



Australian
Plant Phenomics Facility



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The Australian Plant Phenomics Facility

The Australian Plant Phenomics Facility provides an important new set of tools for Australian plant science and increases the ability of plant science to deliver outcomes to Australian agriculture.

The APPF relieves the 'phenotyping bottleneck' which has, until now, limited our ability to capitalise on substantial government and industry investments already made in plant functional genomics and modern breeding technologies.

The Vision

The APPF will be a national facility, available to all Australian plant scientists, offering access to infrastructure that is not available at this scale or breadth in the public sectors anywhere else in the world.

The APPF will be based around automated image analysis of the phenotypic characteristics of extensive germplasm collections and large breeding, mapping and mutant populations. It will exploit recent advances in robotics, imaging and computing to enable sensitive, high throughput analyses to be made of plant growth and function.

New technologies will be developed to ensure that the APPF remains at the international forefront of plant science. Research networks and established pathways to market will ensure outcomes are delivered for the long-term benefit for Australian scientists and primary producers.



The High Resolution Plant Phenomics Centre, Canberra



The Plant Accelerator, University of Adelaide, Waite Campus

The APPF has two nodes, The Plant Accelerator involving the research institutions at the Waite Campus of the University of Adelaide and The High Resolution Plant Phenomics Centre involving CSIRO Plant Industry and Australian National University in Canberra.

What will the APPF do?

The APPF will have basic high throughput imaging using visible, near infra-red, far infra-red and fluorescence technologies, and will enable the development of continuous analysis of plant growth and performance using modern technologies.

Enhancing National Collaborations

Extensive national research networks that already exist within the two nodes will be further expanded to ensure that the APPF is formally linked with, and accessible to, all plant science and plant breeding centres across Australia, and that it is well placed to draw on international developments and collaborative opportunities.

Plant research and agribusiness benefits

The APPF will link molecular genetics, functional genomics, biochemistry and physiology to produce an integrated vision of plant performance for transformational research outputs and new opportunities for Australian agribusiness.

The rapidly evolving scientific discipline of plant phenomics, coupled with gene analysis technologies, has the potential to revolutionise the way that researchers tackle key issues in plant and agricultural biology.

Overview of evolving plant phenomics capabilities

Non-destructive and destructive measurements are made on parts of the plant that are above and below the ground throughout the plant's lifecycle. By linking phenomic measurements to the plant's genetic makeup, we can select or engineer new plant varieties using the genetic diversity in cultivated and wild plants.

A significant part of the proposal involves the development and exploitation of a new generation of technologies to rapidly and non-destructively monitor plant characteristics and performance.

Phenomics:

The study of how the genetic makeup of an organism determines its appearance, function and performance.

New tools for Australian plant science

Applications to plant genome studies

Digital analysis of plant function

Increase the speed and resolution of plant analysis



The Facility is established as part of the Commonwealth government's National Collaborative Research Infrastructure Strategy.

The APPF will provide:

- Sophisticated controlled environments for growing plants across a range of climatic conditions.
- Glasshouse automation technologies to study large populations of plants rapidly and efficiently.
- Leading-edge digital imaging technologies and sophisticated software to measure plant characteristics and their performance in real time.
- The capacity to 'scale up' plant performance measurements from the glasshouse to the field.
- A national focus for scientists to collaborate on key biological and agricultural research problems.
- A unique and integrated system for the rapid capture of genetic resource information and its shared use for plant science and agriculture, both within Australia and internationally.

