PLACE 2025

Long-term food storage in space

p26

Balancing security and governance in outer space

p30

Autonomous agriculture to support space exploration

p24

Landmark spaceflight for P4S

p36

THE ANNUAL REPORT OF

PLANTS FOR SPACE
ARC CENTRE OF EXCELLENCE

Australian Government
Australian Research Council

PLACE

As we enter our second year as a Centre, this Annual Report reflects both where we have come from and where we are heading.

Building on the process that shaped our visual identity in our first year, we once again turned to our community to help define the character of this publication. Through this process, PLACE continues as the identity of our Annual Report—an expression that feels both authentic and purposeful.

The name resonates deeply with our philosophy. Beyond being a contraction of Plants for Space, PLACE reflects a sense of belonging that underpins our work. We are developing technologies for all places – on Earth and in space – aimed at creating more resilient environments while reconnecting people with nature.

We invite both new and returning readers to explore the stories that follow and to engage with the work, people, and vision that continue to shape Plants for Space.

The Plants for Space (P4S) team

PLANTS FOR SPACE
ARC CENTRE OF EXCELLENCE

Australian Government
Australian Research Council

We are a global collaborative network funded by the Australian Research Council and our partners.

Our five Australian University nodes are:

THE UNIVERSITY of ADELAIDE
Flinders University
LA TROBE UNIVERSITY
THE UNIVERSITY OF MELBOURNE
THE UNIVERSITY OF WESTERN AUSTRALIA

Our partner organisations:

Berkeley
UC DAVIS UNIVERSITY OF CALIFORNIA
WISCONSIN UNIVERSITY OF WISCONSIN-MADISON
RICE UNIVERSITY
UNIVERSITY OF CAMBRIDGE
University of Nottingham UK | CHINA | MALAYSIA
INRAE
ETH zürich
vertical future
Space Lab
YIELDX
appn Australian Plant Phenomics Network
The Andy Thomas Space Foundation
dr JOANNA MCMILLAN
VSSEC
Botanic Gardens and State Herbarium
SOUTH AUSTRALIAN SPACE INDUSTRY CENTRE
Australian Government Department of Defence Science and Technology
Government of South Australia Department of Primary Industries and Regions
NASA
Australian Space Agency
AXIOM SPACE
YURI
TWIST BIOSCIENCE
National Imaging Facility
BIOPLATFORMS AUSTRALIA
agrf
SABER ASTRONAUTICS
FOODiQ
DLR

Acknowledgement of Country

In the spirit of reconciliation, Plants for Space acknowledge the Traditional Custodians of Country throughout Australia and their deep connections to land, sea, and sky. We pay our respect to their Elders past and present and extend that respect to all Aboriginal and Torres Strait Islander peoples today.

Contents

Leading Insight

"Globally recognised for pioneering discoveries and leadership in plant, agricultural, and space bioscience, Professor Matthew Gilliham from the University of Adelaide is cementing SA's status as a world-class centre for agricultural innovation."

Professor Craig Simmons FAA FTSE,
Chief Scientist for South Australia

"There are many challenges associated with ensuring humans can live sustainably on the moon. P4S is just one way in which Australia can contribute to making this happen as part of our commitment to the Artemis Accords."

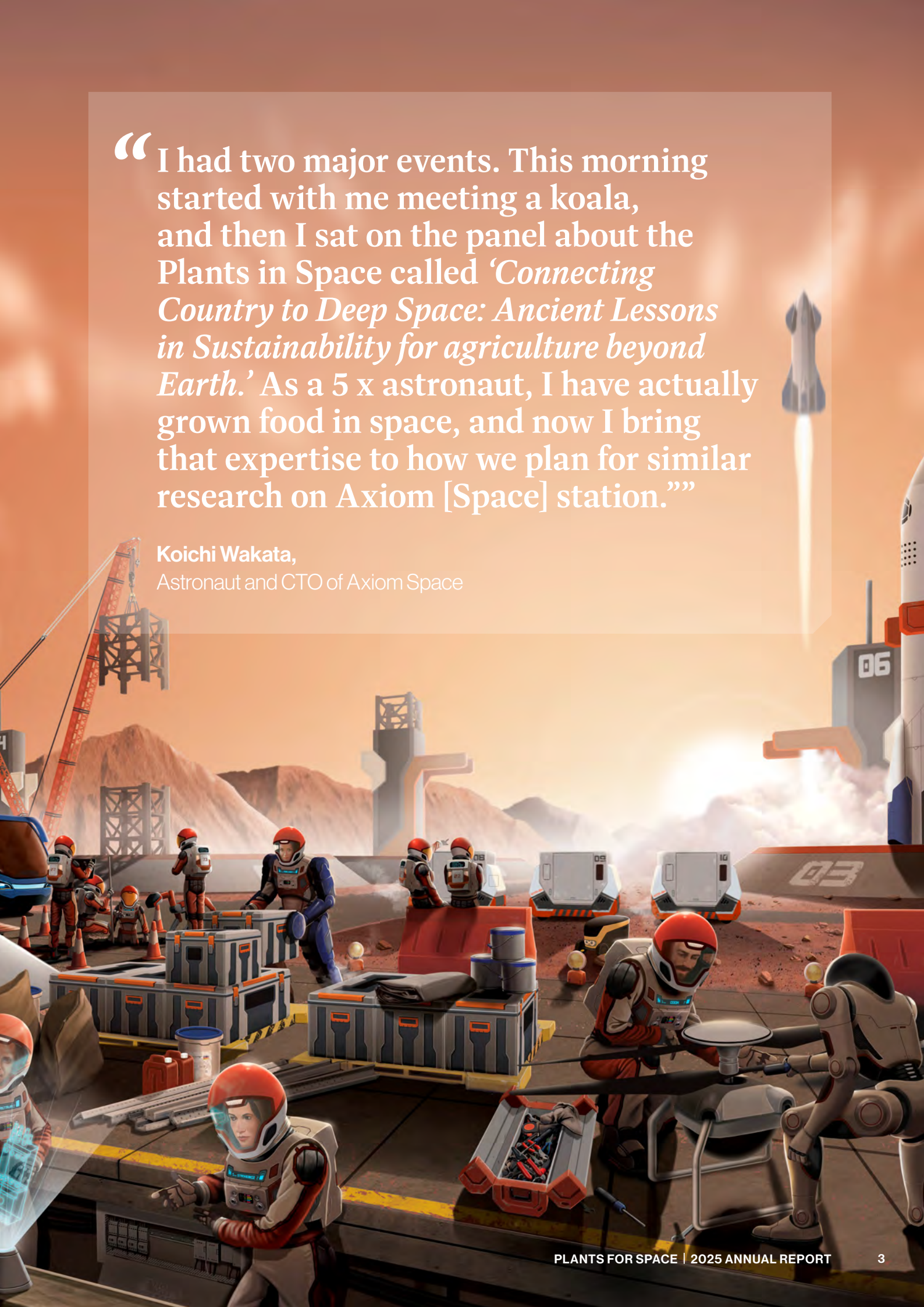
Enrico Palermo,
Head of the Australian Space Agency

"National and global interest around extra-terrestrial exploration presents an opportunity for P4S experts to build upon South Australia's space leadership and Australia's reputation in space research,"

Professor Anton Middelberg,
Deputy Vice-Chancellor (Research), University of Adelaide.

"This project embodies our commitment to improve life on Earth and foster the possibilities beyond it, building a home in space that benefits every human, everywhere,"

Jana Stoudemire,
Director, In-Space Manufacturing at Axiom Space in response to the collaboration between P4S and UK company Vertical Future (VF).



> “I had two major events. This morning started with me meeting a koala, and then I sat on the panel about the Plants in Space called *‘Connecting Country to Deep Space: Ancient Lessons in Sustainability for agriculture beyond Earth.’* As a 5 x astronaut, I have actually grown food in space, and now I bring that expertise to how we plan for similar research on Axiom [Space] station.””

Koichi Wakata,
Astronaut and CTO of Axiom Space

Advancing technologies for on-Earth sustainability

By advancing plant science and cutting-edge technology, **PLANTS FOR SPACE** is helping build a more sustainable and resilient future right here on Earth.

Image of *Spirodella polyrhiza* – one of our target zero waste crops.

From the Chair of the Advisory Committee

I am delighted, as Chair of the Advisory Committee of the ARC Centre of Excellence in Plants for Space, to recognise the work of the Centre during its second full year of operation. On behalf of my colleagues on the Advisory Committee, I wish to congratulate the Centre's leadership, its researchers, staff and associates for their dedication, expertise and vision. The achievements during 2025 demonstrate not only world-class research, but also the Centre's ability to focus on its core mission whilst also finding practical solutions to challenges as they arise.

The global governance of outer space activities stands at a crucial moment, with many ambitious and complex missions being planned and implemented. The increasingly diverse multitude of actors, activities and technologies means that space-related activities now operate within a framework of broad geopolitical, commercial, ethical and scientific factors. Careful consideration must be given as to how humanity moves forward in these endeavours.

In this regard, the Centre has continued to advance our understanding of how plants might be able to thrive in extraterrestrial environments – a critical issue for the future of long-duration space exploration and sustainable life support systems. In addition, the interdisciplinary research undertaken by the Centre not only deepens our fundamental knowledge in this way but can also have tangible implications for terrestrial agriculture, and bioengineering applications here on Earth.

The need for research and carefully calibrated science that supports humanity, the peaceful uses of space and a sense of collaboration have never been stronger. Indeed, the collaborative spirit within the Centre ensures that the research remains cutting-edge and impactful.

We will continue to closely follow and support the work of the Centre and, as always, are ready to provide advice and guidance whenever we can. We all look forward to the ongoing development of the Centre as it continues to push the boundaries of plant science and space exploration.

Steven Freeland

Emeritus Prof Steven Freeland

Chair of the Advisory Committee
ARC Centre of Excellence in Plants for Space

From the Director

Twenty-twenty five was a professional career highlight for me, and a landmark for P4S. Our annual meeting was, without doubt, the most impressive and exhilarating conference I have ever attended. Our Australian based cohort, reaching beyond 150 staff and students, and our partner investigators and advisors were in attendance, with some utilising the online platform. It included updates on projects that are reaching an impressive level of maturity and international and national activities in full swing, it was awe inspiring. The smiles on faces said it all, and the universal feeling of community and support was on full display. Every attendee contributed, with all researchers presenting their work and ample opportunity for robust discussion to progress their projects.

Our professional staff delivered a first too – a meeting without a single hitch. Our people are our centre, and we are fortunate to have commitment and quality across the organisation.

You will read about the centre highlights throughout the report, and it would be unfair of me to pick winners. What I instead would prefer to do is encourage those reading this report that have questions,

"We are staunch advocates for ensuring that all space activities that Australia conducts... should deliver value"

comments, or even see opportunities, to reach out and start or continue a conversation beyond the bounds of this report. We have been entrusted with a time-constrained golden opportunity, to deliver for Australia and the world, new technologies designed to unleash the potential of the Artemis age*. We are committed to making sure we fulfil this promise, connecting not only our existing partners but also those with the ability to deliver synergies for the sector with whom we have not yet connected. We are an open shop so if you like what you read, and see opportunities that align with our culture and missions, please reach out.

We brought on board many researchers in 2025, including Professor Phil Brewer as a new Chief Investigator at La Trobe University. Phil is a leading authority on hormonal signalling in plants and will lead efforts to alter plant architecture for controlled environments and investigate how we might improve crop growth rates by altering the growth-defence trade off.

Unapologetically and necessarily, 2025 has also been a year of reflection regarding the types of opportunities we pursue. We are serious about our commitment to maintaining the quality of what we do, rather pursuing quantity at the cost of delivering meaningful advances. We are staunch advocates for ensuring that all space activities that Australia conducts – which by their nature are costly and logistically complex – should deliver significant value. Space is a serious laboratory and endeavour that obliges those involved to create serious advancement. This is a core message we continue to amplify throughout our industry, academic and public engagements – and as members of the public ourselves we need to make sure we hold ourselves and our peers to account.

In this report, you will read about many of the projects that showcase our expertise and our commitment to meaningful delivery. I hope you enjoy reading about our second year of operations and we get the opportunity to connect in 2026!

MGilliham

Prof Matthew Gilliham

Director
ARC Centre of Excellence
in Plants for Space

A Full Moon Illuminates Artemis I - image courtesy NASA.

*An international consortium of countries, partnered through the Artemis accords, who will deliver humans back to the Moon, and one day to Mars. It is our duty to ensure that, as well as delivering this new frontier, the technologies that we create are put to good use on Earth. This centres around improving the sustainability of agriculture, food provision and biomanufacturing for us. Artemis II is set to launch in 2026 sending humans around the Moon, with a Moon landing on Artemis III scheduled for soon after, taking P4S technology to the Moon and back.

Our Vision

To enable long duration Space exploration and improve on-Earth sustainability through plant and food re-design, while inspiring and equipping the next generation with the skills and ambition to solve the world's great challenges.

P4S STRATEGIC FRAMEWORK

P4S' research capability is led by domain experts with robust discipline-specific expert oversight, while supporting professional development of future research leaders in a framework that facilitates interdisciplinary project delivery for impact.

LEGACY

Enable human travel and habitation in deep space through new plant-based foods and products

Economically and environmentally sustainable plant and food production from CEA

Reduced environmental impact of agriculture due to widespread consumption of appealing and nutritious plant-based foods

Increase Australia's sovereign biomanufacturing capability through a growing local plant-based synthetic biology sector

Enable equitable access to appealing and nutritious plant-based food and plant-derived products in remote and extreme environments on Earth

MISSIONS

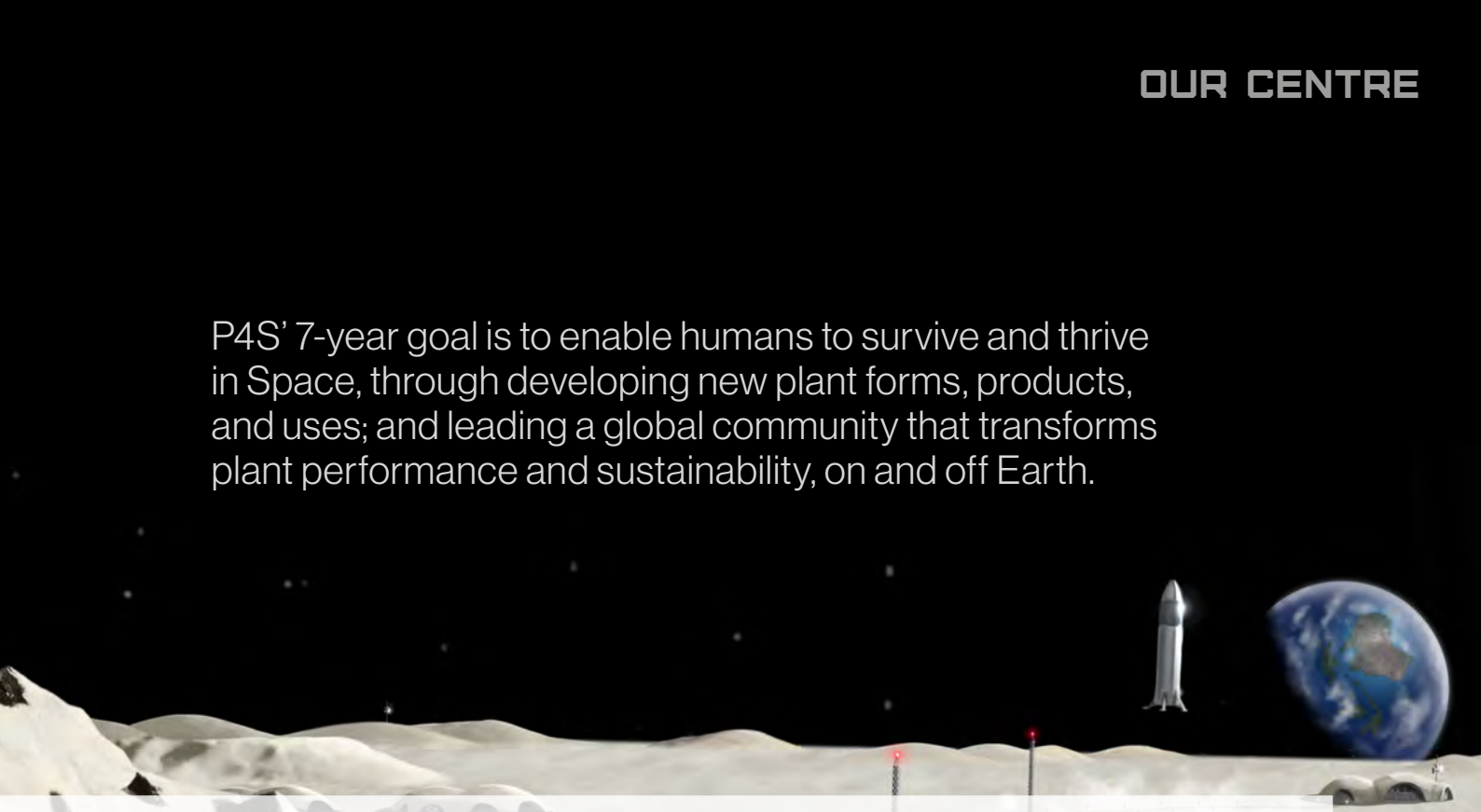
Zero-waste plants optimised for controlled environments

Complete nutrition plant-based foods

On-demand bioresource production

Future-ready workforce and society

P4S' 7-year goal is to enable humans to survive and thrive in Space, through developing new plant forms, products, and uses; and leading a global community that transforms plant performance and sustainability, on and off Earth.



APPROACH

Strategic focus

Research excellence

Translation and impact

Collaboration

Education and inspiration

Capacity building and fostering talent

CAPABILITY

Research expertise (Plants, Products, Processes and People)

Infrastructure and technology

Knowledge translation and impact

Partnerships

Research and administrative support

Funding

MANAGEMENT

Governance and decision-making (PAC, IRAC, TEC, SMG, EMC, PLCs)

Performance management (PLCs, EMC, SMG, Advisory Committees, KPIs)

Risk Management

Financial management

Inter-institutional agreements, compliance and IP

Communication and collaboration systems

Professional learning

Monitoring, evaluation and learning

Year in review – 2025

Throughout 2025, the ARC Centre of Excellence in Plants for Space hosted a diverse range of events, workshops, and collaborations that showcased our leadership in plant science, innovation, and space research. From international partnerships and high-profile visits to professional learning opportunities and public engagement initiatives, the Centre continued to advance its mission of exploring how plants can support life both on Earth and beyond.

February

- P4S Annual Strategy Planning Days, Taikunthi Adelaide

March

- Teacher Professional Learning, Melbourne

April

- Research Seminar: Jess Bunchek (plant scientist and astrobotanist)

- P4S Chief Investigators Workshop, Perth

- Sydney Powerhouse Museum - Powerhouse Academy: Plants for Space

POWERHOUSE

June

- Australian Astronaut and director of space technology at the Australian Space Agency Katherine Bennell-Pegg visits P4S

July

- Centre of Excellence Summit, Melbourne (CoE Summit)

August

- Australian-American Leadership Dialogue, Adelaide – exploring topics shaping the Australia–US alliance, including Space and AI
- P4S Hosted Deputy Premier of South Australia, Susan Close

- Postdoc Symposium – first-ever P4S EMCR Symposium, The University of Western Australia

September

- Dr Raymond Wheeler, renowned NASA plant physiologist and emeritus senior scientist, at the University of Adelaide's Waite Campus

- Hosted delegation from the German Aerospace Center

- Royal Adelaide Show - Speaking with Dr Richard 'Harry' Harris SC OAM, Lieutenant Governor of South Australia

October

- James Lloyd, P4S researcher, awarded 2025 WA Young Tall Poppy Science Award, The University of Western Australia

- IAC Sydney

November

- P4S researchers Prof Matthew Gilliham (UoA), Dr Troy Miller and Professor Harvey Millar (UWA) collaborate with NASA on Plant Habitat-07 (PH-07) project, studying Outredgous Romaine lettuce aboard the International Space Station

- P4S 2nd Annual Conference, Gold Coast

- Prof Matthew Gilliam (Centre Director) SA Scientist of the Year finalist

December

- Curious Minds – Girls in STEM Program

- End-of-Year Celebrations

Annual Conference, November 2025

The 2025 Plants for Space annual conference brought together all nodes at Surfers Paradise in the Gold Coast, Queensland. Over four conference days members shared their latest research, and connected through their work and several workshops.

Conference feedback truly celebrated the event. The overall organisation, the support to engage with colleagues across all different nodes, as well as providing a platform for the broader placement of our research with relevant industry talks by Roo-ver Director Ben Sorenson and Stacked Farms CSO Robert Coe, were all mentioned as great points.

Conference day 1, Monday November 10

Day 1 kicked off with workshops for the Plants for Space Early- and Mid-Career Researchers (EMCR's), aimed towards communication skills and critical thinking.

The morning session was provided by science communication experts from Econnect Communication, focusing on how to pitch and use storytelling when communicating with a broader audience. In the session, P4S EMCR's and students got the chance to pitch their research and receive feedback from the engaging Econnect team, as well as learn how to speak for different types of media.

In the afternoon Dr Peter Ellerton shared his expertise and knowledge on critical thinking. The session brought a lot of lively discussion among the attendees, trying to truly grasp 'what is critical thinking?'. Critical thinking is at the heart of our education and engagement research, and the presentation was provided to set researchers up with some great tools for their school visits, public presentations and student engagement.

Day 1 also brought a moment for our Chief Investigators and Advisory Committee to meet, to share outcomes and results from 2025 as a Centre. During the meeting all programs presented their progress and planning for the next year, allowing the Advisory Committee to learn first-hand of the future direction of the Centre.

This first day was also an opportunity to collect some new video material for the Centre, and interviews took place to learn of the experience of our current PhD students. These videos will be shared over the next year, highlighting the impact of being part of a Centre of Excellence for EMCR's.

The day finished off with the official welcome and opening for all P4S and Advisory Committee members. At our first dinner together, the team was welcomed by Advisory Committee Chair Steven Freeland and P4S Director Matthew Gilliham, sharing their excitement for the days following.

Conference day 2, Tuesday November 11

Tuesday morning was the first day of our conference program, with the plenary seminar *Exodomesticating Duckweed*, delivered by invited partner researcher Dr Alex Ware from the University of Nottingham. The engaging presentation gave insights into the nutrient transport in duckweed, and the newly developed technologies and tools needed to further research this candidate space crop. The seminar was very well received, and strengthened the close ties with the University of Nottingham even further.

Following on from this engaging plenary session, the conference moved into sharing current research work from the four different programs underlining the P4S research structure. The first

Psychological safety workshop run by Genevieve Cavanagh and Emma Earl from Escient

Econnect Communication workshop

set of talks clustered around 'processes', where research is focused on assessing the sustainability, psychosocial, and legal dimensions required to deliver industry-ready solutions. The session was opened by Deputy Director Prof Melissa de Zwart and Chief Investigator Prof Volker Hessel, introducing their broader research. They were followed by their researchers Dr Ciara Finnegan and Mst Irin Parvin, sharing work on regulatory challenges of biological plant payload returns and digital twins in decision-making for vertical farming systems respectively.

The morning finished off with presentations within the 'people' program, with Chief Investigator A/Prof Kim Johnson presenting on the education and engagement progress of 2025. Her presentation was followed by Dr Frazer Thorpe and Jordan Witchard, introducing their view on the P4S approach to education and engagement for impact, and their PhD-research on professional development for science centre demonstrators. All presentations highlighted the inclusive approach of Plants for Space on engagement with students of all ages, as well as the general public – and how the Centre enthusiastically supports P4S members to share their research with broader audiences.

