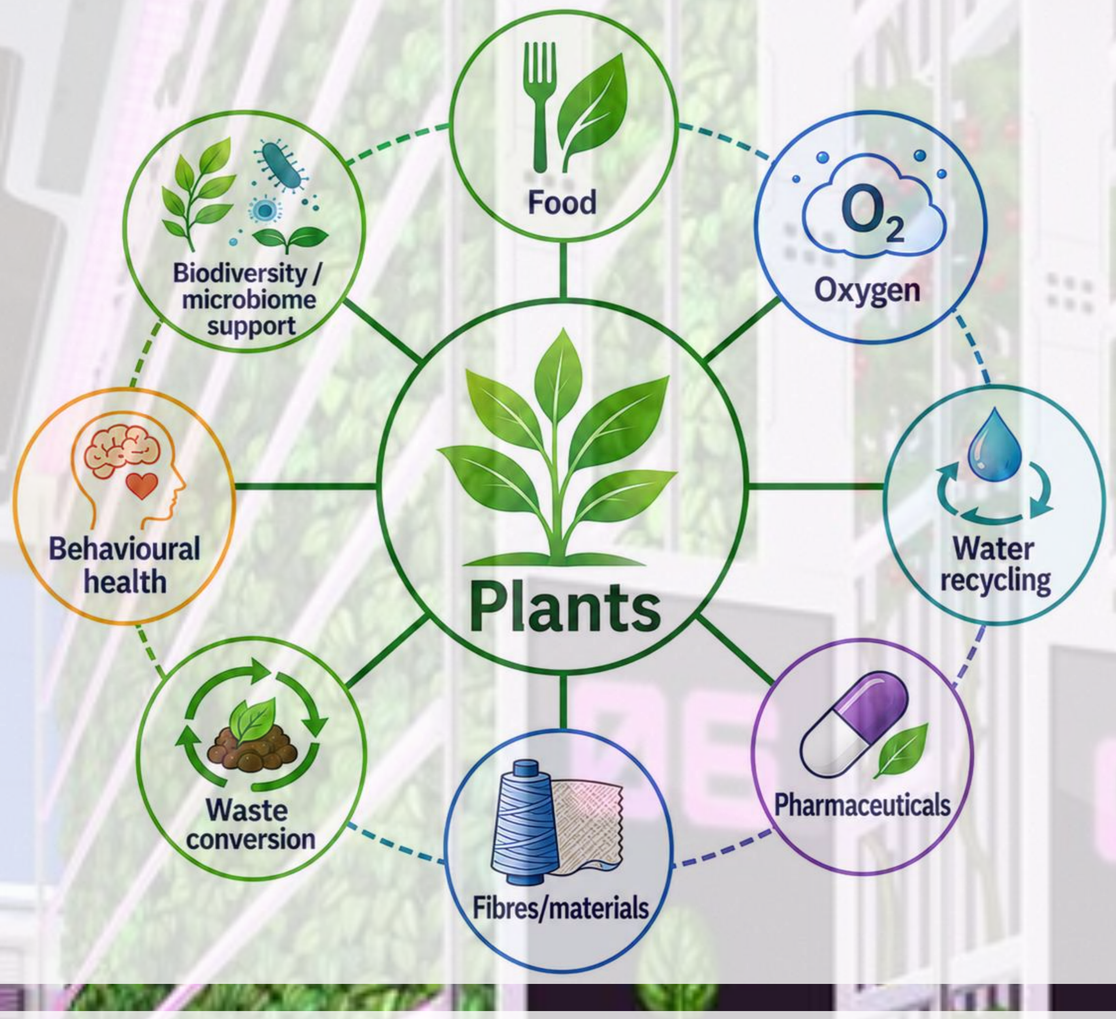
INTERNATIONALLY CONNECTED PLANT BIOLOGY AS AN ENABLER FOR BIOREGENERATIVE LIFE SUPPORT OF LONG-TERM SPACE MISSIONS

WHY PLANTS, WHY NOW?