Applications include:

- Functional genomics of model and crop species
- Screening of mutant or mapping populations, screening for natural variation in diverse populations
- Unravelling signal transduction and environmental interactions
- Climate change research
- Development of novel products for healthy foods
- Development of sustainable practices in agriculture
- Maintenance of biodiversity and the development of new strategies for the remediation of degraded landscapes
- Using plants and biofactories to produce new pharmaceuticals and other products for industry



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The Plant Accelerator



The Plant Accelerator, University of Adelaide, Waite Campus

The Plant Accelerator

The Plant Accelerator will be a world-leading plant growth and analysis facility based at the Waite Campus of the University of Adelaide. It will accelerate pure and applied plant science research Australia-wide and Internationally. The high technology glasshouse, with over 1km of conveyor systems and state-of-the-art imaging, robotic and computing equipment, will allow continuous measurements of the physical attributes (phenotype) of plants automatically and non-destructively. The facility will accommodate 160,000 plants a year in programs such as those aimed at increasing drought and salinity tolerance in wheat and barley. Research on other economically important crops such as grapevines will also be accommodated.

The Plant Accelerator will serve as the national headquarters of the Australian Plant Phenomics Facility. The APPF will have two nodes, one in Adelaide and the other in Canberra. Funding has been provided for The Plant Accelerator by the Commonwealth, as part of the National Collaborative Research Infrastructure Strategy (NCRIS), the South Australian State Government and the University of Adelaide.





The Facility will contain:

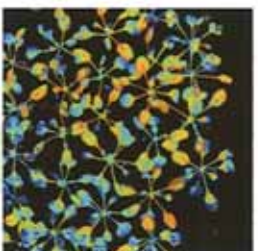
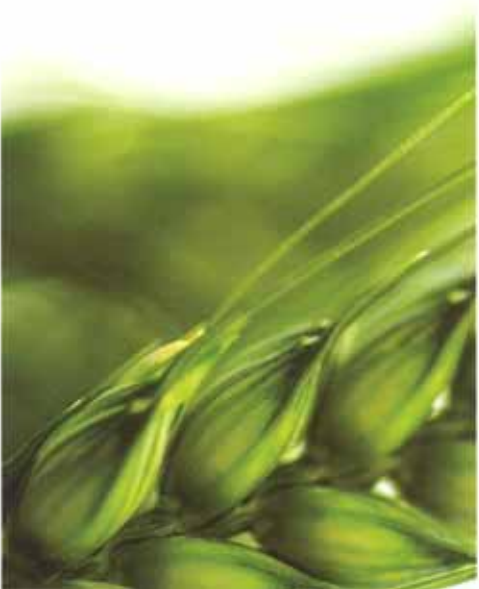
- A range of controlled growth environments in new, high quality facilities
- Over 1 km of conveyors delivering radio-tagged plants automatically to state-of-the-art imaging stations controlled by high capacity computing equipment
- Dedicated bioinformatics support to help manage and analyse data
- Equipment to image shoots in visible, near-infrared and far infrared spectra
- Equipment for fluorescence imaging of shoots
- Equipment to allow near-infrared imaging of pots to obtain a measure of water content in the soil
- Automatic programmable watering to weight of plants on the conveyor system

The Facility will enable non-destructive measurements through time of:

- Shoot mass, leaf number, shape, angle, and other morphometric data, and leaf colour and senescence using visible spectrum images
- Leaf water and carbohydrate content using near infrared images
- Leaf temperature using far infrared images
- Removal of water from soil in pots using near-infrared wavelengths
- Plant health by monitoring the state of chlorophyll using fluorescence imaging
- Fluorescent proteins such as GFP

Scientific applications include:

- Screening of mapping populations, mutant populations and wild relatives of crops for features of plant growth and function
- Forward genetic studies using large numbers of plants
- Thorough characterisation through time of particular lines of interest
- Alteration of plant growth and function to alter components contributing to yield potential
- Increasing drought and salinity tolerance of crops
- Increasing tolerance to mineral nutrient deficiencies and toxicities and biotic stresses such as fungal diseases



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The High Resolution Plant Phenomics Centre