In the afternoon, P4S Chief Operating Officer Dr Richard Harvey guided an engaging panel session with Dr Shannon Walker and Prof Anna-Lisa Paul. NASA astronaut Dr Walker and Horticultural Research Professor Paul captivated the audience with their knowledge and stories on growing plants in space, and their scientific and professional challenges. The panel was a highlight of the conference for many of the attendees. Both Dr Walker and Prof Paul attended the full conference, with many P4S members taking this as an opportunity to continue the conversation with them during the week.

The last part of the day was a change of pace for all – EMCR's and students stepped onto the stage for short lightning talks to introduce their work and invite attendees to view their poster. All presenters found brilliant ways of building curiosity in the audience, to continue conversations during the poster sessions. The short, punchy format was a great way to share a broad range of topics, as well as give a small break from the more traditional presentations.

Tuesday's dinner was held at the hotel, with a scintillating presentation by invited guest speaker Ben Sorensen, Roo-ver mission and ELO2 (EPE + Lunar Outpost Oceania) Consortium Director. Mr Sorensen shared his excitement about Australia's role in future space missions, and the pivotal part of the ELO2 Consortium. It was inspiring to hear about the project, and see the work of Plants for Space within the broader perspective of space research and technology development within Australia and globally. And of course, it was a great opportunity for all our members to meet "Goldie", the model Lunar rover.

Conference day 3, Wednesday November 12

The start of this day was unlike the rest of the week, as all P4S members gathered to race along the Surfers Paradise Esplanade for our team building morning. As a Centre of Excellence there is a challenge in working across different nodes, and fostering collaboration across different states and institutions. The conference set up a perfect environment to interact through knowledge sharing, informal networking sessions, but also more active ways of getting to know each other during morning run club and the *Beyond the Boardroom* Amazing Race-style competition. Small teams solved puzzles, collected items, and collaborated to do a safe egg-drop to win glory and camaraderie.

After a quick break to settle all the excitement of the active morning, the day continued with presentations around 'plants', the research area aimed at creating plants with unparalleled performance and nutritional composition for space and Earth applications. This session was led by Chief Investigators Prof Harvey Millar and Prof Mathew Lewsey exploring plant adaptation, nutrition, and biotechnological innovation.

Dr Marta Peirats-Llobet and Dr Ali Gill shared updates from the LEAF (Lunar Effects on Agricultural Flora) project, examining molecular adaptation of plants to lunar environments, including duckweed heat tolerance and gas exchange. Ryan Edwards discussed the potential

Left: Dr Alex Ware from the University of Nottingham – delivering the plenary address

Above: Members of the P4S Advisory Committee – Dr Shannon Walker (left) and Dr Anna-Lisa Paul (right) during the panel session.

of duckweeds as a nutritional and biotechnological powerhouse, while Dr Ziwei Zhou provided progress on engineering strawberries toward zero-waste plants. Dr Ryan Coates spoke about refining methods to enhance the expression of nutritional proteins in plants, and Dr Troy Miller presented proteomic analyses of lettuce grown on the International Space Station, assessing adaptive responses to microgravity-induced watering challenges.

Following another round of short pitches in lightning talks, the team was introduced to Dr Robert Coe, the Chief Scientific Officer of the company Stacked Farm. The compelling presentation showcased the impressive level of efficiency and accuracy in closed environment agriculture at Stacked Farm, and the gaps in knowledge for this industry to continue growing. The day concluded with another round of lightning talks to pitch posters, and a dinner at Hurricanes restaurant.

Conference day 4, Thursday November 13

With the final day of the conference, the last presentation session was clustered around 'products', focusing in research on developing plant biofactories and transforming food and non-food bioprocessing technologies. Professor Ryan Lister and Professor Sally Gras shared the session with researchers and collaborators from their teams.

Chief Investigator Ryan Lister introduced Dr Farley Kwok van der Giezen, Dr Lee Conneely, and Patrick Gong, respectively researching advancing approaches such as engineering RNA editing proteins to control chloroplast transgenes, using single-nucleus multiomics for precision cell-type-specific expression of medicinal compounds, and designing synthetic genetic circuits for programmable plant engineering and bioresource production.

Deputy Director Professor Sally Gras introduced Dr Kenneth Sim, Dr Lydia Ong, and Kenny Lam for their presentations. Their work on sustainable and innovative plant-based products includes strategies to improve consumer acceptance, structuring water spinach for Earth and space applications, and applying deep learning technology to predict taste profiles of plant-derived compounds.

This highly engaging session concluded the scientific presentations of the week, and was followed by a different type of team-building though an Equity, Diversity and Inclusion session by Genevieve Cavanagh and Emma Earl from escient. The team learned all about psychological safety and behaviours that support big ideas to grow, and it was a wonderful way for all attendees to connect.

This last conference day was closed with one last poster session and a moment to reflect on the efforts of Plants for Space members over the past year through the Awards ceremony. Awards were awarded to members for scientific excellence in their conference presentations, industry engagement, commitment to education and engagement, and the more creative ways of bringing the Centre together. More can be found in our section on 'Awards' in this annual report.

As mentioned in the closing remarks on the conference by Director Professor Matthew Gilliham, the week brought the Centre closer and provided great connection throughout the scientific disciplines combined in Plants for Space. Great organisation, collaboration and excitement will drive Plants for Space innovation further, and the Conference is a highlight of all our team's hard work coming together.

Above: Winning team from Beyond the Boardroom Amazing Race-style competition.

Left: Prof Matthew Gilliham (left) with Ben Sorensen, Roo-ver mission and ELO2 Consortium Director.

Below: Deputy Director Professor Sally Gras from the The University of Melbourne

Overview of the Centre

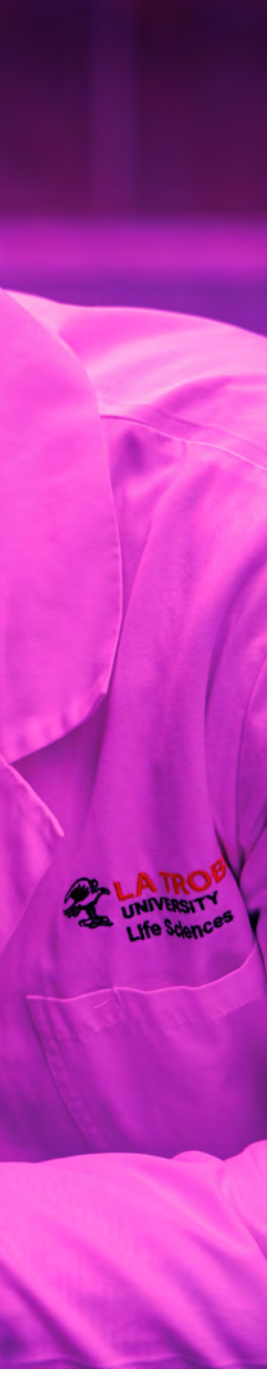
The ARC Centre of Excellence in Plants for Space is on a mission to transform the future of food, sustainability, and space exploration.

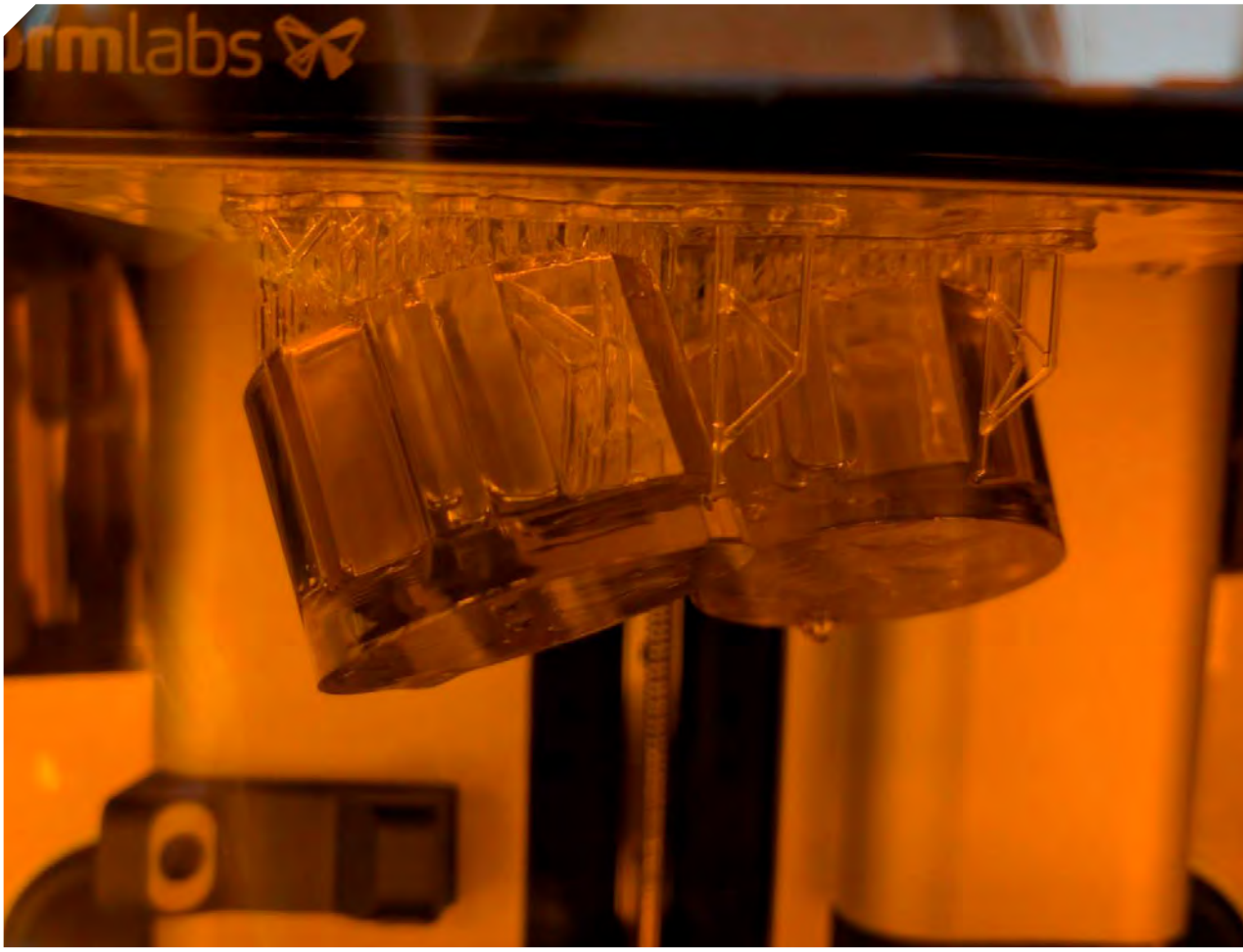
Our goal is to enable humans to not only survive but thrive in space. We will develop innovations that deliver important advancements to our agricultural, food and biomanufacturing sectors on Earth. By developing innovative plant-based solutions, we're working to create a future where food production is more efficient, resilient, and sustainable – whether on Mars, or remote and extreme environments on Earth.

P4S is a unique transdisciplinary collaboration, bringing together experts in plant biology, food chemistry, engineering, psychology, and space law, among others. Our international and national consortium spans industries like space, controlled environment agriculture, plant-based foods and biomanufacturing. P4S is Australian led, building a community of 200 researchers, with plans to have trained 400 students by 2031, while fostering a culture of innovation, entrepreneurship, and public inspiration.

Guided by four key missions – complete nutrition plant-based foods, zero-waste plants for controlled environments, on-demand bioresource production, and a future-ready workforce and society – we aim to revolutionise how we grow, consume, and think about plants. In doing so, we hope to pave the way for a more sustainable and resilient future plant and food systems on Earth and lay the groundwork for long-term space exploration.

Learn more.





Left: Dr Lee Conneely from La Trobe University

Above (top): Creating a home for moon-bound plants

Right: Duckweed under the microscope

Above: P4S merchandise

Our Impact

Turbocharging fundamental science translation through controlled environment agriculture

This review describes how "programmable farms" could work together with redesigned plants to deliver higher yields and specialised products independent of the climate. The paper outlines the progress and pathway forward for how this approach could advance research efforts to transform agriculture into a predictable, efficient system that supports food security in a changing world. Gill et al., (2024) Trends in Plant Science https://doi.org/10.1016/j.tplants.2025.08.014

Light is sufficient to compensate for random positioning machine-simulated microgravity in plant roots

This study demonstrates the ability for light to drive root orientation in plants grown in simulated microgravity. The paper provides an approach for overcoming a key technical hurdle for growing plants in microgravity. David et al., (2025) npj Microgravity https://doi.org/10.1038/s41526-025-00493-w

Spaceward senses: examining retronasal aroma and mouthfeel perception in simulated space-microgravity environments

The study shows that in space-like conditions people experience food differently. Flavours seem weaker but textures feel stronger. Understanding this helps researchers design foods that astronauts will enjoy eating, which is essential for maintaining nutrition, health and wellbeing on long missions to the Moon or Mars. Gonzalez Viejo et al., (2025) npj Science of Food https://doi.org/10.1038/s41538-025-00564-y

Towards sustainable food security: exploring the potential of duckweed (Lemnaceae) in diversifying food systems

This review makes the case that an abundant water plant, duckweed, could help solve the twin challenges of climate-friendly farming and feeding more people. It provides a roadmap for turning duckweed into a practical global food ingredient. Ofoedu et al., (2025) Trends in Food Science & Technology https://doi.org/10.1016/j.tifs.2025.105073

The stories of 'Plants for Space': exploring intentionally positive and sustainable futures

The paper presents and argues for the use of storytelling about growing plants in space as a powerful teaching approach. It encourages young people to engage with climate and sustainability challenges in a positive, problem-solving way, fostering a mindset that can inspire future scientists, engineers, and citizens to design better food systems and environmental solutions. Thorpe et al., (2025) Australian Journal of Environmental Education https://doi.org/10.1017/aee.2025.10065

MADS31 supports female germline development by repressing the post-fertilization programme in cereal ovules

This study uncovers a fundamental mechanism used by plants to make seeds. By applying this knowledge to a plant such as duckweed, research efforts will aim to change seed composition to improve the nutrient composition of the plant. Yang et al., (2025) Nature Plants. https://doi.org/10.1038/s41477-025-01915-z

Government engagement

- Presentation to the Office of International Law, Attorney-General's Department, *Space and National Security*
- Submission to the Department of Industry, Science and Resources *Possible Association to Horizon Europe: Request for Information*
- Invited presentation to the United Nations Institute for Disarmament Research Outer Space Security Conference 2025 *Commercial Actors and Space Security: Evolving Challenges, Roles and Responsibilities*
- Participation in the Australian Space Agency Policy Division Planning Day
- Submission to the Department of Industry, Science and Resources *Strategic Examination of Research and Development*
- Submission to the Australian Research Council Policy *Review of the National Competitive Grants Program*
- Space industry roundtable with Dr Andrew Charlton MP, Assistant Minister for Science, Technology and the Digital Economy

Industry engagement

- Invited presentation to Berries Australia's BerryQuest International 2025 conference
- Participation in the 2025 Bioinnovation Festival
- P4S booth and hosted Special Session at the 2025 International Astronautical Congress
- Participation in the Space Industry Association of Australia Shaping Australia's Space Future: Policy and Strategy Forum
- Presentation at the Space Industry Association of Australia IAA's 2025 Southern Space Forum
- Participation in the Protected Cropping Australia 2025 Conference
- Participation in the Synthetic Biology Australasia 2025 Conference
- Delivered JR Vickery address at the Australian Institute of Food Science and Technology conference
- Participation in the La Trobe Industry Innovation Series | Smart Farming – Technology Transforming Agriculture workshop

32

Journal publications on the top 5% of field by CiteScore

50

Journal articles in 2025

86

Presentations to government and industry

1699

Teachers trained in P4S-hosted workshops

7

Submissions to government and participation in parliamentary inquiries

57,746

Students engaged by P4S educational and engagement activities (including as a result of teacher professional development)

Dr Koichi Wakata (Astronaut and CTO, Axiom Space) and Dr Raymond Wheeler (Emeritus Senior Scientist, NASA) engaging in the special session *Connecting Country to Deep Space*

Plants for Space at the International Astronautical Congress – Sydney 2025

The International Astronautical Congress (IAC) is the world's largest annual gathering of the global space community. Convened by the International Astronautical Federation (IAF), the Congress brings together scientists, engineers, astronauts, policymakers, industry leaders, educators, and students from across the globe to share breakthroughs, debate emerging challenges, and shape the future of space exploration and utilisation.

In 2025, the IAC came to Sydney, marking a rare opportunity for Australia to showcase its growing leadership in space science, technology, and policy on the international stage. The Congress theme, *Sustainable Space: Resilient Earth*, provided a powerful platform for highlighting the role Plants for Space is playing in improving the sustainability of plant and food production systems on Earth through the pursuit of long-duration human habitation in space.

IAC 2025 attracted approximately 7,400 registered delegates from around 99 countries. The Congress also hosted a free public open day, Space Day, that welcomed more than 19,000 members of the public, including school students, educators, and space enthusiasts.

Plants for Space maintained a presence throughout the week, with a dedicated exhibition space that was visited by large numbers of delegates during the professional program and by members of the public on Space Day. The stand became a focal point for conversations about the importance of plants to long-duration Space travel, enabling visitors to engage directly with researchers, explore sustainable on-demand biomanufacturing, and learn how space-driven innovation is reshaping sustainable plant and food production on Earth. Plants for Space researchers also featured in the technical program across the fields of law and ethics, education, sensory sciences and food systems.

A centrepiece of Plants for Space's involvement was leading the special session *Connecting Country to Deep Space: Ancient Lessons in Sustainability for Agriculture Beyond Earth*, one of only 18 selected from

more than a hundred submissions. Designed as an interactive "campfire" dialogue, the session brought together Indigenous knowledge systems and cutting-edge space research to explore how plants will support human health, nutrition, and wellbeing in deep space.

Facilitated by Indigenous cultural leader Professor Deen Sanders OAM, the session featured local and international experts including Professor Matthew Gilliham (Director, Plants for Space), Dr Jennifer Bromley (JAM Agritech), Dr Raymond Wheeler (Emeritus Senior Scientist, NASA), Dr Koichi Wakata (Astronaut and CTO, Axiom Space), Chris Hewett (Australian Space Agency), and Aude Vignelles (Vignelles Space Pty Ltd). Together, they reframed plants not merely as resources, but as active, relational elements within whole systems, drawing on Indigenous understandings of Country as the source of science, ecology, and interconnected knowledge.

Grounded in perspectives shaped by many tens of thousands of years of Indigenous systems thinking, the session explored sustainability not as a technical fix, but as a responsibility to the health of the whole system. Discussions linked the fragility and scarcity of deep space environments with Indigenous thinking that understand plants as medicine, food, fibre, and knowledge-holders. By integrating these perspectives with advances in controlled environment agriculture, closed-loop life-support systems, and space habitats, the session challenged participants to ask not only how humans will survive beyond Earth, but how future systems might sustain the resilience of entire ecosystems.

Across formal sessions, informal meetings, and sustained engagement at the exhibition stand, the Centre connected with industry, academic partners, and international space agencies, progressing collaborations that open new pathways for Centre research to have impact in the world and beyond.

Public engagement during Space Day further highlighted the value people place on plants, not only for nutrition, but for wellbeing more broadly. Many visitors spoke about the emotional and psychological importance of plants in extreme and isolated environments. The event also enabled direct engagement with educators keen to engage with the Centre's education program, extending the Centre's reach into classrooms and inspiring the next generation.

Top: From L-R Chris Hewett (Australian Space Agency), Dr Jennifer Bromley (JAM Agritech), Professor Matthew Gilliham (Director, Plants for Space)
Middle: Professor Deen Sanders OAM presenting facilitating the special session
Bottom: The P4S exhibit at the International Astronautic Congress, Sydney

From seed to galaxy...

How growing plants in space can help us on Earth

P4S Researchers are exploring how engineering plants for space could transform life on Earth. Space-ready crops designed to thrive in microgravity and produce food, medicines and materials are inspiring new solutions to challenges like climate change and food security. From flood-resistant crops to plant-based vaccines, this research shows how the quest to grow beyond Earth is also cultivating a more sustainable future at home.

Left: Dr Troy Miller looking on as the vertical farm operates.

Australia's Space Capabilities: Innovation, Challenges, and Global Impact

The P4S team had a busy and productive day at the Southern Space Conference on 25 March 2025, a flagship event for Australia's space sector held in conjunction with the Avalon International Airshow. The conference brought together leading decision-makers and industry experts to explore the growing role of space in addressing geopolitical, economic, environmental, and strategic challenges. P4S COO Dr Richard Harvey participated in a panel discussion on *Australia's Space Capabilities: Innovation, Challenges, and Global Impact*, and he, along with P4S Centre Deputy Director Professor Melissa de Zwart, also connected with Australian astronaut Katherine Bennell-Pegg, highlighting P4S's strong engagement with the national space ecosystem.

Below: From L-R, COO Dr Richard Harvey, Deputy Director Prof Melissa de Zwart and Katherine Bennell-Pegg

SA Kids In Space Challenge

University of Adelaide Professor Melissa de Zwart and Dr Ciara Finnegan served on the judging panel for the SA Kids in Space Challenge, hosted at Riverdale Primary School and organised by the Andy Thomas Space Foundation in partnership with Makers Empire. Students from 13 South Australian schools showcased innovative STEM projects tackling real-world space challenges. The creativity, curiosity, and enthusiasm on display highlight an exciting future for kids in STEM, inspiring confidence that the next generation of innovators is already taking flight.

Above: Dr Ciara Finnegan and Deputy Director Prof Melissa de Zwart at the SA Kids In Space Challenge.

$12 million grant backs global team to create first synthetic plant chromosome

A world-first effort to build an artificial chromosome entirely from scratch in plants has received more than $12 million in funding from the UK's Advanced Research and Invention Agency (ARIA) through its Synthetic Plants program. An international team of researchers, including P4S Chief Investigator Professor Ryan Lister and P4S Research Fellow Dr James Lloyd from The University of Western Australia, will join collaborators from the University of Cambridge, biotech company Phytoform Labs and the Australian Genome Foundry at Macquarie University, to pioneer technologies to design, build and install synthetic chromosomes in plants.

P4S researchers hit the airwaves

P4S researchers Dr Marta Peirats-Llobet and Dr Declan Lafferty joined Dr Shane and Dr Ray on Einstein A Go-Go, the long-running radio program known for exploring the wonders of science and its impact on society. During the conversation, they shared insights into their latest work within Plants for Space, discussed the challenges and opportunities of conducting cutting-edge research with real-world applications, and highlighted the importance of communicating science beyond the lab. Their appearance offered listeners an engaging glimpse into how P4S researchers are contributing to future-focused solutions both on Earth and beyond.

Above: Dr Marta Peirats-Llobet (second from right) and Dr Declan Lafferty (far right) in the studio for *Einstein A Go-Go*.

University work supporting the UN Sustainability Development Goal

University of Adelaide CI Prof Volker Hessel's research has been showcased as a leading example of how university innovation is advancing the United Nations Sustainable Development Goals. A global pioneer in continuous flow chemistry, Prof Hessel is transforming the way the chemical industry operates by enabling greater efficiency, enhanced safety, reduced waste, and a significantly lower environmental footprint. Reflecting the strong sustainability focus within Plants for Space, his work was recently profiled in a case study aligned with Goal 12: Responsible Consumption and Production, one of the 17 UN Sustainable Development Goals.

Below: Prof Volker Hessel

Revolutionising Space Cuisine: From bubbles to 3D printed delicacies

The University of Melbourne P4S researchers presented groundbreaking work at the MELiSSA Space Research Program conference in Granada, Spain. Their innovations are transforming the future of food in space, from sparkling water and dairy products for astronauts to wine production in zero gravity. Using 3D printing, gourmet meals like wagyu beef or salmon sashimi could soon be enjoyed beyond Earth. This work brings the dream of sustainable, high-quality space dining closer to reality.

Below: Dr Claudia Gonzalez Viejo and A/Prof Sigfredo Fuentes.

