circular bioeconomy while meeting many of the Government's goals for an environmentally and economically sustainable future New Zealand.

The project

Bark biorefinery technologies provide a new economic opportunity to convert an underutilised waste stream into a range of high-value materials and products. These could earn an estimated $400-600 million per annum and contribute $1.8 billion to New Zealand's GDP. With infrastructure and relevant policies in place, regional biorefineries have the potential to add several thousand new regional jobs by 2050.

Coming up with methods that can extract and refine high-value chemicals and create new products in a bark biorefinery is at the heart of our new five-year Scion-led research programme supported by the Ministry of Business, Innovation and

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Forests will be the essence of our bioeconomy

Not so long ago, in New Zealand, the words 'bioeconomy' or 'circular economy' were rarely seen or heard in the public domain. Now, these words are appearing in trade and mainstream publications as the concepts become socialised.

In February, *NZ Business* magazine ran an article titled "Constructing our circular economy". It described the waste that accumulates on a building site and introduced circular solution thinking as the way to reduce the huge cost to our economy and environment from dumping of demolition and construction waste.

We all know about the environmental damage wreaked by plastic waste. The discovery last month of a plastic bag and lolly wrappers at the bottom of the 11-kilometre deep Pacific Ocean's Mariana Trench is unwelcome news.

Clearly the linear, fossil-fuel based economy has had its day. Consumers are calling for action, and at Scion we are helping manufacturers respond with R&D in areas like packaging and biodegradation testing.

While many nations are ahead of us with bioeconomy strategies and embedded sustainable development principles, New Zealand can learn from their experiences and adapt our response to suit our needs.

In our "Strategy to 2030", Scion has defined the 'bioeconomy' as encompassing:

- the production of renewable biological resources, and
- their conversion into food, feed, biobased products and bioenergy via innovative and efficient technologies.

And, when the waste from one process becomes the feedstock, or raw material, for another, we have a circular bioeconomy.

Åsa Ek, CEO of Finnish company Cellutech, has said, "Everything that is made from fossil-based materials today can be made from trees tomorrow"… this statement sums up my vision for the bioeconomy and Scion's mission to make this real.

I believe the future for New Zealand is bright if we embrace the bioeconomy movement, and we can benefit on the global stage more so than under the old fossil-fuel economy. My passion for this was super charged a few weeks ago at the inaugural Ōhanga Āmiomio Pacific Summit hosted by the Ellen MacArthur Foundation. See "Indigenous worldviews and the circular economy" on page 6.

In partnership with the Ministry for the Environment, Scion brought this summit to Rotorua – a location poised to be New Zealand's hub for circular bioeconomy leadership and action. Scion's role in this was affirmed by an invitation received by the Ellen MacArthur Foundation to join a panel discussion on biomaterials at the foundation's London Summit this month. Needless to say, we are participating.

New Zealand's advantage in embracing the circular bioeconomy is many-fold. We can grow renewable biological resources, like trees, very successfully and we have unproductive land for such growing. We have a relative blank canvass for new industries, especially in regional New Zealand. Plus, we have proven R&D and innovation prowess.

Åsa Ek, CEO of Finnish company Cellutech, has said, "Everything that is made from fossil-based materials today can be made from trees tomorrow". For me, this statement sums up my vision for the bioeconomy and Scion's mission to make this real. That journey has started with current technologies like the new 3D printer filament we reported on in this newsletter a year ago. Made from a Scion-developed compound containing New Zealand pine, the filament is 100% biobased and compostable, and sold by a local firm.

Our new research programme to create a 'bark biorefinery' is inspiring. Essentially, we will develop technologies to convert millions of tonnes of bark into high-value materials and products, create new regional jobs and contribute markedly to our GDP. See our article on page 1 to learn about this transformational concept.

Trees will be the mainstay of a New Zealand bioeconomy. Scion's vision – Prosperity from trees - is so apt. Trees are the ultimate renewable resource. They are carbon sinks, they are living factories, they are mini ecosystems in themselves and forests of trees provide many ecosystem benefits.

