Biochemistry & Plant Molecular Physiology

UMR INRA / CNRS / SupAgro / Univ. Montpellier

http://www.montpellier.inra.fr/ibip/bpmp/english

B&PMP presentation

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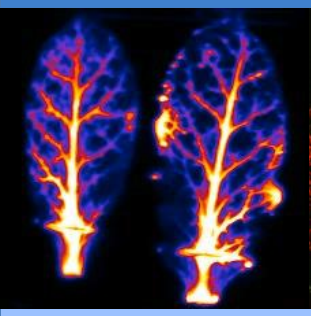
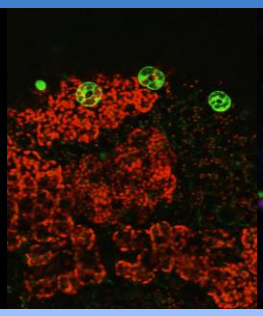
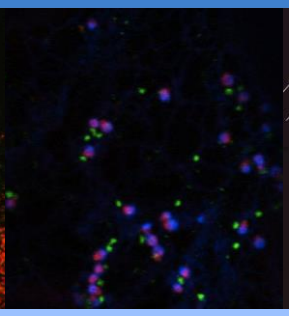
B&BMP has predominantly a research activity, aiming at elucidating the molecular mechanisms involved in the water and mineral nutrition of plants, and at integrating these mechanisms into the whole plant. The focus is on (i) membrane and long-distance transport of water and mineral nutrients (nitrate, potassium, phosphate, iron, zinc, etc…), (ii) storage and metabolism of these nutrients, (iii) signaling pathways ensuring the regulation of these processes and (iv) developmental responses to changes in water or nutrient availability.

A main objective is to characterize the role of the above molecular mechanisms in the adaptive responses of the plants to abiotic stresses (drought, salinity, nutrient deficiency, metal toxicity). Most research projects are using model species (*Arabidopsis*, *Medicago*), but also involve work on crops (rice, wheat, grapevine, lupin, tomato, maize) and symbioses (mycorrhizae, legumes). The experimental strategies are those of the Integrative Biology approach, and mostly rely on genomics (transcriptomics, proteomics, gene network modeling) and on functional and developmental phenotyping (electrophysiology, isotopes, hydraulics, imaging, root system architecture).

B&PMP in brief

Staff in 2017 :
- 81 permanent staff, including 44 scientists and 39 engineers /technicians/administrative assistants.
- 123 non-permanent staff (post-docs, CDD, graduate and undegraduate students).

Publications : 55 in 2014, 49 in 2015 and 55 in 2016.

Funding 2016 (excluding salary of permanent staff and PhD students) : 2 315 k€, including 1830k€ from competitive grants (ANR, EU, Labex, Région LR, private companies).

Significant publications

Shahzad Z., Canut M., Tournaire-Roux C., Martinière A., Boursiac Y., Loudet O., Maurel C. (2016) A potassium-dependent oxygen sensing pathway regulates plant root hydraulics. Cell 167: 87-98.

Fourcroy P., Tissot N., Gaymard F., Briat J.F., Dubos C. (2016) Facilitated Fe nutrition by phenolic compounds excreted by the Arabidopsis ABCG37/PDR9 transporter requires the IRT1 / FRO2 high affinity root Fe^{2+} transport system. Molecular Plant 9:485-488.

Bouguyon E., Brun F., Kubeš M., Meynard D., Pervent M., Léran S., Lacombe B., Krouk G., Guiderdoni E., Zažímalová E., Hoyerová K., Nacry P., Gojon A. (2015) Multiple mechanisms of nitrate sensing by Arabidopsis nitrate transceptor NRT1.1. Nature Plants 1: 15015.

Briat J. F., Dubos C., Gaymard F. (2015) Iron nutrition, biomass production and plant product quality. Trends in Plant Sciences 20: 33-40.

Maurel C., Boursiac Y., Luu D. T., Santoni V., Shahzad Z., Verdoucq L. (2015) Aquaporins in Plants. Physiological Reviews 95: 1321-1358.

Medici A., Marshall-Colon A., Ronzier E., Szponarski W., Wang R., Gojon A., Crawford N.M., Ruffel S., Coruzzi G.M., Krouk G. (2015) AtNIGT1/HRS1 integrates nitrate and phosphate signals at the Arabidopsis root tip. Nature Communications 6: 6274.