Autonomous agriculture to support space exploration

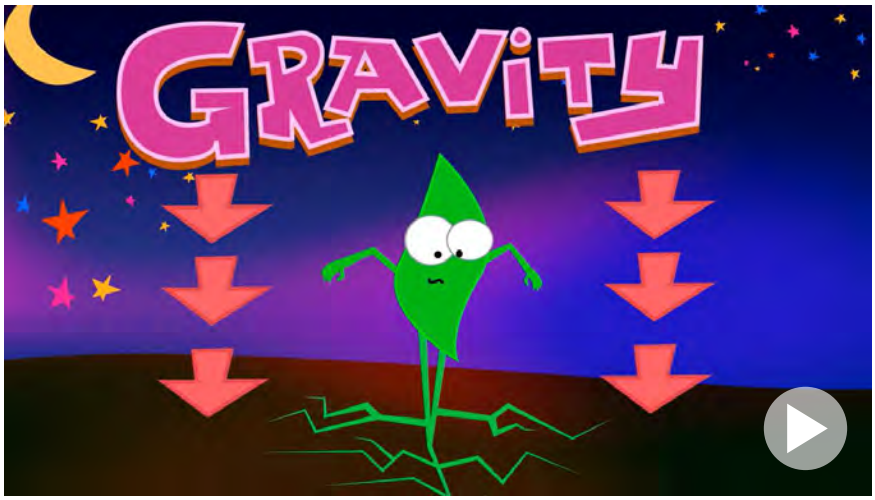
Prof Matthew Gilliham, Prof Jenny Mortimer, The University of Adelaide

This project developed a prototype autonomous controlled-environment agriculture (CEA) system, designed to optimise plant growth in space and support both long-duration missions and scientific experimentation. Through a cross-disciplinary collaboration between plant scientists and space technology providers from the UK, Australia, and the USA, we explored new opportunities for automating crop production in orbit and on Earth.

The system was designed with Axiom Station in mind, building on insights from prior experiments aboard the International Space Station (ISS). A key milestone was the successful parabolic flight of the engineering development unit (EDU), significantly advancing its Technology Readiness Level (TRL) and validating core system capabilities under microgravity conditions.

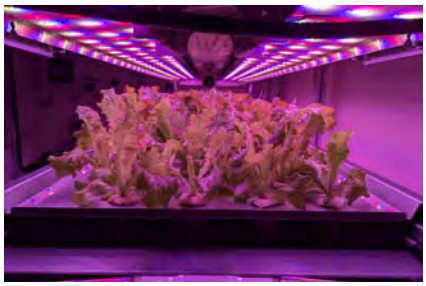
The project also established a global testbed of replicated plant growth sites, enabling robust comparison of environmental and phenotypic data streams across research and commercial environments. These testbeds provided critical input into the development of machine vision tools and decision-support systems, forming a strong foundation for future commercial applications in space and terrestrial AgriTech.

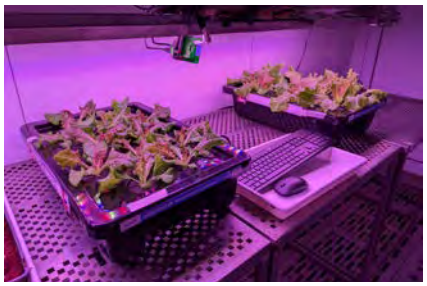
Public engagement was a key pillar of the project. We delivered a comprehensive outreach programme that engaged with government, industry, education, and the general public. This included the development of free educational resources to promote understanding of how space-based research informs the future of food systems on Earth.



A screen shot from one of the four animated educational videos targeted at school-aged children – The effect of gravity on plant development.

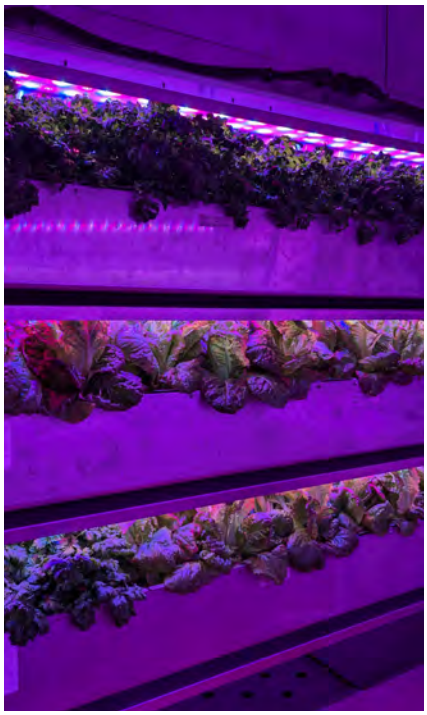
Examples of vertical farming systems (L) Image of pilot scale VF vertical farm in operation at UoA, with Outredgeous red romaine lettuce growing in the lower shelves (R) Image of Syan Farms, UK, a commercial VF operation.





Left: Autonomous agriculture team gathered in front of RSOC (managed by Saber), at the ASA Space Discovery Centre, Adelaide, as part of the Q4 meeting. The plant monitoring platform is displayed on screen behind the team.

Others: Still images showing the set ups at remote sites



Key Outputs, Benefits, and Impact

- **Autonomous Growth Facility for Space:** Designed and built a prototype autonomous CEA system targeted for deployment on Axiom Station. This supports closed-loop crop production and contributes to space-based food security and biological research capabilities.
- **Parabolic Flight and TRL Advancement:** Successfully flew the engineering development unit (EDU) during a parabolic flight campaign. This included demonstrating successful irrigation in microgravity, contributing to a key objective of raising the system's TRL. This represents a significant step toward operational readiness in spaceflight conditions.
- **Integrated Lighting and Monitoring System:** Developed a novel lighting panel integrating power delivery and camera systems, suitable for deployment in microgravity. This innovation supports energy-efficient lighting and continuous plant monitoring in confined or remote environments.
- **Global Data Pipeline Using Common Off The Shelf (COTS) Components:** Designed and implemented a low-cost, open-source monitoring system using commercially available hardware. Deployed at five international sites, the system enables scalable, affordable plant monitoring for diverse users in research, education, and industry.
- **Machine Vision and Imaging Innovations:** Created full-colour imaging protocols and machine vision algorithms capable of monitoring plant health day and night. These tools support non-invasive, real-time diagnostics and improved decision-making in both terrestrial and space agriculture.
- **Open Access and Replicability:** All software, hardware designs, and experimental protocols will be made freely available through public repositories, supporting ongoing innovation, transparency, and reuse by the global research and education communities.
- **Commercial Capability Building:** Supported skill development and technical capability within commercial partner organisations, strengthening their future competitiveness in the rapidly evolving space and AgriTech sectors.
- **Education and Public Engagement:** Delivered a wide range of freely available outreach materials (animations, explainer videos, and teaching resources) designed to inspire and educate audiences about the intersection of horticulture, engineering, and space exploration in future food systems.
- **Scientific Publications:** One publication in Trends in Plant Science, with two research publications due in 2026.

Long-term food storage in space

Dr Ane Aldalur, Dr Lydia Ong, Prof Sally Gras, The University of Melbourne

Storage plays a key role in creating sustainable space food systems, allowing resources to be used efficiently. While reliable storage is important for current space exploration, it will become even more important in the future, as we begin to supplement food sourced from Earth with crops grown and processed in space and as we venture to Mars, where self-sufficiency will be critical.

Currently, food consumed in space is grown, processed and packaged on Earth. Space food developers balance a long list of requirements. Food needs to be nutritious, lightweight, palatable and shelf-stable for long periods to meet astronauts needs. There is no food refrigeration or freezing unit on the international space station (ISS), so all foods must be stable at ~22°C. This shelf-stable food is often supplemented with fresh 'treat' ingredients, sent from Earth.

Long duration missions potentially require food to be stable for up to 5 years. This means potential loss of vitamins (C, D, K, B1) and minerals (calcium and potassium) needs to be carefully considered. To date, no food system has been shown to supply food that could considered both sufficiently tasty and nutritious enough to eat during a 5-year space mission. Other challenges include the restricted mass and volume of spaceflights and the hostile environment, including radiation and extreme temperatures. As a result, it would be helpful for space system engineers to better understand the options available to preserve and store the plant-based ingredients and foods that could be grown and processed in space.

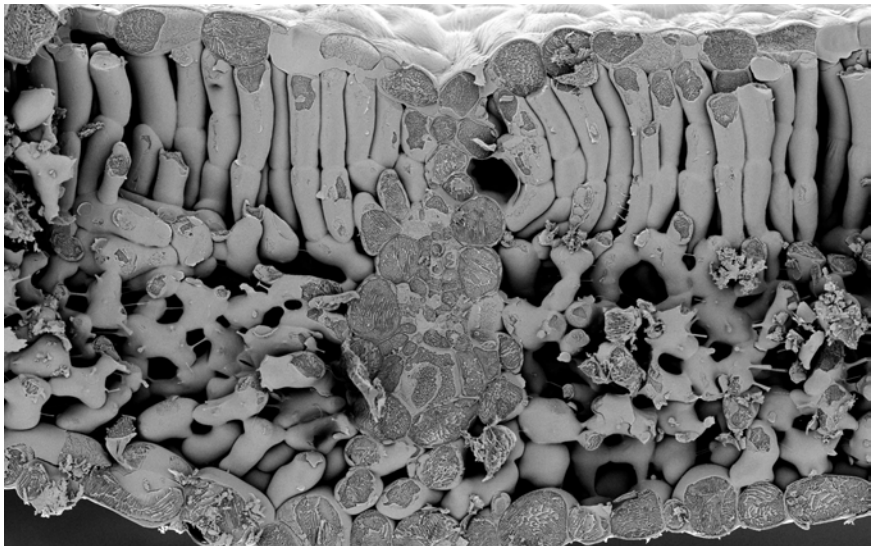
As consumers, we know that fresh fruit and vegetables have a short shelf life. While familiar methods, such as refrigeration and freezing, have been considered for future long-term space missions, other options include thermal and non-thermal processing,

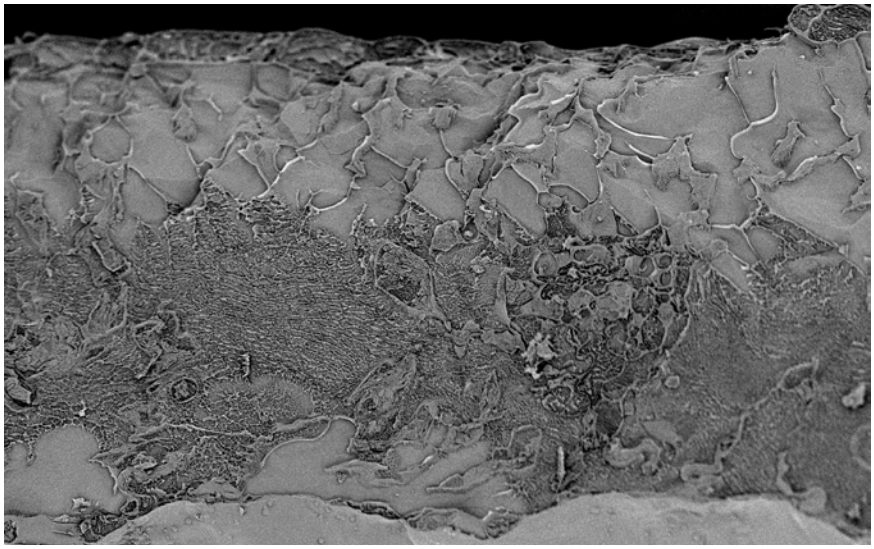
Astronaut Chris Hadfield pointing to stowed food packets. Image from NASA

Freeze drying removes water from food via sublimation, allowing food and ingredients to be further processed into powders that are compact...

storage and packaging technologies. Although food is not currently frozen on the ISS, many scientific samples are stored frozen before their return to Earth, illustrating proof of concept. Some of these systems include Minus Eighty-degree Laboratory Freezer for the ISS (MELFI), General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER) and Polar refrigerator, which can provide temperatures ranging from 4 °C to -160 °C. NASA is also assessing the potential of a "hurdle approach", where several processing and storage technologies are combined to extend the shelf-life of food produced on Earth in order to achieve the 5-year target. It is clear, however, that growing food crops in space that are highly nutritious and can be processed and stored effectively will be essential for long- term survival.

Within Plants for Space, the food engineering team is investigating different storage solutions and engineering strategies to optimise the storage of leafy greens. Freezing and freeze-drying are two examples of long-established technologies that can preserve the nutritional

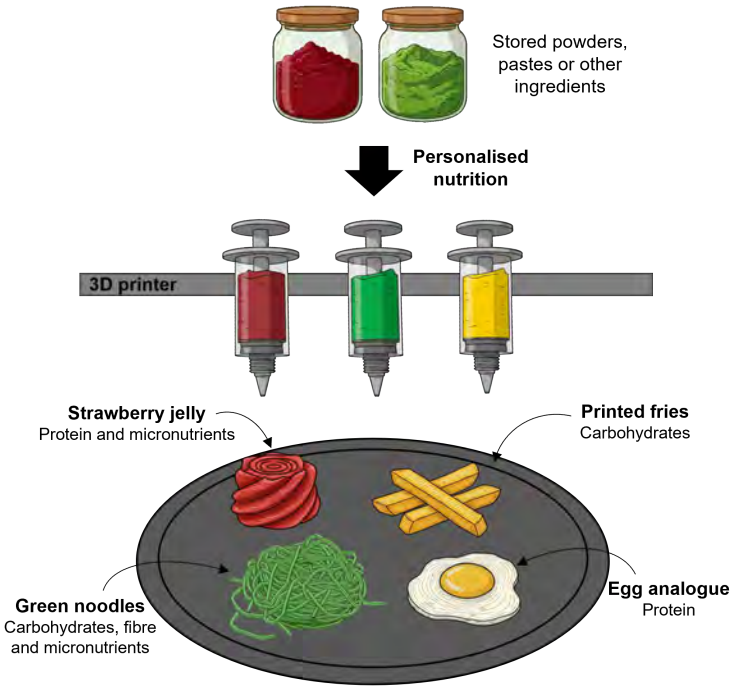




quality of leafy greens and other space crops that are currently being examined. One problem with freezing is that it can impact the structure, texture and sensory characteristics of leafy greens; understanding the physical process of heat transfer can provide insights that may allow process optimisation.

Freeze drying removes water from food via sublimation, allowing food and ingredients to be further processed into powders that are compact, potentially preserving essential micronutrients and valuable biomolecules for longer periods of time. More research is needed, however, to understand the long-term degradation kinetics of nutrients in the hostile space environment.

Shelf-stable green powders or concentrated pastes could be used as ingredients to create newly restructured foods through methods such as 3D printing, helping to create personalised nutrition solutions and combat menu fatigue. The P4S food engineering team at The University of Melbourne, in collaboration with the Digital Agriculture, Food and Wine Sensory team (A/Prof. Sigfredo Fuentes and Dr Claudia Gonzalez Viejo), is currently investigating this approach. Together, they have successfully printed self-supporting gels incorporating green powders and plant-based ingredients. The success of future long-term missions will depend on what foods we can preserve and a wide variety of storage solutions maximises this possibility of success.



Right (above): A cross section of fresh and frozen-thawed water spinach leaves imaged by Cryo Scanning Electron Microscopy at Ian Holmes Imaging Centre.

Right: Schematic drawing of the wide range of potential uses of stored powders, concentrated pastes and other food ingredients using 3D-printing to create a plate of complete and personalised nutrition. Individual vector images were created using Gemini AI.

We are pleased to have received two **Australian Economic Accelerator Ignite Grants** in 2025, supporting early-stage research translation at the University of Adelaide. The Ignite program provides competitive funding to help researchers advance innovative ideas from foundational research through to proof-of-concept in industry-relevant settings.

The two projects outlined below, led by **Professor Volker Hessel** and **Dr Adriane Piechatzek**, showcase cutting-edge approaches to improving agricultural productivity and sustainability. Together these projects create a pathway to impact by advancing plant growth optimisation and predictive modelling in industry settings, capabilities that will be essential for enabling sustainable plant and food production in space.

Improving commercial outcomes for the tomato industry through enhanced vigour and grafting success

Dr Adriane Piechatzek,
University of Adelaide
AEA Ignite Round 1 Funding - $310,264.00

Inspired by Aboriginal rainmaking practices in Queensland, the startup Rainstick uses electric "lightning" to support crop growth and vigour. By treating plants with Variable Electric Fields (VEFs), Rainstick has observed noticeable growth benefits in several crops, with early data indicating enhanced tomato growth. However, more data is needed to confirm these initial results, uncover the molecular mechanisms underlying the growth effects, and identify the most effective treatment protocols for commercialisation. This is where the AEA-Ignite Grant "Improving commercial outcomes for the tomato industry through enhanced vigour and grafting success", led by Dr Adriane Piechatzek, comes in – a highly collaborative project with experiments conducted across multiple sites, including Adelaide University, La Trobe University and James Cook University.

As part of this project, tomato seedlings of different varieties are being evaluated using high-throughput phenotyping at Australian Plant Phenomics Network (APPN) facilities across different treatment recipes, with focus on canopy density, estimated biomass and plant height. The project further examines how electrostimulation affects grafting success as well as fruit yield. This extends to a deeper exploration of its impacts at a molecular, biochemical and physiological level using microscopic, bioelectric as well as multi-omic approaches to provide scientific validation of the VEF technique and potentially increase confidence among end users. Following the results, a business case will be prepared to facilitate the commercialisation of the VEF method, thereby enabling end users to cultivate faster-growing, higher-yielding and healthier tomato plants.

From left: Tomato plants growing to full maturity in a greenhouse. Assessing plant growth to full maturity for yield assessment. Tomato plants on the conveyor system at the APPN facility in Adelaide during high-throughput phenotyping.

Digital Twins in Agriculture: Virtual Farm Model for Enhancing Crop Health, Productivity, and Sustainability

Professor Volker Hessel,
University of Adelaide
AEA Ignite Round 1 Funding - $491,672.00

Imagine multiple experts simultaneously informing food producers about fighting crop pests and diseases as well as improving farm productivity and sustainability through reducing CO2 emissions and nutrient and pesticide pollution. Currently this is an inefficient process, but it could be with the power of machine-learning. This approach will drive rapid decision-making and outcomes for producers without them needing to crunch through data sets and information.

The AEA-Ignite Grant "Digital Twins in Agriculture: Virtual Farm Model for Enhancing Crop Health, Productivity, and Sustainability" of Prof Volker Hessel is designed to drive key investment areas, when protecting viticulture and canola, as well as defending crop pests, and reducing pollution, and improving crop health, sustainability and productivity.

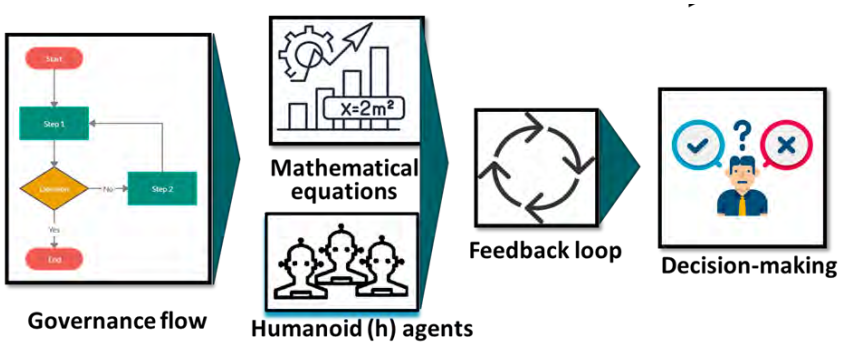
Digital Twins (DT) are a virtual model of a physical process, system, or environment that continuously updates with real-time data, providing simulation, prediction and optimisation to assist organisations to make data-driven decisions. The project intends to develop an innovative DT platform for improved decision-making to foster canola and vineyard production. At the forefront of sustainable agricultural innovation, this platform is organised to provide advice from multiple 'virtual experts', so-called multiagent generative system (MAGS).

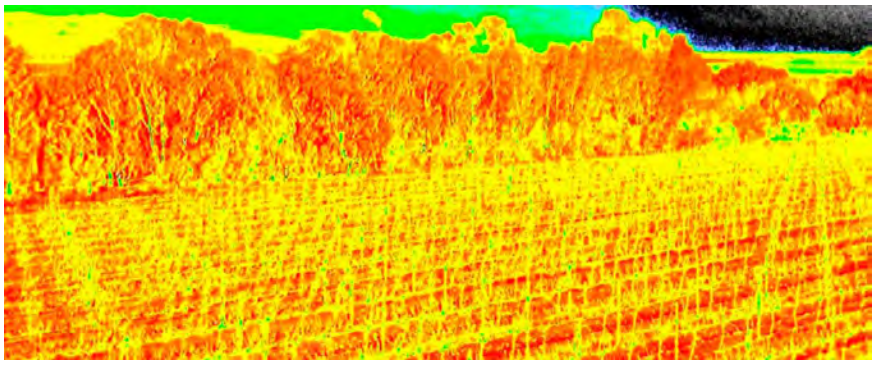
Alongside the University of Adelaide, organisation partner Serafino Wines, a renowned South Australian Family owned and operated wine company situated in the McLaren Vale Wine region, will play a key role in this initiative. Led by CEO, Cavaliere Maria Maglieri, Serafino Wines will contribute by conducting field tests using sensors on their vineyards. These sensors will be installed and operated by a team led by Professor Harpinder Sandhu of the Federation University Australia and their collaborators Constellation Technologies, Melbourne. The data will provide crucial information to support the project's goals.

Left: RGB image of the vineyard block (approximately 2.1 ha).

Below: Governance flow for decision-making using deterministic switch points (governance by equations) and discursive solution provision (governance by computational or humanoid multi-agent generative systems).

Bottom: False-colour thermal/ vegetation intensity map of a vineyard block, taken by canopy imaging of a camera-equipped drone.





Different to current practice in IoT-farm monitoring and mentoring, the modern "living" DT will orchestrate big data into a mature decision-making tool (five-layered governance flow), including proactive countermeasures for plant health and sustainability. This has been co-developed with the Australian DT-company XMPro and is commercially available.

This terrestrial, industry-linked project applies digital twin methodologies in a data-rich environment, providing a robust testbed for refining modelling, validation and iteration processes. These capabilities can be translated to space-based plant growth systems, where data is sparse and high-fidelity predictive modelling is critical.

Balancing security and governance in outer space

Prof Melissa de Zwart,
University of Adelaide

Space activities are regulated by both international and domestic laws. As space is an inherently international domain, with no borders or concepts of sovereignty which may be applied to regulate movement and activities on Earth, those laws must address what states and private actors are allowed to do beyond Earth's atmosphere. Space is a domain for great power competition but also provides a unique opportunity for humanity to work together on projects of significant challenge and complexity. Space has historically been a place of incredible human co-operation and achievement, especially in the domains of science and technology. The laws of space attempt to balance and regulate these many complexities.

In 2025, Plants for Space Deputy Director Melissa de Zwart was invited to contribute to a range of national and international legal projects. These covered matters as diverse as the global management of space debris to the domestic legal requirements of returning materials to Earth from space. The Attorney-General's Department even selected 'Space Law' as its theme for Book Week and invited Professor de Zwart to Canberra to showcase her research as part of those celebrations.

In September 2025, Professor de Zwart was invited to the United Nations Institute for Disarmament Research (UNIDIR)

Space has historically been a place of incredible human co-operation and achievement, especially in the domains of science and technology.

Outer Space Security Conference 2025 in Geneva. The purpose of the conference was to engage the diplomatic community who advise global decision makers, with experts from industry, defence, academia and civil society in a practical dialogue addressing urgent issues of outer space security. The conference promoted the development of practical outcomes which may lead to a more peaceful, secure and accessible space environment.