That's why I'm privileged to lead Scion and be part of the movement towards a bioeconomy for our country. I believe in "The right trees, in the right places, for the right purposes, from permanent forests stabilising land and capturing carbon, to forests for manufacture of high-value products, through to short-rotation energy forests".

I welcome your thoughts on this topic and any other matter raised in this *Scion Connections*.

Dr Julian Elder
Chief Executive

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Students used open-source 3D modelling software Blender to model their kūmara.

3D printing brings kūmara history to life

The humble kūmara has a special place in many Kiwi households, but its place in history and importance to Māori is less well known.

Scion is working with Kai Rotorua and Rotorua Boys High School to bring kūmara history to life.

Beginnings

Te Arawa stories tell of the kūmara voyage from Hawaiki to New Zealand in the kete carried by Whakaotirangi. Despite trials at sea, most of the kūmara varieties stored in the kete made it to Maketū, and on to Mokoia Island in Lake Rotorua. There, kūmara flourished in the gardens of Te Arawa settlers.

These beginnings formed part of the kōrero led by Te Rangikaheke Kiripatea of Kai Rotorua in this project. Kai Rotorua is a non-profit organisation that has been working to reconnect people with Papatūānuku, and create a resilient, well nurtured, well connected community.

In 2016, Kai Rotorua initiated a project with Rotorua Boys High School that connects learning about kūmara history and mātauranga with hands-on learning about growing and harvesting. This year, Scion joined the team to add our 3D printing capability to the project thanks to funding from MBIE's Unlocking Curious Minds.

"To grow and harvest the kūmara. To grow the tipu (seedling). That's how it began. But there was something else inside of that mix. We needed to reach our young men at another level and that was Unlocking Curious Minds, which meant taking their learning to that other level. Another sphere. Tapping into the science of it, where our students, including iwi Māori through them, remain connected to this taonga. Unbroken," says Te Rangikaheke.

3D modelling

Dr Roya Rezanavaz is leading the project team for Scion. Her experience in 3D modelling and printing of complex geometries with different types of 3D printers brought her to the project. Roya says, "We want to provide students with a practical opportunity to engage in science and technology using their own cultural heritage and show them how to become a bridge between western science and mātauranga Māori."

After harvest, students attended history tutorials with Te Rangikaheke and then went on to 3D modelling and 3D printing workshops led by Roya and colleagues Drs Dawn Smith and Ali Nazmi.

Ali explains, "Our work with the boys will help get a basic understanding of how to use 3D modelling software, to model kūmara and prepare a model for 3D printing. This will hopefully get them excited about science and technology."

The next steps are for the models to be printed in Scion laboratories using the corn-based biopolymer PLA.

Restoring connection

Te Rangikaheke believes that the simple activity of planting kūmara can be a tool to restore connection to Papatūānuku and can help the young men to maintain a sense of themselves amongst today's complicated and stressful lifestyles.

"Indigenous food is a great connector for these boys, it helps to stabilise them in their lives and presents challenges of its own, but they're challenges that can be easily met. The idea is to allow the boys the opportunity to continue to engage in this process.

"When the boys came out to help harvest, I lined them up and said 'go down on your hands and knees and look for kūmara' and they were right in there. That's Papatūānuku, reaching in and drawing people to her," he says.

Now students like Taipari Walker can benefit from their knowledge. "I liked learning how to harvest kūmara out of the ground properly, knowing you don't just rip it out of the ground and just learning what our ancestors back in the day did. And this (3D modelling) is my bread and butter, this is what I like doing. Computers and tech, I've been enjoying this, learning about what I can do."

Fellow student Jacob Rawles echoed his comments, "I like the link to the science and the Māori side. It's cool to be part of the kaupapa."

Rotorua Boys High School Teacher Tiahomarama Fairhall said the project was of great help to the boys. "Just in this short time, I have seen the benefits of Te Kete Rokiroki, especially in regard to the boys learning to harvest kūmara, learning how their ancestors grow and plant food and also adding the science of it."

After the kūmara models are 3D printed, Kai Rotorua will use them to depict different kūmara varieties in their planned kūmara museum.