The High Resolution Plant Phenomics Centre, Canberra

The High Resolution Plant Phenomics Centre

The High Resolution Phenomics Centre will be located in Canberra at CSIRO Plant Industry and the Australian National University. This Centre will focus on 'deep phenotyping' (delving into metabolism and physiological processes within the plant) and reverse phenomics (dissecting traits to discover their mechanistic basis). Next generation research tools will be developed and applied to probe plant function and performance, under controlled conditions and in the field. Recent advances in robotics, imaging and computing will be used in applying these technologies and scaling them from the single plant to the ecosystem level. Two levels of service will be provided in the HRPPC. First, projects can be housed in the 'research hotel' environment where screening systems can be developed using facility staff and resources then deployed in the facility and in the user's home institution. Second, users' material can be screened for specific attributes using one or more of the modules housed at CSIRO or the ANU. This node of the facility will focus on flexibility from cereals to dicots and woody perennials at all stages of development.

The High Resolution Plant Phenomics Centre will serve as the sister facility to The Plant Accelerator based at the Waite Campus of the University of Adelaide. Together the Canberra and Adelaide developments will comprise the Australian Plant Phenomics Facility.



THE UNIVERSITY
OF ADELAIDE
AUSTRALIA



CSIRO



THE AUSTRALIAN NATIONAL UNIVERSITY



An Australian Government Initiative
National Collaborative Research
Infrastructure Strategy



Government
of South Australia

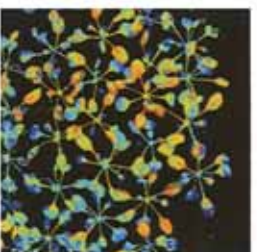
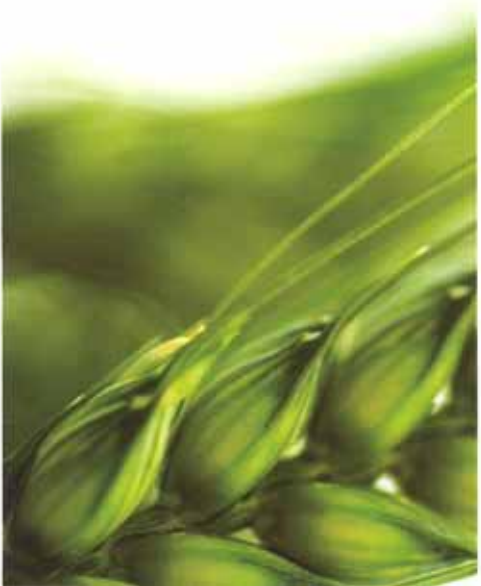


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FUNCTIONAL GENOMICS
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The Centre will provide a suite of analytical tools, packaged into four modules:

- **Small Model Plant Module.** This will provide high throughput growth and deep phenotyping of Arabidopsis in trays and other small seedlings using digital growth and morphological analysis, pulse modulated chlorophyll fluorescence and infra-red thermography for photosynthetic measurements under controlled environmental conditions (light, CO₂ and humidity). This module will interface with destructive robotic sampling and carbon isotope discrimination.
- **Crop Plant Shoot Module.** 3-D imaging for plant architecture and growth analysis, allowing multiple images to be overlaid. Hyperspectral reflectance for plant chemical composition and stress detection, pulse modulated chlorophyll fluorescence imaging and gas exchange for non-invasive estimation of photosynthesis, infra-red thermography and carbon isotope discrimination for water use efficiency screening. This module will be suitable for medium throughput screening and validation of novel screening methods in a wide range of cereals and annual and perennial plants of agricultural importance.
- **Root Module.** This module will comprise optical, infra-red and electromagnetic detection of root morphology, structure and function in soil in controlled environments and in the field. Access to MRI and X-ray tomography will be available through collaborations nationally and internationally.
- **Gateway to Field Module.** Extension to the field is an important part of validating controlled environment screening technologies and provides a powerful high throughput set of tools. Plant growth and composition in field plots will be remote sensed by stereophotography, laser radar and hyperspectral reflectance, combined with thermography, radiative / radar root detection and other developing technologies. These technologies will be integrated into spatial, climatic and precision agricultural data bases through researchers across Australia.



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