Professor de Zwart addressed the topic of Article VI of the Outer Space Treaty, which requires all states to 'authorise and continually supervise' the space activities of their non-governmental entities. This provision forms the legal basis for states regulating the space activities of private companies. This requirement has attracted greater attention in recent years, with the massive expansion of private space operators, including launch providers, satellite companies and even proposed private space stations.

Presenters at the Conference, which was hosted in the historic Palais des Nations, were organised into mixed panels of academics and industry, as well as representing a vast diversity of states. Student participants were also strongly represented at the Conference to ensure a voice for future stakeholders. This is consistent with the Plants for Space focus on ensuring that concepts of intergenerational equity are embedded in our legacy thinking.

In a time of global growth of space activities, Plants for Space, through its engagement with space activities across the globe, partnering with universities, government space agencies and a vast range of commercial operators, is well placed to contribute to local and global debate on space security and sustainable uses of space. This expertise is also influenced by the unique interdisciplinary nature of the research team.

Opposite: The Palace of Nations (Le Palais des Nations) is the home of the United Nations Office at Geneva, Switzerland

Below left: Members of the United Nations Institute for Disarmament Research (UNIDIR) Outer Space Security Conference 2025.

Below right: Deputy Director Prof Melissa de Zwart

Below bottom: Deputy Director Prof Melissa de Zwart speaking at the Outer Space Security Conference in Geneva

Next generation critical thinking

Jordan Witchard, Dr Frazer Thorpe & A/Prof Kim Johnson, La Trobe University

Plants for Space is helping to create the next generation of the space and plant biology workforce by providing immersive experiences to teachers and students supported by P4S research stories and the researchers themselves.

Plants for Space is helping to create the next generation of the space and plant biology workforce by providing immersive experiences to teachers and students, supported by P4S research stories and the researchers themselves. This places researchers in new public-facing contexts, whether on radio stations, in classrooms, or during laboratory visits. In these settings, researchers aim to give young students a positive impression of science, model potential future careers, and encourage critical thinking through authentic scientific experiences. This serves to improve scientific literacy and supports the development of science identities for both teachers and students alike.

However, researchers are not trained teachers and may not have formal communication training. Not every researcher has the confidence or experience to speak with students or facilitate workshops. To address this, the P4S Education and Engagement team is offering researchers opportunities to participate in education and engagement events where they can practise and develop their science communication and teaching skills. This raises important research questions: What teaching skills do P4S researchers currently possess? How do they iterate and improve these skills? How can P4S encourage and support researchers to develop new professional skills while refining those they already have?

To address the first question, we asked P4S researchers to describe what they do when placed in education or communication environments, in order to understand what their default practice looks like. In addition, we asked them to explain why they adopt particular approaches. A broad theme emerging from their responses was that many of their communication skills were not intentionally learned through workshops or formal training. Instead, their approaches often developed through careful observation and reflection on their own practice, as well as on the practice of former teachers or other P4S educators in action.

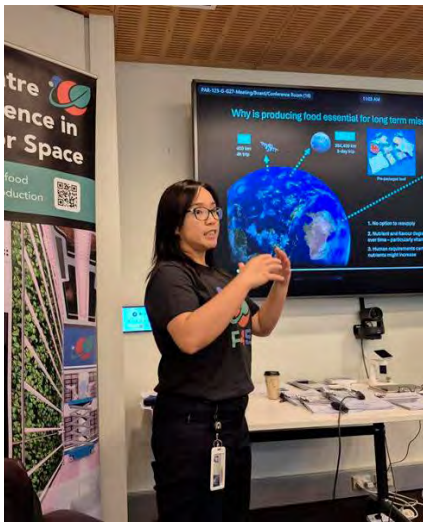
While initial findings suggest that researchers are engaged and thoughtful in their teaching and communication, there is an opportunity to further support this reflective process and provide foundational pedagogical knowledge. To this end, we delivered a professional development workshop for P4S researchers focused on critical thinking. The workshop provided a theoretical framework for understanding how students think, focusing on key cognitive skills such as analysis, justification, evaluation, and explanation. These skills were examined in relation to the attributes valued in high-quality scientific thinking, including precision, accuracy, depth, and cogency. The theory of critical thinking also demonstrated how P4S researchers might apply these principles to their own communication and research practices, offering a shared language to identify strengths and areas for improvement in both writing and verbal interactions with students.

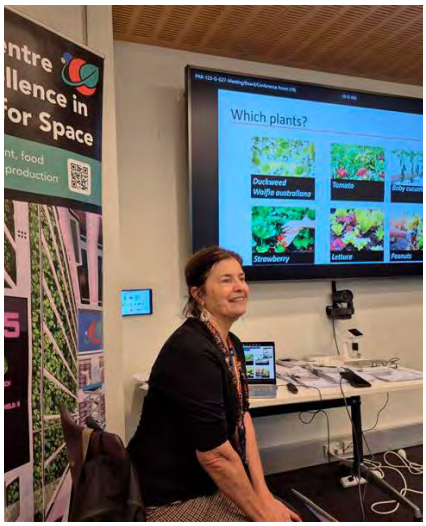
What remains to be seen is how P4S researchers' teaching and communication practices will develop over time, what factors most positively influence their confidence and effectiveness, and how P4S can continue to support and enhance their excellence in the coming year.

Top right: Critical Thinking workshop held during the 2025 Annual Conference

Left and right: Teacher professional learning days held across February and March 2025.

This workshop provided a theoretical backing to how students think, focussing on key mental skills like analysis, justification, evaluation and explanation.





Plant SynBio Australia

Transforming agriculture and biomanufacturing through plant synthetic biology.

By Dr Andrew Jacobs, Chief Operating Officer at Plant SynBio Australia, University of Adelaide node

About Plant SynBio Australia

Plant SynBio Australia (Plant SynBio) is a national network accelerating synthetic biology solutions for climate-resilient agriculture, sustainable biomanufacturing, and global food security. Funded through Bioplatforms Australia under the National Collaborative Research Infrastructure Strategy (NCRIS), with support from state governments and institutional partners, Plant SynBio unites leading universities – including Adelaide University, the Australian National University, La Trobe University, and The University of Western Australia – to deliver an integrated pipeline of innovation, infrastructure, and expertise to advance agricultural productivity and environmentally sustainable biomanufacturing.

P4S played a leading role in establishing the facility across its nodes, with Prof Matthew Gilliham, Prof Mathew Lewsey, Prof Ryan Lister, Prof Matt Tucker, and Prof Jenny Mortimer contributing to its establishment and ongoing management.

Plant Synthetic Biology

Plant SynBio focuses on synthetic biology, using engineering principles, to redesign biological pathways and construct new biological components and systems. The technologies and infrastructure support novel development of plant vaccine production, bio-pharmaceuticals, novel crops and foods, improved yields, and increased resistance to drought, disease or other environmental stresses.

Synthetic biology infrastructure and services

The multidisciplinary team of scientists, engineers, and technical specialists work collaboratively offering unique capabilities to deliver high-quality, reproducible synthetic biology solutions across national nodes. We provide infrastructure and expertise for research providers, government and industry institutions as fee-for-service as well as providing incubation space for the start-up community and opportunities to collaborate. We operate under stringent regulatory frameworks and following biosafety and ethical standards, and stringent quality control protocols to ensure product compliance, safety and efficacy.

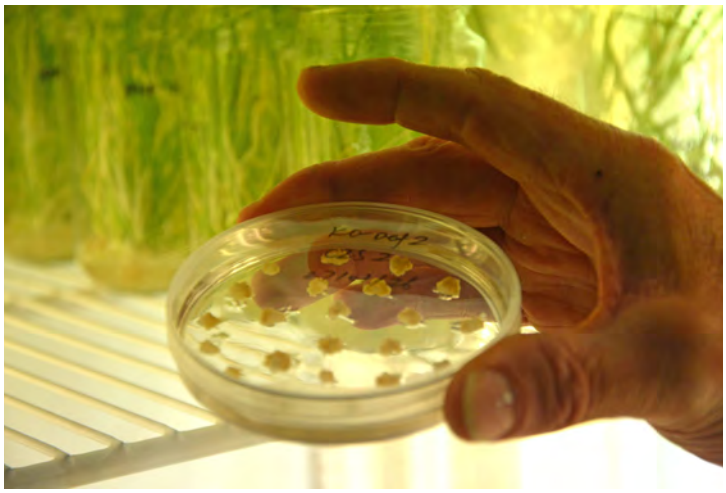
Offerings includes:

Gene editing and GMO services

- Advanced molecular componentry design and characterisation, transient and stable transformation platforms, and omics-based phenotypic evaluation of transformed plants.
- Controlled environment testing, scale-up, and field validation through a national network.

Transformation of multiple crops

- Genetic manipulation of plants, cells, proteins, pathways, and processes for research and commercial applications. Transformation capacity for oilseed, cereal, horticultural, medicinal species and model plant species.
- Validation services for genetic traits and modifications.



A collection of images showcasing transformative agriculture and biomanufacturing through plant synthetic biology.

Transient expression platforms

- Flexible and accessible systems for plant cell-based, cell-free systems to accelerate synthetic biology workflows.

Biomanufacturing

- Upstream cell culture and bioreactor optimisation combined with downstream purification and formulation expertise.

Data

- Project consultation, pipeline optimisation, and data analytics support.
- Integrated bioinformatics and data management solutions.

Integration with national facilities

- Connectivity with other NCRIS investments for validation and analytics.
- Collaboration with the Australian Plant Phenomics Network for advanced phenotyping.

Start up support

- Links to research hotels and industry incubators to promote commercialisation and start-up growth.
- Expert advice on stewardship, regulatory frameworks and intellectual property management.

Plant SynBio unites the capabilities of leading universities including Adelaide University, Australian National University, La Trobe University, and The University of Western Australia

Node locations

Plant SynBio Australia operates as a collaborative network across four university nodes, each offering specialised expertise and infrastructure to address sector-specific challenges. Each facility provides capability across the synthetic biology cycle including design of molecular componentry, genetic editing and transformation, and the phenotypic evaluation of the bio-designed plants. Plant SynBio is located at;

1. Adelaide University in Urrbrae, South Australia,
2. Australian National University in Canberra, Australian Capital Territory,
3. La Trobe University in Bundoora, Victoria,
4. The University of Western Australia in Crawley, Western Australia.

Through its close connection with the ARC Centre of Excellence in Plants for Space and its focus on enabling translation, PSBA is laying the foundations for plant-based innovations that will deliver benefits on Earth and beyond.

A landmark spaceflight for P4S

By Prof Jenny Mortimer and Prof Volker Hessel, University of Adelaide

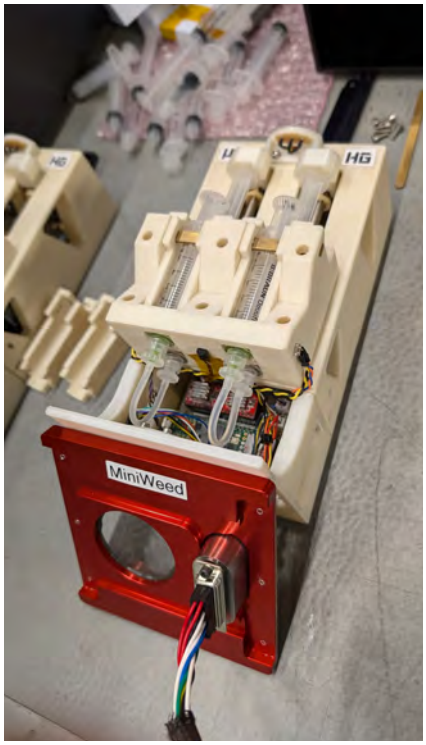
In late 2024, P4S conducted its first spaceflight experiments aboard the German Aerospace Centre's (DLR) MAPHEUS 15 sounding rocket. Launched on November 11 from Esrange in northern Sweden, the mission carried two Centre experiments among 21 scientific payloads from international research organisations. The launch achieved a record altitude of 309 kilometres and provided seven minutes of microgravity conditions for onboard experiments.

MiniWeed: Testing Duckweed in Altered Gravity

The MiniWeed experiment, a collaboration between CIs Profs Jenny Mortimer and Mathew Lewsey investigated the effects of altered gravity on *Wolffia australiana*, one of P4S' candidate space crops. We adapted a custom piece of 3D-printed space hardware, MiniFix, developed by the DLR team (and P4S collaborators) for fixing biological samples during flight, to make MiniWeed. This 10-centimeter cube module was housed within the newly developed MOSAIC rocket segment, which provides standardised interfaces for secure attachment, power and operation in space flight. This reduces development costs and timelines while increasing experimental capacity per flight.

Living duckweed fronds were chemically fixed following either the hypergravity phase, or after the microgravity phase of the flight, along with ground controls. Samples were retrieved within 24h and returned to Australia for analysis. Subsequently, with Partner Organisation BPA (AGRF), we performed transcriptomic experiments revealing early changes in gene expression that result from these changes in gravity. The data will serve two purposes: validating ground simulation systems and establishing baseline measurements for future experiments. This includes NASA's Lunar Effects on Agricultural

Prof Jenny Mortimer.



MiniWeed experiment.

Flora (LEAF) program, where Plants for Space researchers will grow plants on the lunar surface during the Artemis III mission and return samples to Earth for detailed analysis.

StarMed: Pharmaceutical Delivery in Microgravity

The StarMed experiment, led by CI Prof Volker Hessel, working with joint Adelaide-Nottingham PhD student Modupe Adebowale, examined pharmaceutical delivery systems for microgravity environments. Launched in DLRs NyMEx Experimenal module, the research tested nanoemulsion formulations (oil droplets 0.0001 mm in diameter dispersed in aqueous solution) containing melatonin, a pharmaceutical compound that helps prevent bone density loss in astronauts during extended missions.

The experiment compared nanoemulsions with and without chitosan coating. Chitosan, derived from chitin in crustacean shells, is used in controlled-release pharmaceutical formulations. Six experimental vials were exposed to spaceflight conditions, with identical control vials maintained on Earth in both Europe and Adelaide.

The results indicate that chitosan-coated nanoemulsions maintained stable droplet size and distribution under microgravity conditions, while uncoated formulations showed increased droplet size and broader distribution. Smaller, uniform droplets are associated with improved bioavailability and therapeutic outcomes. The findings also suggest that rocket launch vibrations had minimal impact on nanoemulsion stability.

This research addresses a critical requirement for long-duration space missions. Liquid medications currently constitute approximately 40 percent of pharmaceuticals used aboard the International Space

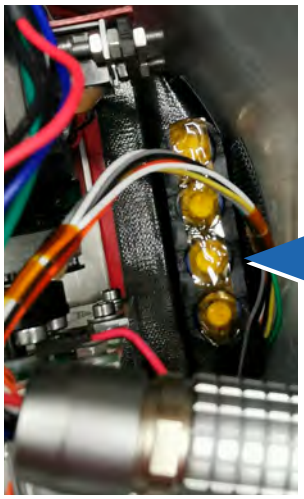
Close up of MiniWeed experiment.

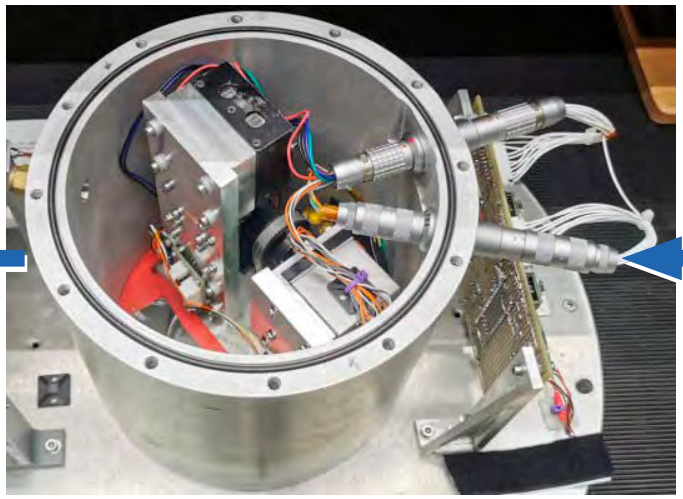

Mapheus rocket

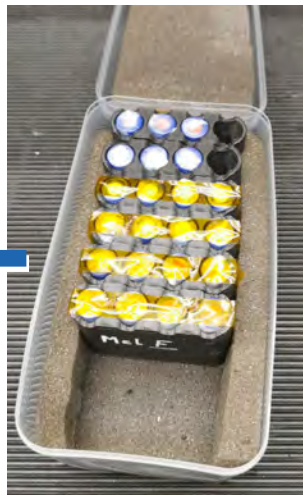
Station. For missions to the Moon and Mars, where resupply from Earth is impractical, astronauts require medicines that can be manufactured on-site and remain stable under both microgravity and cosmic radiation exposure, as pharmaceutical degradation rates increase in space environments.

Applications and Future Directions

These experiments provide foundational data for developing biological and pharmaceutical systems suitable for space environments. The MiniWeed results will inform plant physiology and molecular responses, necessary for designing crops suited for space horticulture, while StarMed findings contribute to pharmaceutical manufacturing capabilities for extended space missions.


P4S flight sample in a niche of NyMEx


NyMEx late access unit with open vaccuum tight vessel (main rocket experiment; P4S samples filled in its niches)


Melatonin nanoemulsions: 6 sample holders, each with 3 or 4 ampullas; for flight, ground, and shaker tests

Making an impact: Insights from our students

> “What are the goals, expected impact, and aspirations of your research?”

Leni Campbell-Clause

The University of Western Australia

“My research is on chloroplasts and using these tiny components as bio-factories to produce proteins, pharmaceuticals, or nutrients. Specifically with chloroplasts, when producing proteins, we want to do it at certain time points, when an astronaut needs something or when the plant is most capable to produce it. My research allows us to control what proteins we produce and when.”

“I hope my research will allow other scientists to use the control elements I find within their systems, but also help improve global food security and food safety.”

Ryan Cheney

The University of Melbourne

“My research explores how plants can be used to produce medical technologies for space. The long-term goal is to incorporate protein production into a plant that can produce oxygen, create biomaterials, and make medicines.”

“I hope my research can be used in space contexts, but also to help people here on Earth. There are many communities – remote, indigenous, or disrupted by natural disasters – where access to medicine is limited. Making medicine more accessible in low-resource ways is important, and I hope my research can contribute to that.”

Sampurna Mukherjee

The University of Adelaide

“I’m working on flow chemistry using capillaries to create microgravity-like conditions, helping us understand how these environments affect chemical reactions. I’m also developing a zero-waste circular process for extraction and nanomaterial synthesis that can be used as a nanofertilizer.”

“My long-term goals include improving the properties and bioavailability of nanoparticles, scaling up production, and making these processes more practical and impactful. Overall, I hope the methods I develop can help make chemical processes more environmentally friendly while supporting plant growth and potentially space applications.”

Camille Bitton

The University of Adelaide

"My PhD looks at lunar resource extraction, with a focus on sustainability. Within Plants for Space, I explore the ethical and sustainability considerations surrounding the nutrition of future space workforces."

"Humankind does not have a great track record on how it's conducted exploration activities in the past. As we are expanding into space, we have an opportunity to do things differently, following some core values to make sure that happens in the best way possible and in conformity with the existing legal framework."

Chelsea Hearl

Flinders University

"My research looks at how people engage and perceive plants. We've studied the sensory appeal, like visual and textural aspects, and how being with plants can improve wellbeing. We found that engaging actively with plants, through tasks like planting, watering, and weeding, improves positive aspects of wellbeing. Over time, simply observing plants also increased wellbeing."

"In future, we'd like to also explore how being with plants affects eating behaviour. For example, plant-based diets and choices, and how interaction with plants may influence what people eat."

Jordan Witchard

La Trobe University

"My research focuses on professional development and critical thinking for researchers. I help our researchers become excellent educators as well as researchers, which fits within the Centre's goal of developing people as well as science."

"I hope my project will provide best practice guidelines for professional development in science education, helping both current and future Centres of Excellence equip researchers to be great educators and communicators."

Anshul Phaugat

La Trobe University

"My research is on controlled environment agriculture, particularly with mini cucumbers. These crops are high-yielding and provide hydration, nutrition, sensory enjoyment, and psychological benefits."

"My work has three main goals. First, to translate controlled-environment techniques to industry, reducing input costs and increasing accessibility to fresh food. Second, to support climate resilience by providing ways to cultivate fresh food in areas affected by natural disasters. And third, to contribute directly to missions to Mars, where astronauts could grow mini cucumbers in controlled chambers using the methods I am developing for lights, water, hydroponics, and nutrient management."

Kenny Lam

The University of Melbourne

"My research uses machine learning and bioinformatics to predict the taste of different compounds. Traditionally, sensory assessment relies on human panels, but these computational approaches allow us to accelerate the discovery of flavourful compounds, saving time and resources."

"The long-term goal is to develop tools that enable scientists to engineer flavourful, nutritious plants for space missions, where taste is vital for astronauts' diets over extended periods. These approaches also have potential applications on Earth, helping create more sustainable and enjoyable plant-based foods while supporting innovation in food design and processing."

Elliot Fourie

The University of Western Australia

"My PhD focuses on developing RNA editing tools to control plant traits. RNA sits between DNA and proteins, and by switching it on or off, we can guide plants to grow efficiently, produce food, or generate therapeutics and materials. These capabilities are important for space missions, where plants may need to serve multiple purposes in controlled environments."

"Beyond space applications, this work also has the potential to improve drought resilience, enhance climate adaptability, and contribute novel insights to plant engineering."

Looking forward to 2026

As we move into 2026, we do so with strong momentum and a clear sense of purpose. The year ahead presents new opportunities to deepen our impact, pursue ambitious research goals, and strengthen partnerships across the sector. Building on recent achievements, P4S is well positioned to navigate emerging challenges and advance innovative solutions. The following highlights outline some of the key activities and priorities that will shape our work in the year ahead.

Plants

- Characterise the protein profile of duckweeds and their nutritional composition.
- Develop approaches to maximise expression of highly nutritious proteins for space crops.
- Assess lettuce tolerance and response to space-encountered stresses and risks.
- Develop spatial transcriptomic analysis protocols for lunar samples from the Artemis III mission.
- Developing hardware for new duckweed sounding rocket mission.
- Improve tomato, lettuce, and strawberry growth and micronutrient content in space-based systems.
- Modify lettuce to improve protein and stress resistance.
- Map hormonal influences on arabidopsis and tomato growth and yield.
- Phenotyping allocation to leaves, roots and fruits in existing strawberry genotypes to identify sources of edible harvest index.

Products

- Assess the expression of plant-derived products, including biopharmaceuticals and the feasibility of extraction, concentration and purification.
- Develop plant-optimised gene editing and regulation tools, and curated DNA parts libraries.
- Expand gene regulatory atlases for priority species to guide engineering targets.
- Advance space-relevant plant products (biopharmaceuticals, materials) to test-ready prototypes.
- Demonstrate pharmaceutical production in a plant cell bioreactor on the ISS.
- Evaluate duckweed and Arabidopsis performance under simulated micro- and lunar gravity.
- Generate Artemis-aligned gravity response datasets and engineering requirements for candidate plants.
- Develop new methods for structuring plant-based foods and producing vegetable juices and powders.
- Predict and enhance the properties of plant-based foods, including taste, such as umami.
- Understand the factors driving sensory and psychological responses to plant-based foods to improve acceptance.
- Investigate the digestibility of plant-based beverages.
- Explore the factors affecting storge of plants and plant-based foods in space and on earth.
- Assess the role that fermentation can play in tailoring desirable functional properties and the taste of vegetable juices.