FOR FURTHER INFORMATION on Scion's role in this project, contact Dr Roya Rezanavaz at roya.rezanavaz@scionresearch.com

The making of a cyborg

New Zealand's biosecurity system is under increasing pressure to prevent establishment of unwanted pests and pathogens.

It is a constant challenge for industry and biosecurity officials, with 8,500 plant pests (insects/pathogens) intercepted at New Zealand's border in 2018. Although only a small proportion of arrivals are likely to be serious pests, those few can do immense amounts of damage if they are not intercepted.

Our best chance to prevent insect pests from gaining hold is to discover them early because small populations are easier to eradicate. Eradication is also more cost effective than long-term pest management.

Scion and our partners are using live insects to detect the signature chemical calling cards of their females. This approach turns the traditional 'set traps and wait' methodology on its head and has the potential to dramatically improve eradication likelihood.

Scion and partners have developed a lightweight portable electroantennogram (EAG) – a device that can use the sensors on insect's antennae to indicate where other insects are lurking.

The science

Male insects have an incredible ability to detect the signature pheromones of their female counterparts. The males sense the unique chemical signature of the female's pheromones with hair-like olfactory sensors on their antennae. The antennae then send an electric signal to the insect's brain.

Scion and partners have developed a lightweight portable electroantennogram (EAG) – a device that can use the sensors on insect's antennae to indicate where other insects are lurking. The aim is to mount this device on an unmanned aerial vehicle (UAV) to actively search for odour traces in tree canopies where concentrations may be greatest.

Using a live moth, researchers attach the moth's antennae to the EAG, which reads the electric signals produced by the moth's antennae. The data collected is transmitted wirelessly in real time to a computer, which is monitored by researchers looking for the tell-tale signs that indicate a moth has sensed female pheromones and a female moth is somewhere nearby.

Researchers are keen to understand if this approach could speed up our biosecurity response times and help eradicate pest species before they have an opportunity to become firmly established. Two hand-held prototypes have been developed and have shown promising results.

During initial testing with gypsy moths in Canada the EAG detected gypsy moth

pheromones 30 m from a dispenser in a controlled turbulent environment. Laboratory results have shown the prototypes are impressively sensitive and could detect one nanogram of gypsy moth pheromones in a microlitre, equivalent to finding one sugar cube in 400 Olympic swimming pools.

It is easy to imagine the possibilities with more research and development, and how a lightweight UAV-ready EAG could help locate pests, speeding up the response time and increase the likelihood of eradication.

A departure from the status quo

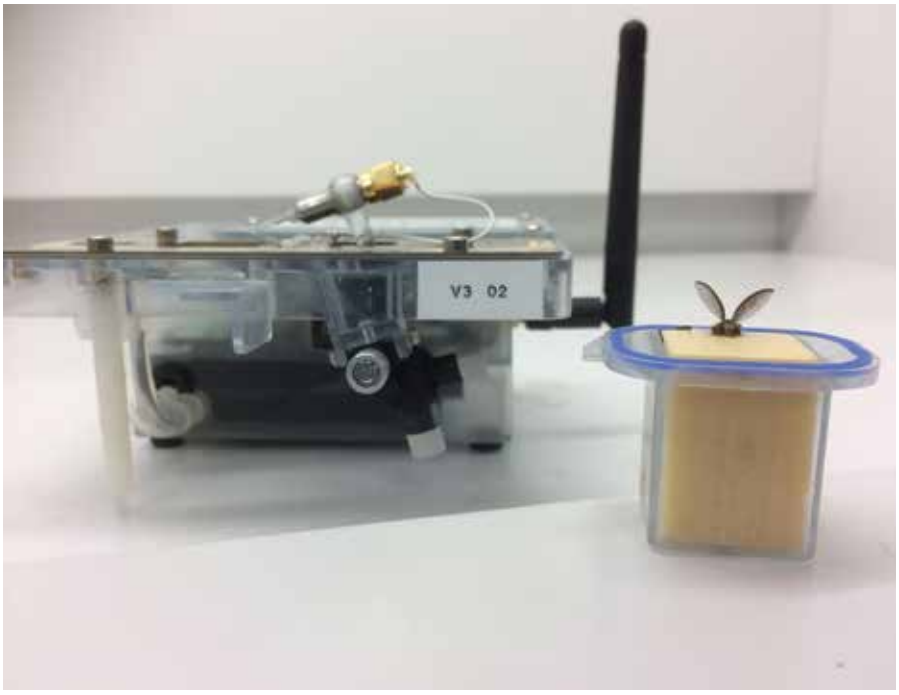
The portable EAG is a departure from current methods for controlling pest species, such as pheromone traps.