Research groups

« Aquaporins » - Group Leader: Christophe Maurel - christophe.maurel@cnrs.fr
aquaporin, water transport, membrane, root, phosphorylation

« Integration of Nutrient Signaling» - Group Leader: Alain Gojon - alain.gojon@inra.fr
nitrogen nutrition, transport and sensing of nitrate, N and C signaling, root development, climate change

« Electrophysiology of plant nutrition and root symbioses » - Group Leader: Hervé Sentenac - herve.sentenac@inra.fr
membrane transport, patch-clamp, spectrofluorimetry, potassium, nitrate, salt stress, water stress, stomata

« KaliPHruit » - Group Leader: Isabelle Gaillard - isabelle.gaillard@inra.fr
membrane transport systems, molecular regulators, potassium, proton, genetic pH probes, climate change, acidity and quality of fruit, translational biology, grape berry, *Arabidopsis,* grapevine

« Hormones, Nutrients and Development » - Group Leader: Benoît Lacombe - benoit.lacombe@inra.fr
nutrients-hormones interaction, nutrients sensing, long-distance signaling, systems biology, machine learning

« Metal Phytotoxicity » - Group Leader: Pierre Berthomieu – pierre.berthomieu@supagro.fr
genetic, genomic and functional approaches, hyper-accumulating plants, wheat, tobacco, plant defensins

« Mineral Nutrition and Oxidative Stress » - Group Leader: Christian Dubos– christian.dubos@inra.fr
crosstalk between nutrients, oxidative stress, Fe-S cluster machinery, roots, transcriptional networks

« Development and Plasticity of the Root System» - Group Leader: Benjamin Peret - benjamin.perret@cnrs.fr
organogenesis, *Arabidopsis*, cluster roots, lupin, hormones

« Iron Transport and Signaling » - Group Leader: Cathy Curie –catherine.curie@cnrs.fr
iron nutrition - long distance transport - metal ligands - iron signaling - membrane protein trafficking

« Iron Transport and Adaptation to Environment in Cereals » - Group Leader: Anne-Aliénor Véry – anne-alienor.very@supagro.fr
rice, wheat, K^+, Na^+, salt stress, drought, electrophysiology

$B_{\&}$PMP and training

$B_{\&}$PMP is strongly involved in higher education training with University of Montpellier and SupAgro engineering school, particularly at master level and the doctoral school GAIA. Since many years, $B_{\&}$PMP anually organise thematic schools for french and foreign students training.

Plant culture facilities

$B_{\&}$PMP hosts state-of-the-art facilities that allow researchers to grow various plant species under controlled conditions. These facilities can be grouped into 2 categories: controlled conditions greenhouses that comply with S2-level of confinement for transgenic plants production, and artificial conditions devices (17 growth chambers and 7 phytotronic cabinets). In addition to providing a precise control of aerial environmental conditions, phytotrons and growth chambers are extensively used for growing plants in hydroponics as it allows easy access to the roots and enables a fine monitoring of the mineral nutrition.

Heterologous Expression and Electrophysiology Platform

Molecular analysis of membrane transport of water and mineral ions in plants requires the identification of proteins responsible for these different transports. A plant has several hundreds of different proteins performing this function, often specific (e.g., for potassium, nitrate, iron, water, etc ...). Therefore, one must be able to isolate them and study them separately.

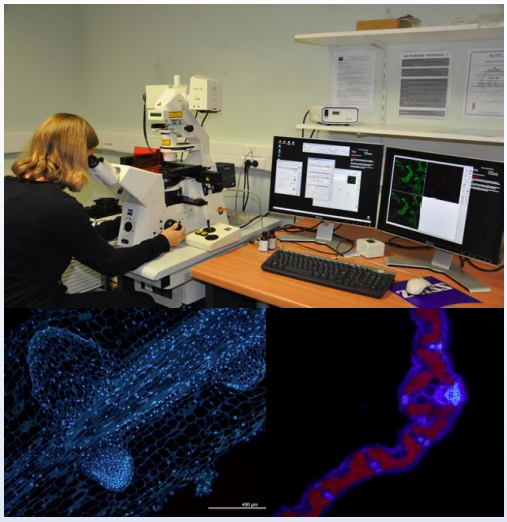
The heterologous expression and electrophysiology platform of $B_{\&}$PMP is a unique device in France dedicated to this type of work for plant proteins. It allows in particular characterizing in detail the activity of membrane transport proteins by measuring the electrical signature of their activity, due to the fact that most nutrients are transported in an ionic form. This platform is largely open to outside users.

Stable Isotope Analytical Platform (AIS)

The AIS is a platform fulfilling a national analytical service for INRA, but it is also open to other French and foreign users.

The AIS is devoted to the analysis of stable isotopes of nitrogen and carbon (^{15}N and ^{13}C) in plant samples (mostly). As such, it is strictly necessary for supporting research projects aiming at investigating transport of nitrogen (nitrate, ammonium, amino acids) or carbon (sugars, carboxylic acids) compounds. It makes it possible to perform tracer experiments for quantifying fluxes of these compounds between the external medium and the plant, and between the various plant organs.