Processes

- Optimise machine learning and apply agentic generative governance flows within digital twins to improve plant growth.
- Develop renewable fertilisers out of (space) plant and other waste by flow chemistry.
- Enforce health nutrient extraction from (space) plant waste; facilitated by plasma cell-wall breakage.
- Design new formulation strategies for health nutrients, specific for space.
- Conduct sustainability assessments for manufacturing systems that couple plant growth (e.g., vertical farms) to health nutrient extraction and other kinds of bioresource production.
- Model supply chains designed through technological advancements in experimentation, including microgravity studies (RPM), regolith as growth substrate, regolith nutrient leaching, LED/HVAC energy efficiency, and more.
- Develop a whole of government framework addressing regulation of launch and return of genetically modified plants.
- Engage with indigenous cultural approaches to space food and space biology.
- Develop environmental and ethical frameworks applicable to future space activities.
- Launch an international conference on legal and ethical issues arising from human missions to outer space.

Left: Thomas Cobbinah, La Trobe University

Below: Shu Liang, The University of Adelaide

People

- Establish and begin to deliver the P4S flagship education and engagement program 'Cosmic Future Crops' through targeted resource development for primary and secondary school students.
- Participation in the Australian Virtual Astronaut Challenge, through the contribution of P4S STEM kits and support for the design challenge, including a teacher podcast.
- P4S STEM kit and design challenge (with teacher podcast).
- Work with partners to develop an interactive P4S-inspired gamified education tool.
- Design and develop Sci-Fi prototyping national science week public engagement.
- Work with partners to develop a STEM Education White paper.
- Continued interviews and thematic analysis of demonstrator interviews from P4S researchers and partners.
- Continuation of P4S mentoring program, with efforts to increase take-up of the program across the Centre.
- Continue to develop and deliver P4S' 'StarPass' professional learning activities to Centre members.
- Grow and develop P4S' place in the international space agriculture community.
- Continue to develop and co-design, with international partners, an implementation plan for the use of plants to support human space exploration.

Governance

- International Research Advisory Committee review of Centre research programs.
- Continue Quarterly Advisory Committee meetings.
- Translation and entrepreneurship committee to meet twice and review the Centre's research program and advise on project progression.
- Annual CIs workshop.
- EMCR and student research symposium.
- P4S Annual Conference.

Centre Community

- Recognition of significant cultural occasions.
- Centre-wide Steps Challenge.
- Continuation of P4S Seminar and Research Updates series.

Plants for Space Engagement

The Education and Engagement team brought together all Centre members to share the research to broader audiences in Australia and worldwide.

Throughout the year Centre members recorded well over 400 individual engagements, ranging from school visits to presentations to government, networking and careers events and public talks of all kinds of formats – like three sessions of 'Science Comedy' during the WA and SA Fringe Festival! Overall, this was a great year for engagement, and larger events showcasing P4S to broader audiences included:

National Science Week

August 2025 P4S truly shared a 'festival of science events', through a range of activities and activations across Australia for National Science Week. All nodes jumped on the opportunity to engage with local schools and communities, but highlights of the efforts were seen in collaborations across all of Australia.

Highlights of National Science Week this year included:

Grow 4 Launch

Over 250 schools and educational groups signed up to receive a STEM kit to set up their own hydroponic grow environment and get hands-on with astrobotany. Students across Australia, and the world, joined in for an online event to get started, after which all teams could work through the workbooks provided through the P4S website. Plants were growing from the Australian Outback to the Netherlands, exploring what it takes to grow your own crops in indoor facilities.

Space cookbook

To connect growing plants to actually eating plants for complete nutrition, P4S challenged space researchers, astronauts and everyone interested in intergalactic dining to put forward their best plant-based meals. The P4S team has been collecting plant-based recipes since Science Week, for release of an informative stellar cookbook in 2026.

Alpacas in Space

Thousands of students joined for this collaborative event with the Museum of Australian Democracy. Author Matt Cosgrove read his latest book 'Alpacas in Space', which was followed by an interactive activity in designing your own space plant. This event was an absolute hit for the youngest space enthusiasts all across Australia. Furthermore, following the live event, the reading and activity are still online available and are regularly accessed by Australian teachers.

Local live events were held at Kings Park in WA, Science in the Outback Pub in SA, and, Scienceworks in VIC. All engagement activities were also widely covered by local and national media, sharing the P4S stories far and wide.

Left: Dr Janine Oldfield (centre) at the World Science Festival, Townsville

Right: Best in show recipient – April Harris (right), The University of Western Australia

Queensland Science Museum

Dr Janine Oldfield travelled to Townsville, to present P4S during the World Science Festival by the Queensland Museum. For two days, Janine was located in the 'surviving space' zone for the event.

On day one students and teachers from ten local Townsville schools had the opportunity to see a presentation and jump onto a photosynthesis assay experiment. At the public event on day 2 families could participate in a range of hands-on activities through photosynthesis measuring experiments, musical plants and Lego plant design, and learn all about astrobotany.

Barunga Festival

More travel up North for Dr Janine Oldfield, as she travelled together with Dr Ziwei Zhou to the Northern Territory running hands-on science activities and workshops for all ages. Janine and Ziwei started by running a stall at the Barunga Festival, an immersive Aboriginal cultural experience festival celebrating Indigenous music, art, culture and sport. At the festival, participants gathered at the stall to play musical fruit and vegetables, create space gardens and new types of plants with Lego plant pieces, examine plants and other 'things' under a microscope, and chat or read about P4S research.

The team then did a whirlwind tour of schools in the Katherine (St Josephs) and Darwin (Haileybury, Parap Primary School, Nightcliff Middle School) regions, with students learning about plants in space and on Earth, and the role of closed systems in future farming, as well as conducting an oxygen assay experiment and creating a Mars base station.

Powerhouse Museum

The P4S engagement team, under guidance of Dr Frazer Thorpe and Douglas Bair, travelled to NSW's Powerhouse Museum to deliver a school holiday program in April 2025. Students explored what humans would need to sustain long-term space missions, as well was what legacy we might leave there. The hands-on workshop involved a range of activities, including designing plants for zero waste, DNA extractions and nutritional research, to making 'space salad' for lunch, and etching a 'message for space travel' on a metal plate.

P4S was very excited to be invited for this Powerhouse museum school program, especially as it also provided tours of their exhibition and a showcase of their Rovers on display.

Perth Garden Show

P4S, Silver Award Winners at the Perth Garden Show!

Not only did Engagement Officer April Harris and her team of P4S researchers win the hearts and minds of people visiting the show, they also received an accolade for the exhibit they set up. Across three days in May 2025, the team engaged with a kids and adults alike to explore the future of sustainable food, on Earth and beyond.

Visitors to the exhibit had the chance to experience the future of food and bioresource production firsthand through engaging interactive exhibits as well as hands-on experiments. The team shared their vision on space-ready crops, sustainable building materials and creating medicinal plants for future space pharmacies.

Students explored what humans would need to sustain long-term space missions, as well was what legacy we might leave there.

Science Alive!

In South Australia, P4S teamed up with our Botanic Gardens partner to showcase the best of astrobotany at the three-day Science Alive! event. On day one, this event showcased the best of scientific endeavours in South Australia and provided upper primary students with great insights on where a career in science can take you. Over 400 students enjoyed the panel discussion on science careers that day, led by P4S Dr Lieke van der Hulst, and over 600 students sat down with a team of P4S researchers to build a terrarium and talk about astrobotany.

Over the weekend the booth attracted another 600 visitors per day as the doors of *Science Alive!* opened for the general public. The event was a great way to connect with a broader audience, as well as providing a positive collaboration with a Centre partner.

Royal Adelaide Show

P4S were invited by the Royal Agricultural and Horticultural Society of SA to showcase the Centre at the Royal Adelaide Show, with great success across engagement numbers as well at attention through presentations and radio interviews across 9 days in August 2025. The display asked visitors to visualise nutritional needs for space exploration, and what their preference would be to have as food source if they themselves were astronauts. The P4S team was met with a lot of interest, great questions and even impressed Lieutenant Governor Dr Richard Harris upon his visit to the booth. Over 1000 visitors were engaged in direct conversation over the duration of the Show, and following the event P4S received many requests for further engagement from local schools.

Science Is A Super Power Festival at Scienceworks

P4S was invited to participate in Museum Victoria's *Science Is a Superpower Festival* at Scienceworks, a weekend event designed to promote STEM engagement among primary and early secondary students, with a particular focus on girls and non-binary young people aged 10–12.

P4S researchers showcased the work of women in science by facilitating hands-on activities, including a sensory exploration of fresh plant produce and a design-your-own space plant paper craft. Participants were invited to "plant" their creations in the P4S Astro Garden, reinforcing key ideas about plant science, creativity, and resilience in space environments.

Members of the P4S team at the Science Is a Superpower Festival

Education and engagement

Education is an important aspect of the engagement efforts within P4S, and specific school-focused events gave rise to close ties with educators. Over 140 school visits (excursions and incursions, as well as some online and international interactions) were provided through the P4S engagement team in 2025, as well as many career and teacher seminars to promote space research for all aspects of STEAM.

A/Prof Kim Johnson was keynote speaker for the Quantum Victoria 2025 STEM conference, where she addressed over 300 primary and secondary teachers on 'Inspiring Futures through STEM'. Her presentation focused on space research for a better future on Earth, and the importance of understanding plant genome regulation to adapt crops for their environment.

CI A/Prof Kim Johnson addressing the audience as the keynote speaker at the Quantum Victoria STEM Conference

Teacher professional Learning

P4S has a sharp focus on teacher professional learning, to position space and all its activities strongly within the STEAM curriculum. To support this, the start of the year, four dedicated teacher professional learning events at the La Trobe University and Melbourne University nodes, provided the basis for over 60 teachers (from Victoria, South Australia and Tasmania) to implement P4S research work in their teaching.

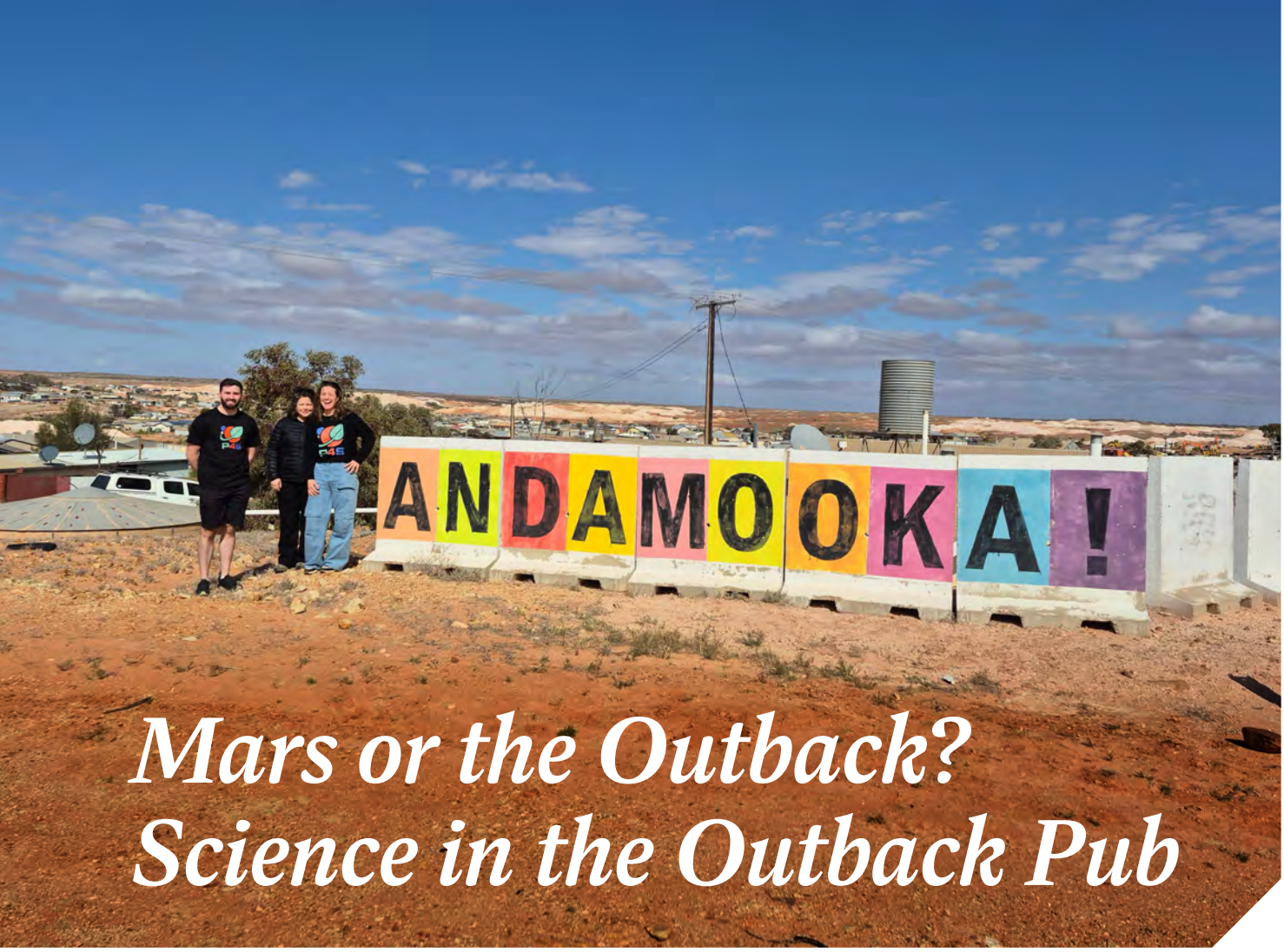
The professional learning was divided over year levels and gave opportunity to showcase P4S research to teachers, but also learn what type of activities will truly activate student's understanding of the range of topics.

Some educators were so impressed with the work of P4S that multiple engagements were set up for their schools. St Columba College in SA was one of these schools, where students from different year levels, as well as their educational staff, interacted with P4S throughout the year.

Susan O'Malley, St Columba College Academic Extension Coordinator: "Our partnership with P4S has enriched the St Columba STEM program in ways we could never have imagined. We extend our heartfelt thanks to Dr Lieke Van der Hulst and the outstanding teams at Adelaide University and La Trobe University for their generosity, expertise and unwavering support. Their commitment to fostering scientific literacy and research skills in young people has made a remarkable difference to our students, who now approach plant science and space-based research with genuine confidence and curiosity.

For our teachers, the professional development, mentoring and high-quality resources provided through P4S have been nothing short of transformative. They have enabled us to bring authentic, cutting-edge science into the classroom and to guide students through real research practices that mirror industry and university standards. P4S has empowered our school community to reach higher, think bigger and believe that our contribution to Australia's future space and plant science capability is both meaningful and achievable."

> "Our partnership with P4S has enriched the St Columba STEM program in ways we could never have imagined."



Mars or the Outback? Science in the Outback Pub

ABC North & West media team interviewing Prof Jenny Mortimer

Plants for Space promoted their research through National Science Week 2025 in a range of different in-person and online events and activities.

Dr Lieke van der Hulst, University of Adelaide

The South Australian node travelled to the Outback to share current P4S research, in a mini tour of rural South Australia, under the name 'Science in the Outback Pub', co-organised with the Outback Communities Authority.

Prompted by the (perhaps slightly tongue-in-cheek) question *Is it easier to grow food on Mars than in the South Australian outback?*, PhD-candidate Robert Rintoul, Prof Jenny Mortimer and Dr Lieke van der Hulst joined local residents from rural Andamooka and Copley over two nights of science engagement.

The Outback tour consisted of a school visit to Andamooka Primary School, two nights of presentations and interaction with the local community at the Andamooka Community Hall and the Copley Pub, and a meeting with the Copley Community Garden and Botanical Garden groups. During the night-time events Jenny, Robert and Lieke spoke about the current Plants for Space research into the complex processes involved in growing plants for astronauts on future space missions, and how that knowledge could be adapted to outback conditions.

The red, arid dirt of outback South Australia is often likened to Mars, and on the surface, both look like the last place fruit or vegetables could ever grow. Many parallels can be drawn between space and the outback, as logistical challenges in obtaining fresh food, but also the low availability of water and a suitable environment to produce crops, are similar.

Because of this, the events led to really interesting and extensive discussions with community members, sharing their own stories and expertise on gardening in the outback. The audience shared many excellent questions for our researchers, about space, Mars, and the difficulties of keeping human beings alive in sealed vessels hurtling through space, or perched on a planet or a moon.

For the school visit both lower and upper primary students spent time with the team, and students were excited to learn about space exploration, measure photosynthesis on plants around the school yard, and build mini terrariums to grow their own space crops. The terrariums proved to be an ongoing educational tool and success, as the students looked after their plants for weeks after the visit.

In Copley, the Plants for Space team visited both the Community and Botanical Garden, to discuss their food production efforts. Based on the exciting results from their hard work, we can we can for now probably state that, yes – it is indeed easier to grow food in the SA Outback, than it is on Mars.

The Science in the Outback tour also garnered a lot of media attention, through press releases from Science in Public and Plants for Space own social media. ABC North & West sent a media team to cover the event in Andamooka. An online story and two video segments were broadcast on ABC News, as well as two radio interviews and extensive social media exposure, covered the engaging outreach efforts in the North of SA.

Overall, the tour was a great success, promoting both Plants for Space and STEM in an area that is often underserviced for not only easy access to fresh food, but also science engagement activities and inspirational research stories.

Left: In the classroom, local Andamooka primary students hearing from Prof Jenny Mortimer

Above: Dr Lieke van der Hulst, Prof Jenny Mortimer and PhD-candidate Robert Rintoul

Below: PhD-candidate Robert Rintoul speaking with primary school students.

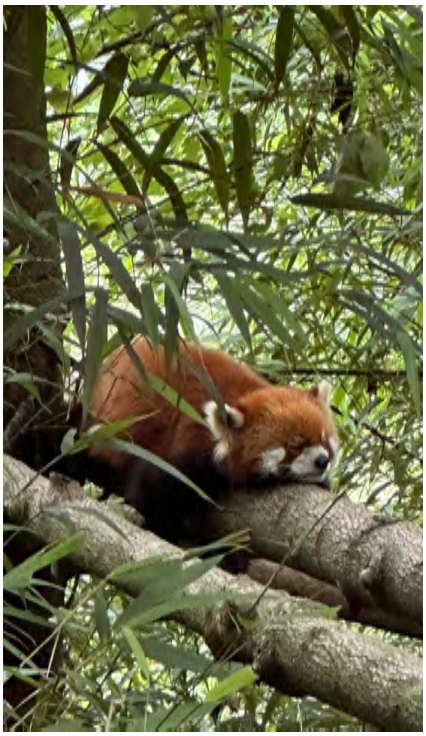
Small Steps Challenge

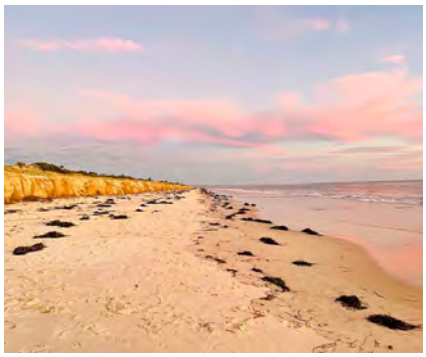
Florence Ly, The University of Western Australia

The Small Steps Challenge was run for the first time in July 2025 to build connections across the Plants for Space Nodes through team-based competition. For 5 weeks, participants recorded their total steps and teams competed to have the highest step count. By the end of the challenge, a total of 15.8 million steps were tracked by the 45 participants.

A key focus of the Small Steps challenge was to promote communication and teamwork as everyone shared updates and encouraged each other to increase their step count every week. The initiative was designed to be simple and accessible with minimal equipment required and therefore, there was participation from each Plants for Space node including students, research assistants, postdoctoral researchers, chief investigators, and professional staff. In addition, participants shared delightful photos taken while walking their dogs, running at local parks, and sightseeing on holiday with their team. This was a fun way for teams to get to know each other and inspire them to get outside.

By the end of the challenge, it was clear that we can travel further as a team than we can on our own. An estimated total distance of more than 11,000 kilometres was reached by everyone involved in the Small Steps Challenge. Everyone put in their best effort and we celebrated the consistency, progress, and teamwork demonstrated in this challenge.





Imagery from P4S team members during the five week step challenge.

Members of the winning team Charlotte Bampton, Jalitha Wasath, A/Prof Kim Johnson, Dr Lieke van der Hulst and Dr Troy Miller.

Leaderboard

Team No	Team Members	Total Steps
4	Charlotte Bampton, Jalitha Wasath, Kim Johnson, Lieke van der Hulst, Troy Miller	2,033,061
8	Cadell Canute, Luca Pedroletti, Melissa de Zwart, Nikki Hodge, Shehan Galbadage Don	2,022,297
2	Adriane Piechatzek, Ciara Finnegan, Declan Lafferty, Douglas Bair, Leni Campbell-Clause	1,850,314
6	Alex Karami, Sze Wai (Anna) Tse, Matthew Gilliham, Sandra Clavijo, Shu Liang	1,824,365
1	Ane Aldalur Soto, Anshul Phaugat, Christine Feinle-Bisset, Farley Kwok van der Giezen, Rebecca Vandeleur	1,691,781
7	Alison Gill, Siwei (Eliza) Guo, Frazer Thorpe, Milly Petterson, Richard Harvey	1,663,938
3	Anna Bond, Jon Diab, Marta Peirats Llobet, Matthew Tucker, Nigel Vermonde	1,645,429
9	Amy Griessl, Elliott Fourie, Mst Irin Parvin, Penelope Fitzgerald, Thomas Cobbinah	1,611,457
5	Jenny Mortimer, Kenny Sim, Lee Conneely, Lydia Ong, Yunti Ge	1,467,893

The Inaugural Plants for Space Postdoc Symposium

Dr Farley Kwok van der Giezen, The University of Western Australia

The University of Western Australia, Perth, 10th-12th September 2025

In the first calendar year of Plants for Space (P4S), the national team has grown rapidly, with each node actively recruiting the inaugural cohort of talented early-career researchers who will help drive the centre's missions forward. This diverse community of scientists brings together expertise spanning cutting-edge molecular biology through to legal policy and regulatory frameworks. From the earliest conversations at the centre's launch in 2024, it was clear that P4S presents a unique opportunity to lead and engage in truly multi- and cross-disciplinary research.

When Dr Caterina Selva and Dr Claudia Gonzalez Viejo took on the roles of early- and mid-career researcher representatives on the Executive Management Committee, they issued a call to action to strengthen and better connect the P4S community. Responding to this call, Dr Farley Kwok van der Giezen, Dr Ryan Coates, and Dr Troy Miller from the UWA node developed a proposal to host a symposium for the centre's early- and mid-career researchers. The proposal was enthusiastically and generously supported by the Executive Management Committee.

Hosted at the UWA P4S node, the three-day symposium brought together twenty-three postdoctoral researchers from across the centre. Participants presented their research with a focus on the P4S missions they contribute to, while round-table discussions identified shared interests and opportunities for inter-node collaboration. These conversations culminated in the development of an action plan aimed at strengthening cross-node communication, as well as sharing expertise and protocols through centre platforms such as Discourse and SharePoint.

Beyond the formal outcomes, the symposium fostered meaningful connections and friendships that helped establish an open, inclusive, and welcoming community. This spirit of collaboration was clearly evident again at the P4S Annual Conference held on the Gold Coast in November.

Outcomes and Action Plan

Machine learning integration: Identifying opportunities to combine knowledge and datasets to effectively apply machine learning approaches to molecular modelling.

P4S Omics Meta Database: Establishing a centralised resource cataloguing genomic, transcriptomic, proteomic, and metabolomic datasets across the centre, along with key points of contact, to reduce duplication of effort.

Communication and advocacy: A shared commitment to active engagement on P4S communication platforms, advocacy for HDR students, and the development of collaborative resources, including a shared library of bioinformatic and laboratory protocols hosted on SharePoint.

Cross-node collaboration: Identifying and designing projects across P4S nodes to generate impactful collaborative research outcomes.

Survey Feedback from the P4S Postdoc Symposium

"It was very helpful to get to meet people from different nodes, knowing what each of us is doing and how to collaborate, and I really liked the roundtable where we came up with the action list of going forward with the review and sharing of materials and information."