For example, the gypsy moth caterpillar is a voracious eater with nasty stinging hairs. It was eradicated from New Zealand in 2005 and officials developed an extensive pheromone trapping network to ensure it does not re-establish here.

The long-term research goals include turning these insect searching behaviours into algorithms, enabling a cyborg to search just as a live moth would, reducing the need for humans to make decisions to guide the moth.

With each new species that arrives, it can take months to years to isolate the right pheromones and its passive nature requires biosecurity control officers to wait and hope pests find the traps.

For the portable EAG to work, all researchers need is a male moth of the right species. They can tune the device and begin actively searching for females and receive results in real time. There is also potential to easily adapt the portable EAG to a wide range of species (though detection proximity will vary between species depending on the male's sensitivity to the female pheromones).



Scion has developed two handheld electroangennograms that use live insects to detect pheromones.

Trialling the approach

We need to better understand insect behaviour and this research could be a game changer.

Using this approach researchers could begin to understand how insects move around and search for each other. There is also potential to learn how pheromone clouds behave in the atmosphere and how they are affected (and diluted) by turbulence.

The long-term research goals include turning these insect searching behaviours into algorithms, enabling a cyborg to search just as a live moth would, reducing the need for humans to make decisions to guide the moth.

Brooke O'Connor travelled to Canada to test the EAG on gypsy moths in a controlled environment.

For now, the project team is refining and developing their two handheld prototypes on three different species - the *Agrotis ipsilon* - greasy cutworm (France), *Lymantria dispar dispar* – European Gypsy moth (Canada), *Epiphyas postvittana* - light brown apple moth (New Zealand).

Next steps include testing how the prototypes detect a pest in a known location and taking the portable EAG from laboratory and wind tunnel environments into the field.

Collaboration

This work is part of a wider research programme entitled 'Protecting New Zealand's primary sector from plant pests; a toolkit for the urban battlefield' focused on developing novel approaches to increase the effectiveness of eradication programmes for insect pests of plants. The programme was funded by the Ministry of Business, Innovation and Employment's Endeavour Fund, working in collaboration with Institut national de la recherche agronomique (INRA), Chargé de recherche CNRS, LORIA, Natural Resources Canada (NRCAN) - Great Lakes Forestry Centre.

FOR FURTHER INFORMATION about the portable electroantennogram contact Dr Stephen Pawson at steve.pawson@scionresearch.com

The Ōhanga Āmiomio Pacific Summit took place at Te Puia in Rotorua, where conference attendees were welcomed to Te Arawa rohe.

Indigenous worldviews and the circular economy

What new approaches can we unlock when contemporary economics meet indigenous worldviews?

This question formed a key theme at the Ōhanga Āmiomio Pacific Summit (the summit) hosted by the Ellen MacArthur Foundation (EMF) and the Ministry for the Environment in partnership with Scion and Te Arawa.

EMF are global leaders in circular economy thinking and the summit was their first foray into the Pacific. They brought together Māori, Pasifika, circular economy leaders, speakers and storytellers – all in aid of facilitating a new economy that has designed waste out.

Scion has long been promoting the benefits of a circular bioeconomy and was proud to be a key partner and co-organiser of the summit.

Mātauranga, materials and manifestos

The day had three themed sessions - mātauranga, materials and manifestos.

Kōrero on mātauranga focused on shifting emphasis from caring about the environment, to caring for the environment. Using an introduction to te ao Māori, environmental activist Teina Boasa-Dean gave an example of a social-political framework where people and nature are considered as one, and humans become relevant because of their connections to the natural world.

Teina was backed by Leilani Unasa, Systems Design lead at the Cause Collective, who expressed the need for a new evolution on the inherently human-centric, co-design methodology. She spoke of a design approach based on wairua to complement co-design methods and make space for a wider range of considerations.