Histology and Plant Cell Imaging Platform (PHIV)



Understanding the integrated function of genes and proteins in the whole plant requires the determination of their expression sites. This is made possible with various imaging techniques that enable visualizing gene activation and protein localization in each plant cell.
To run these techniques, $B_{\&}$PMP has developed a histocytology and plant cell imaging platform (PHIV), together with the AGAP laboratory. This platform is located on two different sites: SupAgro-INRA campus (PHIV – La Gaillarde) for $B_{\&}$PMP, and CIRAD campus (PHIV-Lavalette) for AGAP. PHIV is part of the large regional MRI platform (www.mri.cnrs.fr, ISO9001 and NFX 50-900 certification), and gathers a team of technicians, engineers and researchers making available a large palette of plant imaging skills and facilities to research groups (plant anatomy, histocytology, *in situ* hybridization, immunofluorescence, live cell imaging microscopy, spectral imaging, fluorescent and luminescent probes, biosensors).

Mass Spectrometry Proteomics Platform (MSPP)

Changes in the abundance and/or activity of key proteins play a major role in the response of plants to adverse environmental conditions. The objective of MSPP (Mass Spectrometry Proteomics Platform of $B_{\&}$PMP) is to develop skills and expertise in the fields of protein identification, molecular characterization of their post-translational states and protein quantification by mass spectrometry. MSPP is one of the two mass spectrometry sites of Pole Proteome Montpellier (PPM). PPM is certified ISO 9001, and has national (GIS IBiSA) and regional (Large Equipment for Technological Evolution and Scientific Initiation) labels.

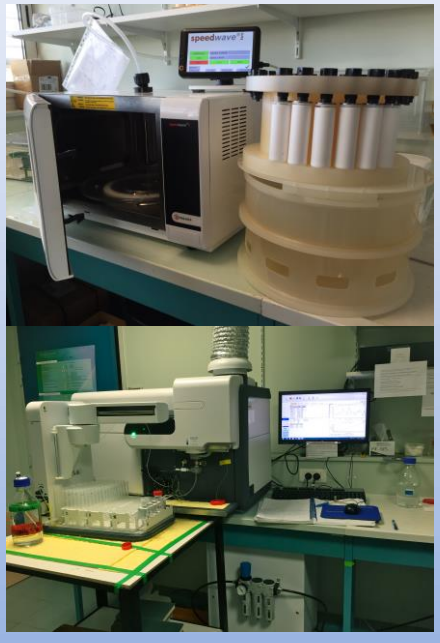
Technology Platform GeneAtlas® System

$B_{\&}$PMP is equipped with the GeneAtlas System from Affymetrix Company, which allows fast acquisition of genome-wide transcriptome data by hybridization of microarrays. To date, the system provides access to gene expression in several species such as *Arabidopsis thaliana, Medicago truncatula*, soybean and rice. For example, Arabidopsis microarrays provide expression data for more than 28,000 genes, including precursors of miRNAs.

This facility is a key tool for developing Systems Biology approaches, involving systematic and iterative strategies in which each transcriptomic analysis feeds the elaboration of models of gene regulatory networks that control nutrient homeostasis in plants.

Root phenotyping Platform

The Root Phenotyping facility is dedicated to kinetic and non-destructive analysis of seedling root system architecture of many species including *Arabidopsis*, rice, tomato, rapeseed, and *Medicago*…. grown *in vitro.* Its main objective is to develop approaches, tools and methods to characterize the effect of different stresses, nutrient deficiency or excess, or biotic interactions alone or in combination providing the basis for further genetic and molecular physiology approaches.
The phenotyping facility includes a self-contained imaging unit that can handle up to 200 plates at 12µm resolution with high contrast. Images are analyzed through semi-automated or fully automated pipelines integrated in the OpenAleaLab suite (https://team.inria.fr/virtualplants/software/).



Multi-Elemental Analyses Platform (SAME)

The Multi-Elemental Analyses Service (SAME), created in july 2016, is devoted to the atomic quantification from plant samples (roots, leaves, fruits, seeds, cellular fluids…) as well as from soil materials. Basically, the samples (dry material) are digested by acidic hydrolysis that disrupts molecular structures to release their atomic content (phosphorus, calcium, magnesium, sodium, iron, zinc…). After this hydrolysis step, the chosen elements are quantified by atomic emission spectrometry. The service proposed by the platform includes the hydrolysis of the samples, the choice of elements and the quantification by spectrometry. The equipment is composed of a microwave with 2x24 reactors for the acidic digestions and a microwave-plasma atomic emission spectrometer (MP-AES, Agilent) equipped with an autosampler.