"Because it was more discussion than presentation focused, I felt we really had the ability to understand what each other's skills and needs are a lot better. Then we based further conversations on how this can lead to collaboration. This format has the potential to be highly useful..."

"It was a great opportunity to meet the other EMCR's in the centre. I particularly enjoyed the discussions on how we can support each other's research and form new collaborations across nodes."

Clockwise: The P4S Post-Doctoral cohort coming together after several productive days of collaboration, conversation, and shared ideas. Winding down after a full day's work, enjoying good company and the mix of new connections and familiar faces. Postdoc collaborative discussions Taking a moment to unwind by the Swan River in Perth, reflecting on the work and connections made throughout the week. Team members working collaboratively to exchange ideas and shape initiatives with lasting impact at the Centre.

In the Media

In 2025 Plants for Space shared research stories through a range of press releases, which were picked up through various outlets for print, radio and tv. Press releases covered high impact publications, grants and National Science Week events, and were often shared efforts with media teams at different nodes and partner organisations. A selection of releases included the following:

Shrimp shell material may control space drug delivery (4 May 2025)

By sending nanoemulsion formulations on a space flight, scientists are investigating whether chitosan – a material derived from shrimp and widely used to control the release of medications – performs well in controlling medicine delivery when exposed to zero gravity. Their preliminary results suggest that drugs needed by astronauts can be delivered effectively in space.

P4S researchers Professor Volker Hessel and Modupe Adebowale are working with the German Aerospace Center (DLR), Institute of Aerospace Medicine, who conducted the StarMed experiment by exposing six small glass vials on a space flight and then analysing the stability of the emulsion on its return to Earth. The same number of identical control vials were on the ground in both Europe and Adelaide.

"Our experiments are testing whether the chitosan-layered nanoemulsions are stable in space and function well for melatonin delivery," said Professor Hessel. "Preliminary data suggest that the droplet size and distribution of nanoemulsions without chitosan coating increased while nanoemulsions with chitosan coating did not change at all. And small, more uniform droplets are desired for better uptake and medical outcomes.

$12 million grant backs global team to create first synthetic plant chromosome (3 June 2025)

A world-first effort to build an artificial chromosome entirely from scratch in plants has received more than $12 million in funding from the UK's Advanced Research and Invention Agency (ARIA) through its Synthetic Plants program.

An international team of researchers, including Professor Ryan Lister and Dr James Lloyd from P4S, will join collaborators from the University of Cambridge, biotech company Phytoform Labs and the Australian Genome Foundry at Macquarie University, to pioneer technologies to design, build and install synthetic chromosomes in plants.

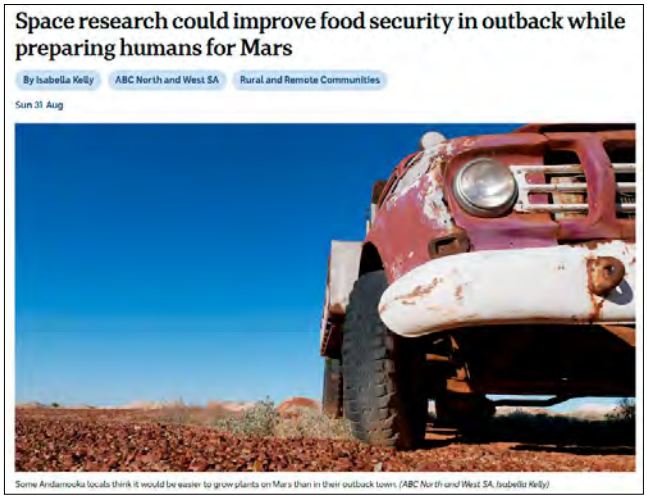
The project will use the moss *Physcomitrium patens* – a unique, highly engineerable plant – as a development platform to build and test a bottom-up synthetic chromosome. ARIA's Synthetic Plants program, led by Programme Director Angie Burnett, supports ambitious, high-risk research to enable fully synthetic plant genomes in the future. Professor Lister said the project delivered on ARIA's vision to push the boundaries of what's possible through bold scientific innovation.

National Science Week (August 2025)

2025 was a big year for P4S National Science Week activities, and the news on P4S events and activations was taken up all across Australia. Focus for news activities was on 250 STEM kits sent all over Australia and the world, as well as the South Australian 'Science in the Outback Pub', Victorian collaboration with the Museum for Australian Democracy and Matt Cosgrove reading of Alpacas in Space and the large uptake of the Western Australian events at Kings Park.

From space science to dinner plates: the future of farming indoors (1 October 2025)

Extreme weather events, from heavy rainfall to heatwaves and droughts, are increasingly threatening crop yields globally, so new solutions are needed for agriculture.



Space research could improve food security in outback while preparing humans for Mars

By Isabella Kelly | ABC North and West SA | Rural and Remote Communities

Sun 31 Aug

Some Andamooka locals think it would be easier to grow plants on Mars than in their outback town. (ABC North and West SA: Isabella Kelly)

An international team from the University of Adelaide, University of Cambridge, The University of Western Australia and NASA have reimagined how we grow food into the future. The paper has been published in the journal *Trends in Plant Science* and has been chosen for inclusion in an upcoming 30th anniversary special issue titled 'Big concepts – shaping the future of plant science'.

"Controlled environment agriculture allows crops to be grown indoors under the precise control of light, temperature, humidity, carbon dioxide, and nutrients, while reducing pest risks," says P4S researcher Dr Alison Gill. "The result is food that can be produced anywhere, year-round, with yields up to 20 times greater than traditional agriculture, with much less arable land and water required.

A greener future for Earth through space exploration research (27 November 2025)

Global scientists have developed a new roadmap for using plants to support long-term human life on the Moon and Mars, using technologies that could also transform sustainable food production on Earth.

Published today in New Phytologist, the project brings together more than 40 scientists from 11 countries and seven space agencies, who outline the plant science breakthroughs needed to create self-sustaining, plant-based life-support systems for deep space exploration. These systems would grow fresh food, recycle water and air and support astronaut health and wellbeing.

P4S Associate Professor Sigfredo Fuentes said designing plant systems for the Moon offers powerful insights for improving agriculture on Earth. "Space pushes us to design plant systems that are highly efficient, resilient and precisely monitored," Associate Professor Fuentes said. "This work will help us grow food sustainably in drought-prone regions, cities and remote communities." P4S Director Professor Matthew Gilliham said technologies developed for space exploration will also drive a more sustainable future on Earth. "The innovations that will keep astronauts alive on the Moon, such as closed-loop farming, recycling and resource efficiency, are the same technologies that will transform how we grow food and medicines on demand anywhere on Earth, from inner cities to remote regions, at any time of year," Professor Gilliham said.

P4S researchers also found their way to podcast microphones, radio and tv interviews and other written media pieces. Highlights for this include:

- the team of Dr Troy Miller, Dr Farley Kwok van der Giezen and Dr Ryan Coates writing for The Conversation, to answer the question 'why grow plants in space', introducing the Centre to broader Australian audience
- Professor Matthew Gilliham on ABC Radio National Breakfast and Associate Professor Sigfredo Fuentes on 9News (above) to discuss the roadmap for space agriculture, highlighted in the New Phytologist
- Professor Jenny Mortimer on ABC TV on the visit to the South Australian Outback for National Science Week
- Multiple radio interviews by Professor Mathew Lewsey on joining the $20M agriculture innovation network through La Trobe University

Experiment puts space lettuce under the microscope (10 December 2025)

Lettuce samples from the International Space Station are being studied to determine the effects of microgravity on crop development. P4S researchers Dr Troy Miller and Professor Harvey Millar are collaborating with NASA on their Plant Habitat-07 (PH-07) project.

The experiment aims to study romaine lettuce grown in spaceflight conditions, to identify its response to varying moisture levels combined with the unique water dynamics under microgravity. "Water acts very differently without gravity, and it becomes a balancing act between flooding or underwatering plants in space," Professor Harvey said. In collaboration with the team at the NASA Kennedy Space Centre including Dr Gioia Massa, the lettuce samples were grown on the International Space Station between December 2024 and March 2025, under several different watering regimes. Initial outcomes of the experiment show that plants have significant metabolic differences when grown in spaceflight compared to on Earth. "We are now looking deeper to determine if this response is detrimental to plant productivity or a clever adaptation mechanism to growing in space," Dr Miller said.

Arabidopsis thaliana does not like the RUBY marker – image taken by competition winner Matthew Morgan from the University of Adelaide.

Advancing ethical and sustainable innovation on Earth and in space

At the core of P4S lies a dedication to ethical and sustainable innovation that supports space exploration while delivering value back to Earth. Our Cultural Charter shapes our principles, behaviours, and ways of working, ensuring that everything we do is anchored in integrity and responsibility.

Guided by our Cultural Charter, we uphold values, behaviours, and interactions that ensure every part of our work reflects integrity and responsibility.

Key Commitments of P4S

A Diverse, Supportive and Cooperative Team

- Recognise creativity and accomplishments through ongoing events and communication activities.
- Provide mutual support through both structured and informal mentoring and training opportunities.
- Embed inclusive practices across recruitment and communication, nurturing a culture grounded in respect, kindness, and inclusion.

Research Excellence & Integrity

- Uphold the highest levels of research quality and integrity in alignment with the ARC Centres of Excellence objectives and the ARC Research Integrity Policy.
- Support cross-disciplinary collaboration, cooperation, and teamwork to deliver outcomes of global significance.

Promoting and Supporting Australian Science, Education & Industry

- Work with schools, universities and industry across metropolitan, regional and remote communities to promote the P4S vision and inspire the next generation of Australian scientists and engineers.
- Ensure all education and engagement initiatives reflect diversity and inclusion, and present Australia as a global leader in science and sustainability.

Sustainable Space Habitation & Benefits for Life on Earth

- Encourage the sustainable, ethical and responsible use of plants for food, medicine, materials, and psychological support.
- Collaborate with Earth-based industries to co-develop products and processes that deliver sustainable outcomes for both Space and terrestrial environments.
- Provide education on waste management and resource utilisation in Space habitats, informed by leading global standards.
- Develop a variety of foods that appeal to diverse users, respect cultural norms, and are suitable and digestible for as many people as possible.
- Draw insights from Indigenous cultures and practices, including those living in remote and challenging environments and integrate culturally respectful approaches into our interactions with Earth and Space.
- Comply with, contribute to, and advance ethical, health, and legal frameworks governing the production of plant-derived products in Space and in controlled environments on Earth.

“At P4S, our mission extends well beyond conducting research; it encompasses a broader effort to contribute to a safer, more sustainable future by exploring and utilising the extraordinary potential of plants in Space. We are committed to maintaining responsible and transparent practices throughout our work, ensuring that what we do remains aligned with the evolving needs, expectations, and values of society.”

Above: Dr Rebecca Vandeleuer interacts with young STEM enthusiasts at the Royal Adelaide Show.

Right: P4S team members enjoying an Amazing Race–style team-building activity, taking on a series of fun and engaging challenges.

Below: At the Edible Urban Futures exhibition, P4S members from The University of Melbourne explore sustainable food innovations.

By pushing the boundaries, Plants For Space is helping to create a sustainable and more resilient future.

We bring together a diverse group of researchers spanning plant science, nutrition, food science, engineering, psychology, and law.

Professor Matthew Gilliham

Director
University of Adelaide

"The innovations that will keep astronauts alive on the Moon, such as closed-loop farming, recycling and resource efficiency, are the same technologies that will transform how we grow food and medicines on demand anywhere on Earth, from inner cities to remote regions, at any time of year"

Professor Sally Gras

Deputy Director
The University of Melbourne

"P4S aims to establish a versatile plant-based food industry serving both space and Earth. The initiative focuses on developing sustainable food sources for long-term space missions. These innovations will simultaneously tackle global food security and sustainability issues on Earth, providing new solutions for feeding a growing population in a changing climate."

Professor Melissa de Zwart

Deputy Director
University of Adelaide

"Seen through an indigenous perspective, Earth is connected to Sky Country. Space is not separate from Earth. We are not separate from Space. I look forward to learning more about how that connection can enable humans to live well beyond Low Earth Orbit"

Professor Phil Brewer

Chief Investigator
La Trobe University

"Strigolactones have antioxidant-like properties that are healthy for plants and people. But plant production is very low and chemical synthesis is expensive. So, it will be important to develop ways to produce a lot more for farming or medical applications."

Professor Christine Feinle-Bisset

Chief Investigator
University of Adelaide

"I love being a scientist for many reasons - one of them is seeing the excitement in young students when embarking on new projects and the wonder about what they might discover in the process"

Professor Volker Hessel

Chief Investigator and Program Leader
University of Adelaide

"Engineering space systems is fascinating because it brings together the most advanced technology on Earth to tackle research challenges that are often as unknown as science was during the Renaissance 500 years ago. Guided by digital twins (AI) and a focus on sustainability, it is ultimately curiosity, inspiration, and polymath knowledge that drive progress."

Associate Professor Kim Johnson

Chief Investigator and Program Leader
La Trobe University

"Supporting life in Space is a huge challenge but also offers amazing opportunities for innovation and creativity. I love being able to work with people from all different areas –science, engineering, chemistry, law and psychology - to come up with solutions for better quality of life in Space and sustainability on Earth."

Professor Eva Kemps

Chief Investigator and Node Leader
Flinders University

"To successfully address the issues of food insecurity and sustainability, it is important that the to-be-developed plant-based food products are acceptable to members of the general public and that they are willing to consume these products."

Professor Mathew Lewsey

Chief Investigator, Program Leader and Node Leader
La Trobe University

"It turns out that sending an experiment to the Moon is incredibly difficult. But the journey is fascinating."

Professor Ryan Lister

Chief Investigator and Program Leader
The University of Western Australia

"This project is pushing the frontier of synthetic biology in plants. For the first time, we're not just editing DNA, we're attempting to write entire chromosomes from the ground up. If successful, it will unlock powerful new ways to give crops complex new traits such as improved resilience, productivity, or the ability to produce useful materials."

Professor Harvey Millar

Chief Investigator and Program Leader
The University of Western Australia

"The Protein Mission of P4S is ramping up to explore protein expression in plants on the International Space Station and develop new high protein plant-based food for long term space missions. We can't go if we can't grow, and protein is the king of all the macronutrients in what we grow."

Professor Jenny Mortimer

Chief Investigator and Node Leader
University of Adelaide

"One of the most exciting aspects of working in the space sector is its extraordinary multidisciplinary nature. It requires a diverse range of expertise; no single field can tackle the challenges alone. To keep humans alive in space and enable them to thrive and succeed in missions, we need to draw on research that wouldn't normally be involved in space, which includes thinking about how we feed people and keep them healthy. Plants could play a really important role in this."

Associate Professor Sigfredo Fuentes

Chief Investigator
The University of Melbourne

"Space pushes us to design plant systems that are highly efficient, resilient and precisely monitored. This work will help us grow food sustainably in drought-prone regions, cities and remote communities."

Professor Ian Small

Chief Investigator and Node Leader
The University of Western Australia

"The centre's mission goes beyond food, we aim to design biobank plants that provide medicines, plant-based building materials, and sustainable solutions both on and off Earth. Many of the challenges needed for long-term life on Moon and Mars are also faced by agriculture on Earth and need to be researched to advance the efficiency of plant-based foods for example increasing fertiliser use efficiency."

Professor Matthew Tucker

Chief Investigator
University of Adelaide

The centre (P4S) is looking for plants that can grow well and reproduce on demand in constrained spaces such as outer space; and one of those plants is duckweed. Duckweed is intriguing since it has these properties where it can grow in quite stressful conditions under limited water, perhaps even polluted water."

Professor Michelle Watt

Chief Investigator and Node Leader
The University of Melbourne

"Our research will examine the role of plant roots in space and seek to improve key measures of plant efficiency, such as harvest index, allowing us to use all plant parts in resources we grow in space and here on Earth."

Prof Mathew Lewsey, La Trobe University

P4S Centre Partners

AGRF

AGRF is aligning its cutting-edge genomics platforms with global sustainability challenges. Through its collaboration with P4S, AGRF is developing plant solutions for space exploration and aims to deliver significant benefits for agriculture and climate resilience on Earth.

Andy Thomas Space Foundation (ATSF)

ATSF is supporting space education and outreach, inspiring young people to pursue STEM careers. Through school programs and public events, ATSF is showcasing the research and challenges addressed by space-related scientific fields, including those of P4S, helping ignite curiosity and promote the importance of space science.

*APPN (formerly APPF)

Advancing plant production systems for space exploration and Earth sustainability, APPN is enhancing its globally leading research infrastructure in sensing, imaging, and analytics to develop controlled environment agriculture technologies, including vertical farming. This collaboration is enhancing plant growth and biofactory production for both off-Earth and terrestrial applications.

Australian Space Agency

The Australian Space Agency (ASA) and P4S are collaborating to foster innovation and growth in the local space sector. By leveraging ASA's leadership in coordinating civil space activities across government and its commitment to aligning space policy and initiatives nationally, P4S is helping strengthen South Australia's position as a leader in the global space industry.

AXIOM Space

Axiom Space is developing plant-based solutions in microgravity using its commercial space station as a platform. In collaboration with P4S, this partnership aims to assess the effectiveness of innovative plant systems and processes, advancing space exploration and Earth-based sustainability through frequent access to low-Earth orbit.

Bioplatforms Australia

Bioplatforms Australia is leveraging its expertise in 'omics research infrastructure to generate critical data needed for plant redesign and biomolecule production projects in collaboration with P4S. Through financial support, internships, and strategic collaborations, Bioplatforms is contributing to the development of high-efficiency plant production systems while providing opportunities for students to engage with leading biotechnology initiatives.

Defence Science and Technology Group

DSTG is exploring innovative solutions in food, nutrition, and human performance in closed environments, such as space and submarines. This partnership builds on existing research and provides opportunities for work-based PhD students and internships, supporting DSTG's strategic goals to strengthen Defence capabilities.

Department of Primary Industries and Regions (PIRSA-SARDI)

SARDI is enhancing the development of novel plants and food processing systems for space exploration. By contributing expertise in plant nutrition, food processing, and innovative growing systems, SARDI is advancing space agriculture research while supporting South Australia's food and plant industries through PhD student co-supervision and collaborative projects.

*DLR (The German Aerospace Centre)

DLR is advancing bioregenerative life support systems, focusing on nitrogen recycling to support plant growth for off-Earth habitation. This collaboration combines DLR's expertise in aerospace medicine and closed-loop systems with P4S's research on sustainable plant systems, enhancing space exploration and agricultural sustainability on Earth.

Dr Joanna McMillan

Dr Joanna McMillan is contributing her expertise in nutrition and health to enhance food production for space exploration. With her background in nutrition science, she is helping develop innovative solutions to improve the nutritional content, efficiency, and sustainability of food, with applications that extend beyond space to address global food security and wellness.

ETH Zurich

ETH Zurich is advancing sustainable food production for space exploration in collaboration with P4S, particularly in the food products sector. Through its Institute of Food, Nutrition, and Health, ETH Zurich is contributing innovative solutions in food science, food structure and texture design, to support P4S efforts to address the challenges of feeding humans in space, and improving the sensory experience for plant-based foods on Earth.

Food IQ

Following its March 2025 launch, FOODiQ Global's Mission MushVroom was successfully deployed aboard a SpaceX Falcon 9 mission, marking a major milestone for Australian-led space food research. Early findings showed that oyster mushrooms were able to colonise in microgravity, supporting NASA priorities for sustainable nutrition systems, with further analysis conducted to assess fruiting outcomes and future scalability. FOODiQ also collaborated with P4S to provide science-backed food and nutrition insights, supporting the development of sustainable food systems for both space exploration and Earth-based applications.

INRAE

INRAE is addressing the unique challenges of feeding humans on the Moon, combining its expertise in sustainable agriculture and food systems with P4S's research to assess and improve the digestibility and nutritional value of novel plant based foods developed for space and earth applications.

NASA

NASA is collaborating with P4S to create transformational advances in space crop production, which are critical for feeding and supporting long-term space exploration. This partnership is advancing food systems for space missions and supporting NASA's efforts for crewed Mars missions in the 2030s, with advice and consulting from NASA's experts.

National Imaging Facility

The National Imaging Facility (NIF) provides advanced imaging infrastructure that supports plant research within P4S. Through a NIF Fellowship in Plant Imaging at The University of Melbourne, MRI, PET, and CT technologies are being applied to develop next-generation tools for plant systems. This capability enhances P4S's ability to generate high-resolution insights into plant performance in space and extreme environments.

One Giant Leap Australia

One Giant Leap Australia is delivering space and agriculture-focused STEM programs for primary and secondary school students in collaboration with P4S. With its expertise in space education and established relationships with global space agencies, it is expanding outreach to inspire the next generation of students to pursue careers in STEM and space science.

Rice University

Rice University is initially contributing to P4S through its expertise in team dynamics and psychology in space. Building on its longstanding relationship with NASA, Rice is advancing the development of sustainable space agriculture and bioregenerative life support systems to support P4S's space exploration efforts.

Saber Astronautics

Saber Astronautics are providing next-generation spaceflight operations expertise and software to support mission design and space operations. This collaboration optimises plant growth and sustainability in space environments, advancing research in space agriculture.

South Australia Space Industry Centre (SASIC)

SASIC is supporting the growth of South Australia's space sector by focusing on food production in space. Leveraging the state's expertise in agriculture for resource-constrained environments, this partnership supports South Australia's Space Sector Strategy and promotes innovation, research excellence, and workforce development for both space and Earth applications.

*denotes project partners

SpaceLab Technologies

SpaceLab Technologies are advancing sustainable space food production, contributing to technologies that support off-Earth habitation and improve life on Earth. By combining its expertise in space agriculture with space research, this partnership is driving innovation in plant growth and productivity.

Government of South Australia | Botanic Gardens and State Herbarium

The Botanic Gardens and State Herbarium (BGSH) of South Australia

BGSH is advancing scientific understanding of plant systems in space and promoting public engagement with space botany in collaboration with P4S. By integrating research into educational programs and digital platforms, BGSH is contributing to public communication and outreach, fostering a deeper connection between the public and the future of space agriculture.

Twist Bioscience Corporation

Twist Bioscience is supporting the development of plants with enhanced nutritional value and biosynthetic potential through its advanced synthetic DNA tools and biomanufacturing capabilities. This collaboration is helping accelerate innovations in food sustainability and bioengineering for both space and terrestrial applications.

University of California, Berkeley

UC Berkeley are bringing their world-leading expertise in engineering biology to advance high-efficiency, zero-waste plant production systems for space habitats to P4S. Our work with UCB's researchers in genomics and space engineering is fostering innovative plant designe and biomolecule production to create transformative solutions for sustainability in both space and on Earth.

University of California, Davis

The EPiC program at University of California, Davis, in collaboration with Axiom Space and P4S is pioneering biochemical engineering and plant-based bio-pharmaceutical production to advance sustainable, high-efficiency plant systems for space exploration. The program includes spaceflight testing on the ISS and STEM education components.

University of Cambridge

The University of Cambridge's Department of Plant Sciences is driving advancements in plant productivity, particularly in controlled environments. By utilising the expertise of partner investigators and collaborating with industry leaders, Cambridge is contributing to pioneering research on plant circadian rhythms and nutrient management for space agriculture.

University of Nottingham

The University of Nottingham is leveraging its expertise in agricultural, environmental, plant, and food sciences. As a member of the Russell Group, Nottingham is internationally recognised for its research excellence and global partnerships. This collaboration is building upon the University's strengths in plant science and sustainable agriculture, supporting efforts to advance space-based food production and Earth sustainability.

University of Wisconsin-Madison

The University of Wisconsin-Madison has extensive expertise in spaceflight plant biology, particularly through partner investigators who have led recent experiments on the International Space Station. This collaboration is providing new insights into space biology, with applications in bioregenerative life support systems and agricultural innovations for both space and Earth environments.