- Artemis-era exploration is making sustained human presence beyond low Earth orbit increasingly tangible
- Future missions will need enabling technologies that reduce dependence on Earth resupply
- Bioregenerative Life Support Systems (BLSS) is a sustainable platform that combines engineered and biological technologies
- Plants provide BLSS: food, oxygen, water recycling, fibres, fuels, pharmaceuticals, materials and behavioural-health benefits

PLANTS - MULTIFUNCTIONAL ENABLERS OF BLSS



BUILDING AN IMPLEMENTATION PLAN

- Progress requires coordinated international activity across space life sciences, food systems, engineering and mission design.
- A dedicated ELGRA workshop (2024) led a community space plant biology roadmap (Fountain *et al.* New Phytologist, 249: 656–669) outlining priorities; aligned perspectives have recently emerged
- The next step is a consensus implementation plan that proposes timelines for enabling activities (see below) and funding priorities
- The plan must align plant, food- and life-support system development with specific long-duration mission scenarios

ROADMAP TIMELINE

Co-designing the pathway toward mission-ready BLSS

FROM CRL TO BRL

- Plant use in space must be evaluated within full mission constraints: mass, volume, energy, crew time, reliability, risk and system integration
- Existing Crop Readiness Level (CRL) metrics have been essential in progressing crop readiness for space, but additional criteria are required to evaluate BLSS Readiness Level (BRL)
- A BRL framework should integrate assessments of crop productivity with reliability, resource efficiency, system compatibility, crew workload and potential failure modes.
- BRL expands the evaluation beyond the question, "Can this plant grow?" to the more mission critical "Can this crop operate reliably as integrated component of a life-support system?"

FROM CROPS TO CLOSED-LOOP LIFE SUPPORT

Extending crop readiness towards functional bioregenerative life support

BLSS Readiness Level
Building on crop readiness to achieve functional BLSS integration

9	GROWN/USED/EATEN AS PART OF FUNCTIONAL BLSS
8	BLSS CONTRIBUTIONS UNDER EXPLORATION SETTINGS
7	FULL INTEGRATION WITH BLSS SUBSYSTEMS
6	BLSS TESTING IN GROUND ANALOG HARDWARE
5	CULTIVATION WITH RECYCLED NUTRIENTS
4	WASTE MANAGEMENT INTEGRATION & OPTIMIZATION
3	STREAMLINE PROCESSING, STORAGE & SHELF-LIFE
2	RELEVANT BLSS ENVIRONMENTAL TESTING
1	HIGH CRL CROP IDENTIFICATION/MODIFICATION FOR BLSS

BLSS readiness extends from and builds on Crop Readiness Level

Crop Readiness Level
Establishing crops suitable for space cultivation and consumption

9	CONSUMED IN SPACE
8	GROWN IN SPACE
7	FLIGHT-LIKE TESTING
6	SEED OR PROPAGULE SANITIZATION
5	CHEMISTRY & SENSORY ACCEPTABILITY
4	BASELINE MICROBIOLOGY
3	RELEVANT ENVIRONMENTAL TESTING
2	CULTIVAR SCREENING
1	CROP IDENTIFICATION

Increasing readiness

see Fountain *et al.* 2026. *New Phytologist* 249: 656–669 for more details

NEXT STEPS & KEY MESSAGES

- We invite the global R&D community to co-design an implementation plan for developing BLSS technologies that support long-term human space habitation and their transfer on Earth to improve the sustainability of aligned industries.

International Network for Space Plant Innovation, Research & Exchange

Catalysing innovation through global collaboration in space plant science

INSPIRE

INSPIRE is an informal and unofficial network currently consisting of researchers and executives from universities, research institutes, government agencies and industry from North and South America, Europe, Asia and Australasia facilitated by the ARC Centre of Excellence in Plants for Space. New members are welcome, especially representation from Africa.

Connect with us! For more and leave a message scan QR and attend F0.2, International Life Support Panel – Tuesday 4th August 1100-1230

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