This call for an evolution on the ideology was also applied to the circular economy itself. "I have a problem with the metaphor of the circular economy," said Traci Houpapa, Chair, Federation of Māori Authorities. "I believe in the spiral economy where there's regeneration and growth." Traci went on to capture the essence of the session when she said, "It's about the western world catching up."

The session on materials saw business and regulatory leaders give examples from the Pacific, where the issue of plastics pollution is complex, urgent and visible, to inspire others to design a better system in which plastics never become waste.

Leota Kosi Latu, Director General, Secretariat of the Pacific Regional Environment Programme, kicked off the manifestos section of the conference with a plea to widen people's knowledge of the circular economy. "Many of our countries have now adopted legislation and policy but what we need to do is go further, beyond that, we need to start mainstreaming the circular economy into our budgets, into our planning, just as we have done with climate change."

From theory to practice

Following the conference, an event hosted by local Te Arawa groups took the theories and indigenous values expressed on day one, and breathed life into them.

Te Arawa hosted 50 participants to see, feel and experience some of the ways Te Arawa people are using circular economy values in their rohe.

Hamurana Springs is one such example. Hamurana Springs is a new Māori-owned ecotourism business, at the site of a formerly polluted waterway that is now pristine and home to many native species. The springs were one of a number of sites that allowed summit attendees to have deeper conversations, link problems with real-life solutions and explore new applications and interpretations of circular economy thinking.

Nelson Meha, Business Development Associate at Scion, says, "The term circular economy may not come naturally to te ao Māori, but in terms of what that means and in practice – we do it."

He says, "Whakaaro Māori naturally lends itself to the circular economy."

Following the summit

Following the summit, Scion will be looking to continue the momentum. Having established a relationship with EMF, Dr Florian Graichen, Scion Science Leader Biopolymers and Chemicals, will now present at the annual Ellen MacArthur Summit in London.

Meanwhile, Scion will continue to build support and accelerate the transition to circular bioeconomy for New Zealand through our thinking and practice.

FOR FURTHER INFORMATION on Scion's involvement in the summit contact Nelson Meha at nelson.meha@scionresearch.com

Biodegradation facility gains international accreditation

The compostability facility can assess biodegradation in a range of environments including compost, soil, water and marine.

Scion's biodegradation facility is now accredited by DIN CERTCO to carry out compostabiity testing to internationally recognised standards.

The accreditation allows Scion to help companies certify their packaging products as compostable and use internationally recognised labels to communicate to consumers.

We are the only testing facility accredited in Australasia, and now we can meet the demand from local and international companies who want to back up their compostability claims.

There is a growing need for materials to be compostable. For example, if the packaging at an event is all compostable the food waste can easily be diverted from landfill. Another good example is in the horticultural industry where growing aids such as string and clips can contaminate green waste making it impossible to compost.

For more products to be compostable, it is important that companies can get independent verification that their products meet the required standards. This gives consumers the confidence to choose products, and composters the confidence to accept products they know will be compostable.

The accreditation covers both industrial and home compostable materials.

FOR FURTHER INFORMATION on Scion's compostability facility contact Dr Florian Graichen at florian.graichen@scionresearch.com

Bark: A building block for a circular bioeconomy

(Continued from page 1)

Employment's Endeavour Fund.

By 2023 Scion and partners will have made the first crucial steps towards creating bark biorefinery technology leading to the development of a demonstration plant.

This biorefinery concept will stretch far beyond bark. The approach can be applied to many of New Zealand's biomass streams. Once the necessary science and infrastructure is complete, regions all around New Zealand could be running their own biorefineries employing people in highly skilled jobs producing high-value, environmentally friendly products.

Why bark?

Around 2.3 million tonnes of bark is produced annually by the New Zealand forest industry. It is an underutilised resource that will increase as a ban on methyl bromide use comes into effect from 2020, and only de-barked logs will be permitted for export. At present, most bark is left in the forest, with small amounts collected for boiler fuel or used as soil additives (for example, in potting mix) and some is exported still on logs.