Vertical Future

Vertical Future is applying its expertise in controlled environment agriculture to advance space-based food production systems. The partnership focuses on optimising vertical farming techniques for space environments, driving innovations in sustainable food production for space missions and Earth-based applications.

Victorian Space Science Education Centre (VSSEC)

VSSEC incorporates cutting-edge research from P4S into its educational programs for primary and secondary students. By leveraging discoveries in space agriculture, VSSEC updates its curriculum and develops new programs focused on space exploration and food production challenges.

Yield X

Yield X (formerly GAIA Project Australia) have developed innovative cultivation systems through cutting-edge research on plant growth and nutrition both for space, as part of the NASA-CSA Deep Space Food Challenge, and for Earth. Our partnership is focussing on optimising food production for space environments and offering valuable research opportunities for students, advancing both space-based agriculture and Earth applications in controlled environment farming.

YURI

YURI is developing biological products such as pharmaceuticals, nutritional products, and new materials using plants in simulated microgravity and space. In collaboration with P4S, YURI brings its expertise in microgravity research and engineering solutions, providing flexible, on-demand platforms, including mini-bioreactors and greenhouses, to support the goals of space biomanufacturing.

Interdisciplinary Collaboration

Molecular Plant Science

THE UNIVERSITY of ADELAIDE

THE UNIVERSITY OF WESTERN AUSTRALIA

Plant Physiology

THE UNIVERSITY OF MELBOURNE

NASA

National Imaging Facility

Plant Pharma

LA TROBE UNIVERSITY

UCDAVIS UNIVERSITY OF CALIFORNIA

Plants as Bio-Resources

Berkeley

Controlled Env. AG.

vertical future

appn Australian Plant Phenomics Network

YIELDX

Systems Engineering

THE UNIVERSITY of ADELAIDE

Space Lab

SABER ASTRONAUTICS

AXIOM SPACE

DLR

YURI

Food Structuring

THE UNIVERSITY of MELBOURNE

University of Nottingham UK | CHINA | MALAYSIA

Australian Government Department of Defence Science and Technology

dr JOANNA MCMILLAN

National Imaging Facility

Food Processing

ETH zürich

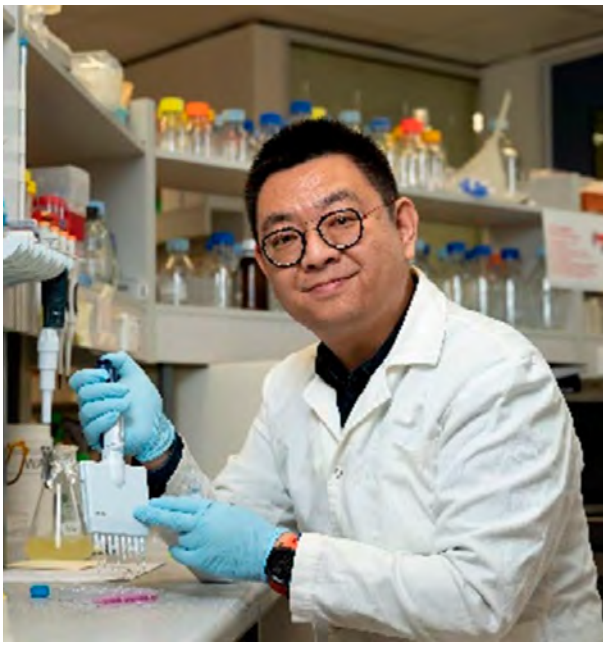
P4S CENTRE PARTNERS

Digestion	The University of Adelaide; FOODiQ global; INRAE; Government of South Australia Department of Primary Industries and Regions; SARDI South Australian Research and Development Institute
Single Cell 'Omics	The University of Western Australia; La Trobe University; BioPlatforms Australia
Gene Editing	The University of Western Australia; Berkeley; TWIST Bioscience; agrf
Law and Policy	The University of Adelaide; Australian Space Agency; South Australian Space Industry Centre
Education	VSSEC; The Andy Thomas Space Foundation; The Giant Leap Australia
Outreach	NASA; Botanic Gardens and State Herbarium; dr Joanna McMillan
Psychology	Flinders University; Rice University; NASA
Sensory Science	The University of Melbourne; The University of Adelaide; University of Nottingham UK | China | Malaysia

Grants

At Plants for Space, we are excited to highlight the incredible achievements of our members. In 2025, they were awarded a number of grants that recognise their innovation and drive. These grants not only celebrate their hard work but also provide the resources needed to push their projects forward.

Researcher/s	Awarding Organisation	Funds awarded
Prof Sally Gras	Melbourne-Birmingham (Priestley Scholars)	Scholarship, Tuition waiver +$5,000 PhD scholarship
Dr Alison Gill	University of Freiburg	€5,000 travel grant
Dr Alison Gill	Yitpi Foundation	$1,200 Event Funding
Dr Zheng (Tommy) Gong, Prof Jenny Mortimer	Bioplatforms Australia – NCRIS Synthetic Biology Voucher Scheme 2025-26	$6,500 Research Funding
Prof Jenny Mortimer, Prof Matthew Gilliham	National Science Foundation - Led by UC Davis, Partner investigator Prof Karen McDonald in collaboration with Axiom (EPiC)	$3,000,000 USD Research Funding
Prof Jenny Mortimer	Australian Research Council	$4,933,330 Research Funding
Prof Jenny Mortimer	Australia's Economic Accelerator	$198,679 Research Funding
Prof Matthew Gilliham	Australian Research Council - Discovery Scheme	$970,000 Research Funding
Prof Ryan Lister	Bioplatforms Australia	$2,800,000 Research Funding
Prof Ryan Lister, Dr James Lloyd	ARIA (UK)	£6,600,000 Research Funding
Prof Harvey Millar	GRDC	$1,749,312 Research Funding
Prof Harvey Millar	ARC – Discovery Project	$644,595 Research Funding
Dr Caterina Selva	The University of Adelaide Charlick Endowment Fund	$12,830 Research Funding
Jorja Hooper, Dr Caterina Selva	Mortlock Bequest	$3,000 Research Funding
Prof Matthew Gilliham, Prof Matthew Tucker	Grains Research and Development Corporation	$222,760 Research Funding
Dr Bo (Weasley) Xu, Associate Investigator Dr Alex Ware	Adelaide-Nottingham Alliance	$9,092 Seed Funding
Prof Mathew Lewsey	Eagle Fund - La Trobe and Breakthrough Victoria (BV)	$1,000,000 Technology commercialisation
Prof Michelle Watt	National Imaging Facility	$275,000 Research Funding
Prof Kim Johnson, Dr Lieke van der Hulst, April Harris, Dr Frazer Thorpe, Douglas Bair, Janine Oldfield	Department of Industry, Science and Resources	$20,000 Event Funding
Prof Volker Hessel, Dr Van Duc Long Nguyen	Department of Education – Australia's Economic Accelerator	$492,000 Research Funding
Prof Matthew Gilliam, Prof Matthew Tucker, Prof Mathew Lewsey, Dr Adriane Piechatzek	Department for Education - Australia's Economic Accelerator	$310,264 Research Funding



Clockwise from top left: Prof Ian Paulsen met with ARIA project collaborators Prof Ryan Lister (right) and Dr James Lloyd (centre) of The University of Western Australia. Deputy Director Professor Sally Gras. Dr Bo (Weasley) Xu. Dr Alison Gill (second from left) and Prof Jenny Mortimer (third from left) at the Women in Plants Science breakfast. Dr Zheng (Tommy) Gong presenting to the delegation from German Aerospace Center (DLR), led by Anke Pagels-Kerp (Divisional Board Member for Space).

Awards & Achievements

Dr Troy Miller

- People's choice award for best ECR presentation at the WA EMCR Symposium.

Dr Troy Miller, Jess Gugliotta

- Successfully awarded the ISC Space Engagement Support Scheme totalling $1,500 to supplement travel costs to attend the annual P4S conference in the Gold Coast. The grant is awarded to staff and students at UWA requesting support to engage in space related activities and outreach.

Prof Michelle Watt

- Michelle Watt was invited by the ASPS executive committee to deliver the prestigious RN Robertson Lecture at the 2025 ASPS Conference at Flinders University. Presented every two years, this lecture recognised individuals with a distinguished record in plant science research and teaching.

Prof Eva Kemps

- Staff Service Award in recognition of 25 years of dedicated service to Flinders University.

Sebastian Garcia Daga

- University of Nottingham - Lamming Travel Award.
- Dean's Commendation for Doctoral Thesis Excellence.

Wendy Sullivan

- Winning entry for the P4S inaugural annual report magazine name: PLACE.

Ryan Edwards

- Keystone Symposia – Conference travel award.

April Harris, Dr Adil Khan, Harish Jadhav, Dr Sze Wai Tse

- Silver Award for Best in Show at the Perth Garden Show.

Frazer Thorpe, Kim Johnson, Douglas Bair, Jordan Witchard

- La Trobe University – Finalist for Vice Chancellors prize for "Engagement".

Prof Matthew Gilliam

- Finalist for the 2025 South Australian Scientist of the year.

Dr James Lloyd

- Western Australian Young Tall Poppy winner.

Prof Volker Hessel

- Recognised for leading research supporting the UN Sustainable Development Goals, particularly Goal 12 (Responsible Consumption and Production), through his world-leading work in continuous flow chemistry.

Yunti Ge

- Valedictorian – 2025 Graduating class – Masters degree in Biotechnology (Biomedical) (Advanced)

Prof Mathew Lewsey

- Dean's Nominee (School of Agriculture Biomedicine and Environment) for the Vice Chancellor's Overall Researcher Award 2025 .

Clockwise. Florence Ly, Education activity winners. Dr Ziwei Zhou, Dr Declan Lafferty.

2025 Annual Conference Award Recipients

Dr James Lloyd

- Industry Engagement

Dr Lydia Ong

- Collaborative Excellence Award

Florence Ly

- Community and Culture Champion

Dr Farley Kwok van der Giezen, Anshul Phaugat, Dr Lydia Ong, Dr Kenneth Sim

- Commitment to Education and Engagement Activities x 4 awardees

Matthew Morgan, Dr Ryan Coates

- Best Image x 2 Awardees

Jacob Calabria

- Outstanding P4S Team Member

Ryan Edwards

- Best Oral Presentation (Student)

Jess Gugliotta

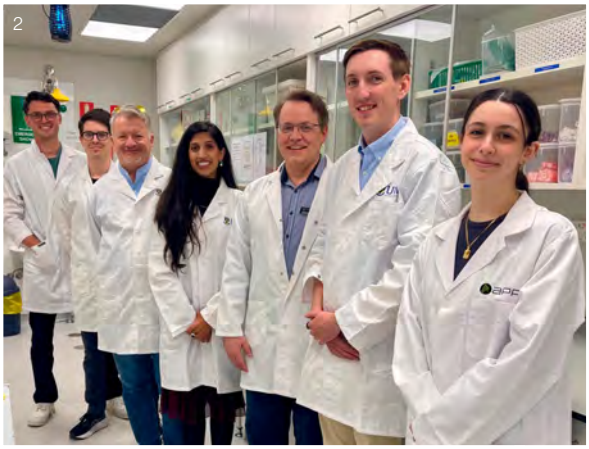
- Best Poster (Student)

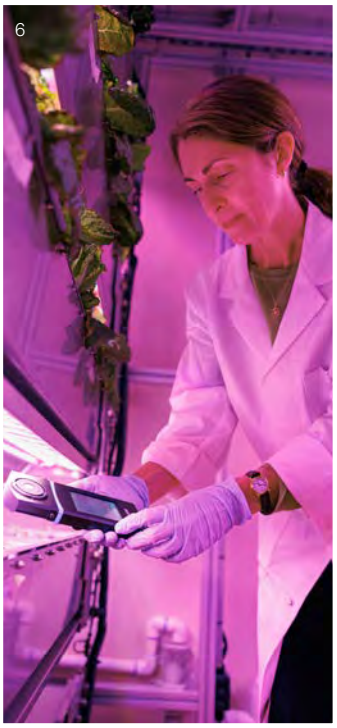
Dr Alison Gill, Dr Ziwei Zhou

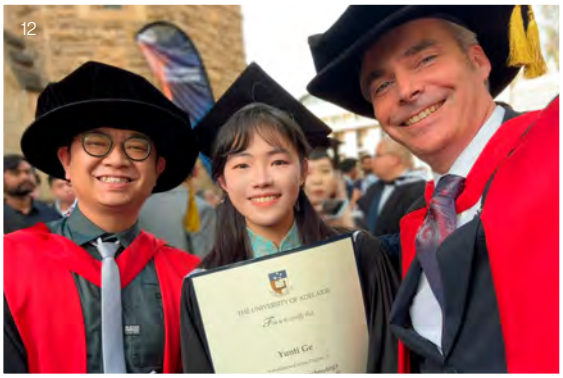
- Best Oral Presentation - Joint winners Education

Dr Declan Lafferty

- Best Poster







1: Dr Troy Miller (right) receiving the People's choice award for best ECR presentation at the WA EMCR Symposium. 2: Jess Gugliotta (far right) and Dr Troy Miller (second from left) pictured with astronaut Dr Shawna Pandya and SETI President & CEO Bill Diamond during their visit to the International Space Centre's ICRAR. 3: Prof Eva Kemps from Flinders University celebrates 25 years of service. 4: Sebastian Garcia Daga at the University of Adelaide. 5: Prof Michelle Watt 6: Wendy Sullivan, Laboratory Manager at the University of Adelaide. 7: Dr Frazer Thorpe (2nd from right), Douglas Bair (centre), Thomas Cobbinah, Jordan Witchard (left), and Dr Lee w 8: Ryan Edwards (left) pictured with P4S members Jonathan Diab (centre) and Josh Ng (right). 9: Prof Volker Hessel 10: Dr James Lloyd 11: Prof Matthew Gilliam (left), finalist, with Prof Kishan Dholakia (right), winner of the 2025 South Australian Scientist of the Year. 12: Dr Bo "Weasley" Xu (left) and Prof Matt Gilliam (right) celebrating with Yunti Ge at her graduation ceremony, where she delivered the valedictorian address in Bonython Hall. 13: Prof Mathew Lewsey

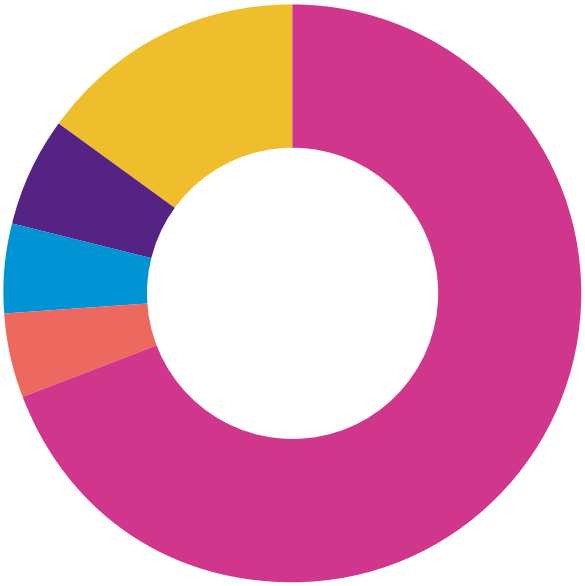
Financial Statement

Income

Income	2025
ARC Grant	$5,807,378.76
Partner Income	$490,000.00
University contributions	$1,404,515.00
Total	**$7,701,893.76**

Expenses

Expenditure	2025
Personnel	$4,335,096.02
Equipment	$289,357.28
Maintenance	$315,008.45
Travel	$375,997.75
Other	$927,944.46
Total	**$6,401,895.33**



A greener future for Earth through space exploration research

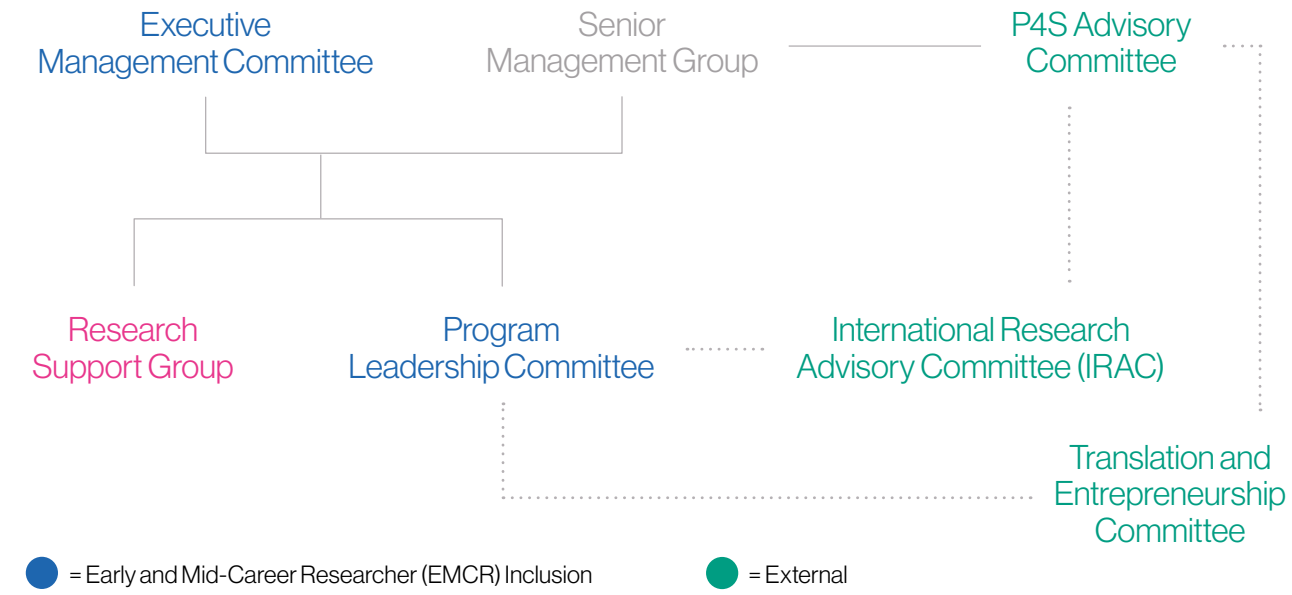
"Plants are our life support system on Earth. They provide food, oxygen, water purification, and even psychological comfort. Without plants, life support will be a whole lot more challenging as we explore Moon, Mars and beyond, long-term."

Dr Elison Blancaflor, Program Scientist for NASA's Biological and Physical Sciences Division

Governance

The P4S governance framework is structured to support agility, effective delivery of outcomes, and strong connectivity with the international space–agriculture community. P4S' internal committees and decision-making arrangements embed the control mechanisms of the P4S risk management plan, enabling ongoing oversight of Centre project performance, succession planning, and the appropriate management and allocation of funds across the Centre.

P4S' external committee structure provides access to independent strategic, industry, and academic expertise that informs and guides the Centre's research programs. This advice helps shape the Centre's priorities and strategic direction, ensuring its activities remain aligned with evolving international industry and academic trends. The participation of early- and mid-career researchers (EMCRs) on internal committees further strengthens professional development and supports the Centre's succession planning objectives.



Members of the CI Team gathered in Perth for the annual CI workshop.

Executive Management Committee (EMC)

Prof Matthew Gilliham
Prof Melissa de Zwart
Prof Sally Gras
Dr Richard Harvey
Prof Mathew Lewsey
Prof Philip Brewer
Prof Harvey Millar
Prof Ryan Lister
Prof Volker Hessel
A/Prof Kim Johnson
Prof Ian Small
Prof Michelle Watt
A/Prof Jenny Mortimer
Prof Eva Kemps
Prof Matthew Tucker
A/Prof Sigfredo Fuentes
Prof Christine Feinle-Bisset
Dr Gioia Massa
Dr Caterina Selva (alternating EMCR representative)
Dr Claudia Gonzalez Veijo (alternative EMCR representative)
Anshul Phaugat (alternating HDR student representative)
Florence Ly (alternating HDR student representative)

Senior Management Group (SMG)

Prof Matthew Gilliham - Centre Director
Prof Melissa de Zwart - Deputy Director
Prof Sally Gras - Deputy Director
Dr Richard Harvey - Chief Operating Officer

P4S Advisory Committee (PAC)

Prof Steven Freeland (Chair)
Dr Jitendra Joshi
Dr Shannon Walker
Carey Taylor
Dr Brett Biddington AM
Prof Fiona Cameron
Prof Anna Koltunow FAA FTSE

International Research Advisory Committee (IRAC)

Prof Anna Koltunow FAA FTSE
Prof Anna-Lisa Paul
Dr Raymond Wheeler
Prof Birger Lindberg Møller
Prof Harjinder Singh
Ms Sally McPhee

Research Support Group (RSG)

Dr Richard Harvey
Dr Rebecca Vandeleur
Dr Lieke van der Hulst
Nikki Hodge
Sandra Clavijo
April Harris
Cassie Watts
Dr Linda de Melis
Amy Griessl
Amy Kirkup

Node Coordinators

Dr Rebecca Vandeleur , SA Node Coordinator (UoA & Flin)
April Harris , WA Node Coordinator
Cassie Watts , UM Node Coordinator
Sandra Clavijo Arango , LTU Node Coordinator

Translation and Entrepreneurship Committee (TEC)

Prof Jay Keasling
Dr Aude Vignelles
Dr Judy Halliday
Dr Natalie Curach
Prof Matt Gilliham (Co-chair)
Prof Sally Gras (Co-chair)
Dr Richard Harvey
Dr Michael Millan
Dr John Coulton

Key Performance Indicators

Performance Measure	2025 Target	2025 Actual
1. Number of research outputs		
· Journal articles	20	50
· Conference presentations	25	52
– Of which, invited presentations	10	10
2. Quality of research outputs		
· Publications in Q1 journals within specified fields as defined by CiteScore	16	43
· Number of publications in journals in top 5% of field by CiteScore	1	32
· Citations of P4S papers	325	263
· Publications with co-authors from POs	13	14
· Publications with co-authors from 2 or more P4S nodes	8	7
· Awards/prizes	2	12
3. Number of workshops/conferences held/offered by the Centre		
· P4S workshops	2	8
· External meetings supported	1	3
4. Number of training courses held/offered by the Centre		
· Training workshops	5	13
· Equity & Diversity campaigns	2	4
5. Number of additional researchers working on Centre research		
· Postdoctoral researchers	10	17
– Of which, Fellows	3	3
· Honours/Masters students	19	14
· PhD Students	20	17
· Undergraduate work experience	50	46
· Associate Investigators	11	8
· National visitors to P4S nodes	5	3
· International visitors to P4S nodes	3	15
6. Number of postgraduate completions		4
7. Number of mentoring programs offered by the Centre		
· Mentoring activities/workshops	5	4
· External/industry PhD internships	10	4

Performance Measure	2025 Target	2025 Actual
8. Number of presentations/briefings		
· To the public	20	34
· To government	3	14
· To industry/business/end-users	15	72
- Of which, non-PO industry/business/end-users	5	54
9. Number of new organisations collaborating with, or involved in, the Centre	1	4
· Of which, from target regions		
10. Number of female research personnel	45%	51%
· Senior Management Group	45%	50%
· Chief Investigators	45%	43%
· EMCRs	45%	45%
· Students	45%	52%
· Research support and professional staff	45%	90%
P4S-specific KPIs		
· New grants won by P4S staff and students	10	20
· P4S alumni in academia	2	9
· P4S alumni in industry/government	2	4
Public inspiration		
· Number of students engaged by P4S education and engagement activities (incl. school events, public events and as a result of teacher professional development)	20,000	29,251
· Teachers trained in P4S-hosted workshops	80	1699
· Total potential number of students reached including as a result of P4S-facilitated teacher professional learning (23 students per primary teacher and 100 per secondary teacher)	30,000	57,746
· Press releases	10	21
· Website hits	25,000	41,800
· Social media reach	15,000	255,429
Translation		
· Uptake of technologies by industry		
· Technologies used in CEA/Space		
· P4S spin-out companies		

Publications

Book Chapters

Auroux, L., Liew, L.C. and Lewsey, M.G. (2025). "An overview of single-cell high-throughput technology in plants." In: *Guide to Plant Single-Cell Technology*, pp. 1–34.

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Charbeaux, R.S.F., Waymouth, V.J., Calabria, J., Miller, T., Andeer, P. and Watt, M. (2025). "Synchronizing germination rates across plant species for fabricated ecosystems EcoFAB 2.0." *Bio-protocol*, 15(23), e5537.

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50

Journal articles in 2025

43

Publications in Q1 journals

14

Publications with co-authors from Partner Orgs

7

Publications with co-authors from two or more P4S nodes

Arabidopsis thaliana

Members

Centre Director

Prof Matthew Gilliham, The University of Adelaide

Deputy Directors

Prof Melissa de Zwart, The University of Adelaide
Prof Sally Gras, The University of Melbourne

Chief Operating Officer

Dr Richard Harvey, University of Adelaide

Chief Investigators

Prof Philip Brewer, La Trobe University
Prof Christine Feinle-Bisset, The University of Adelaide
A/Prof Sigfredo Fuentes, The University of Melbourne
Prof Volker Hessel, The University of Adelaide
A/Prof Kim Johnson, La Trobe University
Prof Eva Kemps, Flinders University
Prof Mathew Lewsey, La Trobe University
Prof Ryan Lister, The University of Western Australia
Prof Harvey Millar, The University of Western Australia
Prof Jenny Mortimer, The University of Adelaide
Prof Ian Small, The University of Western Australia
Prof Matthew Tucker, The University of Adelaide
Prof Michelle Watt, The University of Melbourne

Postdoctoral Researchers

Dr Javad Anjom Shoae, The University of Adelaide
Dr Matthew Briggs, The University of Adelaide
Dr Ryan Coates, The University of Western Australia
Dr Lee Conneely, La Trobe University
Dr Ciara Finnegan, The University of Adelaide
Dr Alison Gill, The University of Adelaide
Dr Zheng (Tommy) Gong, The University of Adelaide
Dr Claudia Gonzalez Viejo, The University of Melbourne
Dr Dang Sang Huynh, La Trobe University
Dr Farley Kwok van der Giezen, The University of Western Australia
Dr Declan Lafferty, The University of Melbourne
Dr Xu Li, The University of Melbourne
Dr James Lloyd, The University of Western Australia
Dr Gunya Malhotra, La Trobe University
Dr Troy Miller, The University of Western Australia
Dr Sourav Mukherjee, The University of Western Australia
Dr Van Duc Long Nguyen, The University of Adelaide
Dr Marina Oliva, The University of Western Australia
Dr Lydia Ong, The University of Melbourne
Dr Luca Pedroletti, La Trobe University
Dr Marta Peirats Llobet, La Trobe University
Dr Adriane (Adri) Piechatzek, The University of Adelaide
Dr Caterina (Cate) Selva, The University of Adelaide
Dr Kenneth (Kenny) Sim, Flinders University
Dr Laura Steel, La Trobe University
Dr Sze Wai (Anna) Tse, The University of Western Australia
Dr Frazer Thorpe, La Trobe University
Dr Rebecca Wolters, The University of Western Australia
Dr Bo (Weasley) Xu, The University of Adelaide
Dr Ziwei Zhou, The University of Melbourne
Dr Changping Zhuang, The University of Adelaide

PhD Students

Mrs Modupe Adebowale, The University of Adelaide
Ms Camille Bitton, The University of Adelaide
Ms Jess Bunchek, The University of Adelaide
Ms Leni Campbell-Clause, The University of Western Australia
Ms Cadell Canute, The University of Adelaide
Ms Yiwen Chen, The University of Adelaide
Mr Ryan Cheney, The University of Melbourne
Mr Thomas Cobbinah, La Trobe University
Mr Jonathan Diab, The University of Adelaide
Mr Rabin Duwal, The University of Adelaide
Mr Ryan Edwards, The University of Adelaide
Mr Elliott Fourie, The University of Western Australia
Mr Shehan Galbadage Don, The University of Melbourne
Mr Sebastian Garcia Daga, The University of Adelaide
Mr Patrick Gong, The University of Western Australia
Ms Lucia Hammelehle, The University of Melbourne
Ms Gabrielle Herring, The University of Western Australia
Ms Bryony Hodge, The University of Adelaide
Mr Harish Jadhav, The University of Western Australia
Mr Mohammad (Alex) Karami, The University of Adelaide
Mr Kenny Lam, The University of Melbourne
Ms Shu Liang, The University of Adelaide
Ms Florence Ly, The University of Western Australia
Mr Matthew Morgan, The University of Adelaide
Ms Sampurna Mukherjee, The University of Adelaide
Mr Xiao Yu (Josh) Ng, The University of Adelaide
Ms Sahar Nottagh, The University of Melbourne
Mr Chigozie Ofoedu, The University of Adelaide
Mrs Mst Irin Parvin, The University of Adelaide
Ms Milly Petterson, The University of Western Australia
Mr Anshul Phaugat, La Trobe University
Mr Akshat Raghuvanshi , La Trobe University
Mr Mohammadreza (Reza) Sheikhikouhsar, The University of Melbourne
Ms Amy Viljoen, The University of Western Australia
Mr Jalitha Wanni Arachchige, The University of Melbourne
Mr Jordan Witchard, La Trobe University
Ms Xingyi (Raven) Zhou, The University of Adelaide
Ms Jia Yuan (Meggie) Zhu, The University of Western Australia

Masters Students

Mr Mick Bailey, The University of Melbourne
Mr Roberto Damico, The University of Adelaide
Ms Yunti Ge, The University of Adelaide
Ms Jess Gugliotta, The University of Western Australia
Ms Siwei (Eliza) Guo, The University of Melbourne
Ms Sophia Jones, The University of Melbourne
Ms Yujia (Cora) Liu, The University of Adelaide
Ms Jiayue Wang, La Trobe University
Mr Anxing (Andy) Zhang, The University of Adelaide

Honours Students

Mr Ian Cullen, La Trobe University
Ms Chelsea Hearl, Flinders University
Ms Jorja Hooper, The University of Adelaide
Mr Evan James, The University of Western Australia
Mr Levi McKenzie, The University of Adelaide
Ms Stephanie Nicholls, La Trobe University
Ms Angelica Rossi, La Trobe University

Undergraduate Students

Ms Hong Ngoc Tran, La Trobe University

Professional Staff

Mr Douglas Bair, La Trobe University
Ms Sandra Clavijo, La Trobe University
Dr Linda De Melis, The University of Melbourne
Ms Amy Griessl, The University of Adelaide
Mrs April Harris, The University of Western Australia
Ms Nikki Hodge, The University of Adelaide
Mrs Amy Kirkup, The University of Adelaide
Dr Janine Oldfield, The University of Melbourne
Dr Lieke van der Hulst, The University of Adelaide
Dr Rebecca Vandeleur, The University of Adelaide
Ms Cassie Watts, The University of Melbourne

Research Assistants

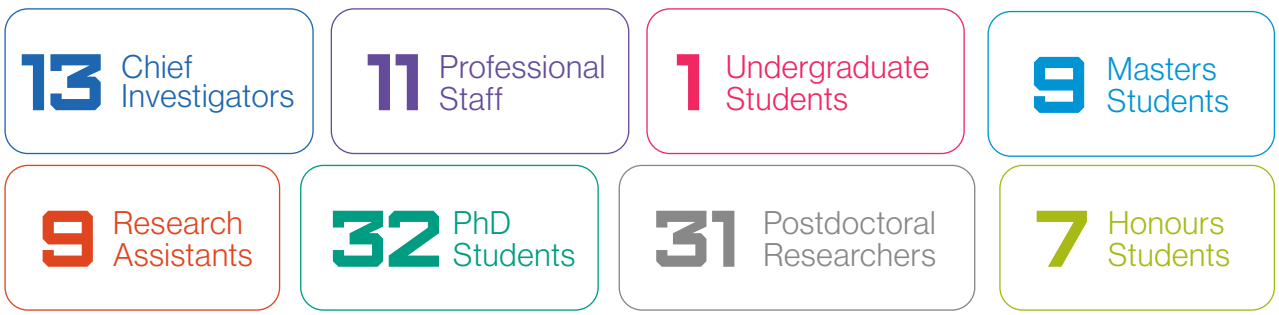
Dr Ane Aldalur Soto, The University of Melbourne
Dr Mohammad Hossain Babla, The University of Adelaide
Ms Charlotte Bampton, The University of Adelaide
Ms Anna Bond, The University of Western Australia
Mr Jacob Calabria, The University of Melbourne
Ms Natalie Harris, The University of Melbourne
Ms Sarah Hollitt, Flinders University
Mr Hamish McNamara, The University of Adelaide
Ms Wendy Sullivan, The University of Adelaide

Partner Investigators

Prof Adam Arkin, University of California
Dr Jennifer Bromley, Vertical Future
Ms Jacqueline Carpenter , One Giant Leap
Prof Jennifer Doudna, University of California
Dr Didier Dupont, INRAE
Mrs Christine Escobar, Space Lab Technologies
Dr Flavia Fayet-Moore, FOODiQ
Prof Ian Fisk, University of Nottingham
Prof Simon Gilroy, University of Wisconsin-Madison
Mr Mark Gleeson, Victorian Space Science Education Centre
Mr Nadun Hennayaka, Yield X
Dr Gioia Massa, National Aeronautics and Space Administration
Prof Karen McDonald, University of California
Dr Joanna McMillan, Dr Joanna McMillan Pty Ltd
Prof Raffaele Mezzenga , ETH Zurich
Dr Darren Plett, Bioplatforms Australia
Ms Sumen Rai, South Australian Space Industry Centre
Prof Eudardo Salas, Rice University
Dr Lucie Low, Axiom Space

Associate Investigators

A/Prof Susan Bastian, The University of Adelaide
A/Prof John Culton, The University of Adelaide
Prof Zhong-Hua Chen , The University of Adelaide
Dr Sara Langston, The University of Adelaide
Dr Arturo Mayorga-Martinez, The University of Melbourne
Dr Alex Ware, University of Nottingham
Prof Rainer Hedrich, The University of Adelaide
Dr Bahman Tahayori, The University of Melbourne



The Gallery

Top left: Deputy Director Prof Melissa de Zwart on set, recording an episode of the YouTube series *Sustainable Space Farming Starts on Earth.*

Above right: Renowned NASA plant physiologist and emeritus senior scientist Dr Raymond Wheeler (second from right) at the University of Adelaide's Waite campus.

Right: A/Prof Sigfredo Fuentes takes the stage as a keynote speaker at the Korean Society of Food Science and Nutrition Conference (KFN 2025) in Busan, Korea.

Below: P4S researchers from The University of Melbourne showcase their work on long-term food storage, preservation, nutrient stability, flavour retention, and sensory perception for space missions.

Bottom right: During his visit to Chiba University, Japan, Prof Matthew Gilliham delivered a session titled *P4S: Re-designing Plant, Food and Bioresource Production for Space and Earth.*

Above: Representatives from P4S partner, the German Aerospace Center (DLR) tour the APPN Plant Accelerator.

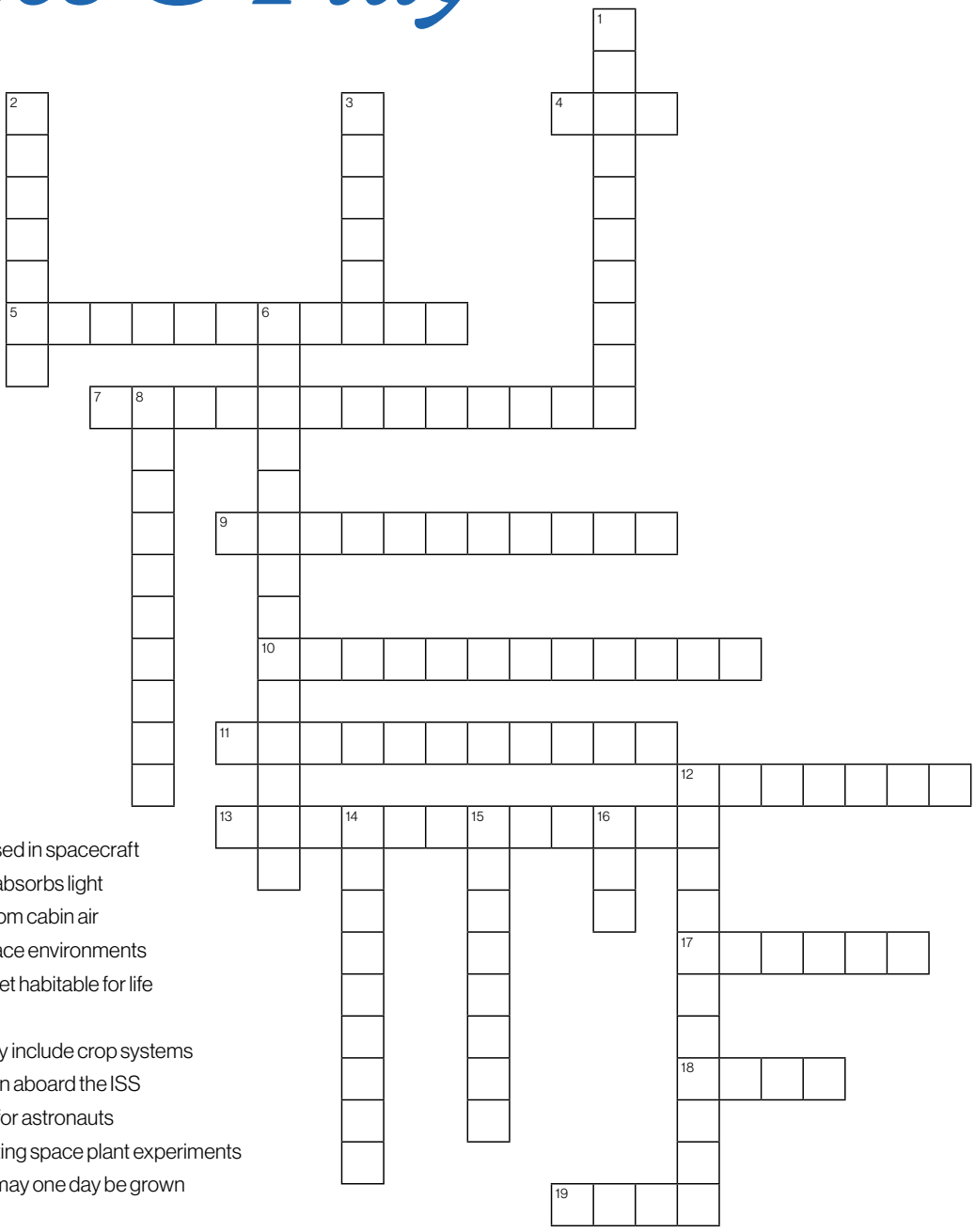
Right: COO Dr Richard Harvey and PhD student Anshul Phaugat attend the Protected Cropping Australia Conference in Adelaide.

Bottom right: Prof Jenny Mortimer leads Former Deputy Premier Susan Close (centre) through the Vertical Farm.

Below: Australia's first female astronaut, Katherine Bennell-Pegg, tours the University of Adelaide's P4S Node.

Bottom: Prof Mathew Lewsey in discussion with representatives from the Nagoya Cituba Productivity Centre on how P4S innovations can advance sustainability.

Creative Cosmos: Puzzles & Play



Across

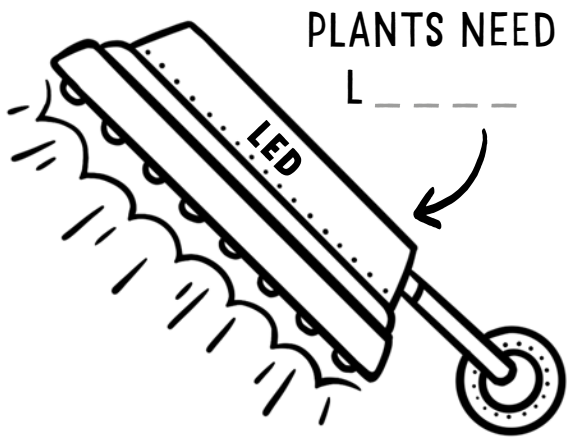
4 Artificial grow light used in spacecraft
5 Green pigment that absorbs light
7 Gas plants absorb from cabin air
9 Study of plants in space environments
10 Making another planet habitable for life
11 Sprouting of a seed
12 Living space that may include crop systems
13 Low-gravity condition aboard the ISS
17 Gas plants produce for astronauts
18 U.S. agency conducting space plant experiments
19 Planet where crops may one day be grown

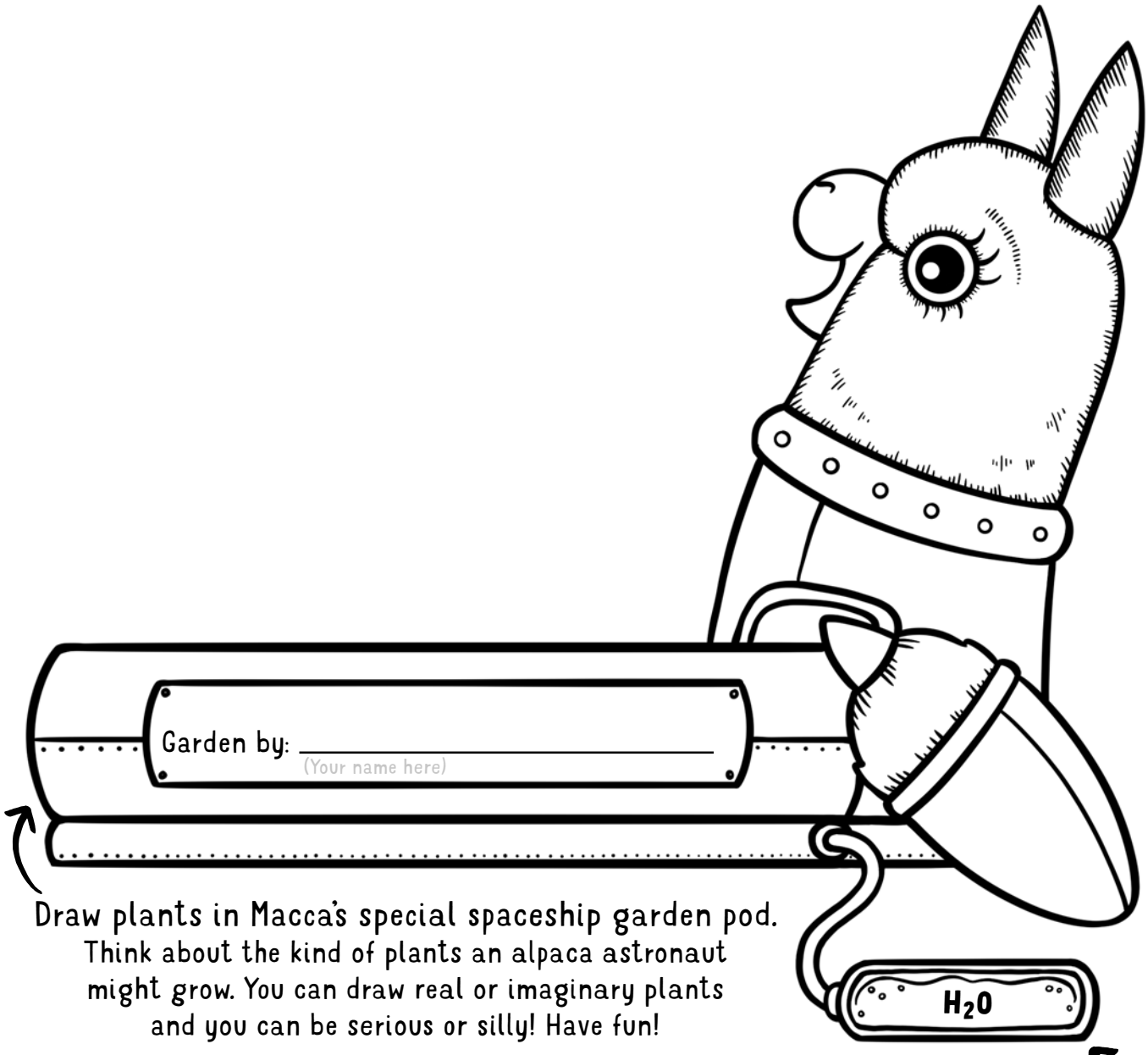
Down

1 Controlled environment for growing plants
2 First fresh vegetable grown on the ISS
3 Scientific study of plants
6 Process plants use to convert light into energy
8 Growing plants suspended in air with misted nutrients
12 Growing plants without soil
14 Space hazard affecting plant growth
15 Moon or Mars soil used for experimental planting
16 Orbiting laboratory where space crops are tested

Help Macca the Alpaca grow

Plants in Space!





Draw plants in Macca's special spaceship garden pod. Think about the kind of plants an alpaca astronaut might grow. You can draw real or imaginary plants and you can be serious or silly! Have fun!

PLANTS NEED
W _ _ _ _

PLANTS FOR SPACE
ARC CENTRE OF EXCELLENCE

MUSEUM OF AUSTRALIAN DEMOCRACY
OLD PARLIAMENT HOUSE

Find more activities at **www.mattcosgrovebooks.com**

Image credit – Matt Cosgrove

Acronyms and abbreviations

Instutions

AGRF	Australian Genome Research Facility
APPN	Australian Plant Phenomics Network
ARC	Australian Research Council
ASA	Australian Space Agency
Axiom	Axiom Space
BGSH	South Australia Botanic Gardens
BPA	BioPlatforms Australia
DLR	German Aerospace Centre
DSTG	Defence Science and Technology Group
ETH Zurich	Eidgenössische Technische Hochschule Zürich
Flinders	Flinders University
INRAE	Research for Agriculture, Food and Environment
LTU	La Trobe University
NASA	National Aeronautics and Space Administration
OGL	One Giant Leap Australia Foundation
PIRSA	Department of Primary Industries and Regions, South Austalia
RICE	Rice University
Saber	Saber Astronautics
SASIC	South Australian Space Industry Centre
Space Lab	Space Lab Technologies, LLC
Twist	Twist Bioscience
UC Davis	University of California, Davis
UCB	University of California, Berkeley
UoA	The University of Adelaide
UoC	University of Cambridge
UoM	The University of Melbourne
UoN	University of Nottingham
UW Madison	University of Wisconsin-Madison
UWA	The University of Western Australia
VF	Vertical Future
VSSEC	The Victorian Space Science Education Centre
Yuri	Yuri GmbH

General

AEA	Australia's Economic Accelerator
AI	Associate Investigator
CI	Chief Investigator
CoE	Centre of Execellence
COO	Chief Operating Officer
D&I	Diversity and Inclusion
ECR	Early Career Researcher
EDI	Equity, Diversity & Inclusion
EMC	Executive Management Committee
EMCR	Early and Mid-Career Researcher
EXTERRES	The Extraterrestrial Environmental Simulation laboratory
HDR	Higher Degree by Research
IRAC	International Research Advisory Committee
KPIs	Key Performance Indicator
LEAF	Lunar Effects on Agricultural Flora
P4S	Plants for Space
PAC	P4S Advisory Committee
PDRA	Postdoctoral Researcher or Postdoctoral Research Associate
PI	Partner Investigator
PLC	Program Leadership Committee
PO	Partner Organisation
PSBA	Plant Synthetic Biology Australia
RSG	Research Support group
SMG	Senior Management Group
TEC	Translation and Entrepreneurship Committee

Dr Lydia Ong (Front), The University of Melbourne

PLANTS FOR SPACE

ARC CENTRE OF EXCELLENCE

General enquiries
p4s_admin@adelaide.edu.au

For media and communication enquiries
m.parks@adelaide.edu.au

Chief Operating Officer
richard.harvey@adelaide.edu.au