Pine bark is a rich source of polyphenols, terpenes and resin acids that each have unique functional and structural properties. The Scion research team plans to use a combination of extraction techniques to obtain high-value products, as well as water treatments to extract tannins. The remaining solid waste has a high residual energy content and could be processed into bark briquettes and used as a renewable biofuel, for example.

Some tannins are currently on the market, predominantly used in leather tanning and adhesives, but they are hydrolysable tannins. Pine bark contains condensed tannins, which are more readily chemically modified, offering a wider range of applications.

The bark biorefinery also promises to deliver significant quantities of new water-repelling (hydrophobic) polymers. Hydrophobic polymers are used in items from paper coffee cups and rainwear to touchscreen coating technology. The current market is dominated by petrochemical-based polymers, but bio-based hydrophobic polymers are part of a rapidly growing market niche.

International connections

Globally, no bark biorefineries exist yet, though research to extract valuable chemicals from forest waste streams through biorefineries has been underway for some time. By partnering with collaborators, the Scion programme is taking advantage of existing international expertise and linking their capabilities with our research aims. Our collaborators are VTT (Finland), Fraunhofer IGB (Germany), University of Lisbon ITQB NOVA (Portugal) and Auckland University of Technology.

The long-term vision

Around 90 billion tonnes of raw materials are used every year to support the global economy – we all are responsible for more than 12 tonnes per person. By 2050 these numbers will have doubled. Unless we can find ways to use these resources more sustainably and efficiently, we will continue to use more reserves than the earth can generate. Biorefineries in New Zealand will be one of our contributions to this challenge.

Scion's bark biorefinery programme is the spark to ignite this wave of technology, infrastructure and opportunity in New Zealand.

FOR FURTHER INFORMATION on the bark biorefinery research programme contact Dr Warren Grigsby at warren.grigsby@scionresearch.com or Dr Florian Graichen at florian.graichen@scionresearch.com

Dr Florian Graichen (Scion), Rachel Barker (Plastics New Zealand), Hon. Eugenie Sage, Dennise Chapman (Plastics New Zealand), Marc Gaugler (Scion) and Sharon Humphreys (Packaging Council of New Zealand).

A future free from plastic waste

Plastic waste is an undeniably large global challenge, but it is important to remember that plastic itself is not the problem. It's what we do with it. The onus is on us to be far smarter in how we use this material.

We have a vision for a future global economy where plastics never become waste thanks to the Ellen MacArthur Foundation's report *New Plastic Economy: Rethinking the future of plastics*. This vision is based on circular economy principles and countries like the United Kingdom are already adopting it.

In May 2019, Associate Minister for the Environment Hon. Eugenie Sage announced a new Scion-led project working with New Zealand's plastics industry to build our own roadmap to a new plastics economy.

Kiwi challenges

Unlike other countries, New Zealand's plastics industry is influenced by three factors that can greatly shape the way we transition to the new economy.

- The New Zealand plastics market is small. This means we have less leverage to demand change and it affects the feasibility of establishing a comprehensive plastic recycling sector.
- All polymers used to make plastic products are imported. This makes access to new material options and working with the full life-cycle of plastics challenging for the domestic plastic industry.
- Most of New Zealand's manufactured plastic products are exported, and demand is subject to the importers' requirements (consumer or regulatory).

Industry-focused

To address these unique New Zealand factors, the project team will be working closely with industry so they can lead the way.

Work will begin with setting up a stakeholder group of industry and research partners, Packaging New Zealand, Plastics NZ and the Sustainable Business Network.

The project will also establish a material flow of plastics in New Zealand, understanding where it goes, and how it is dealt with as a waste.

"This is not about regulation," says Project Leader Marc Gaugler.

"Working with manufacturers allows us to start at the beginning of the value chain and that is what will set our roadmap apart."

This two-year project is funded by the Ministry for the Environment's Waste Minimisation Fund. The final 'New Zealand - New Plastics Economy Roadmap' will be completed mid-2021.

FOR FURTHER INFORMATION on New Zealand's New Plastics Economy Roadmap contact Marc Gaugler at marc.gaugler@scionresearch.com

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