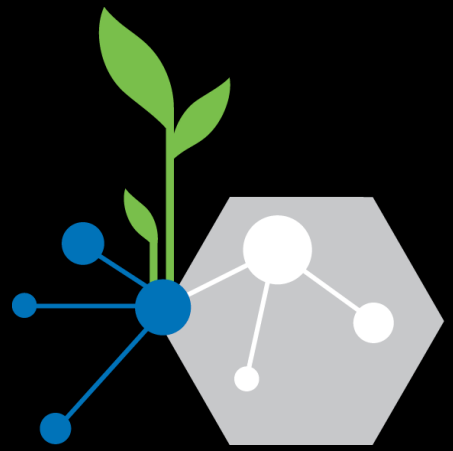


Bordeaux METABOLOME

Pierre Pétriacq (PhD, FHEA, HDR)

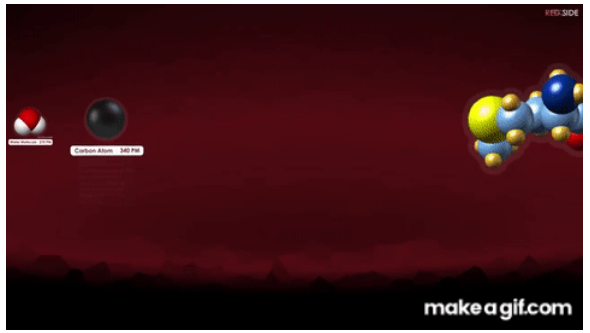
Associate Professor, UMR1332 BFP

Director *Bordeaux Metabolome*

Vice President RFMF

21 May 2025

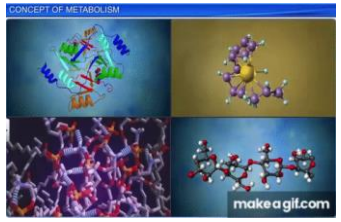
METABOLOME, THE CHEMICAL BROTHER...



Plant → Cells → Molecules

All matter is made up of molecules.
Matter composition reflects the functioning of the whole molecular, cellular machinery...

Σ Metabolites



Metabolome

= complete set of small molecules (< 1500 Da)
= byproducts of **metabolism**
= closer to the phenotype

METABOLISM ?

From ancient Greek
μεταβολή (metabolē) = "**change**“

Athena, goddess of reason, wisdom and knowledge…

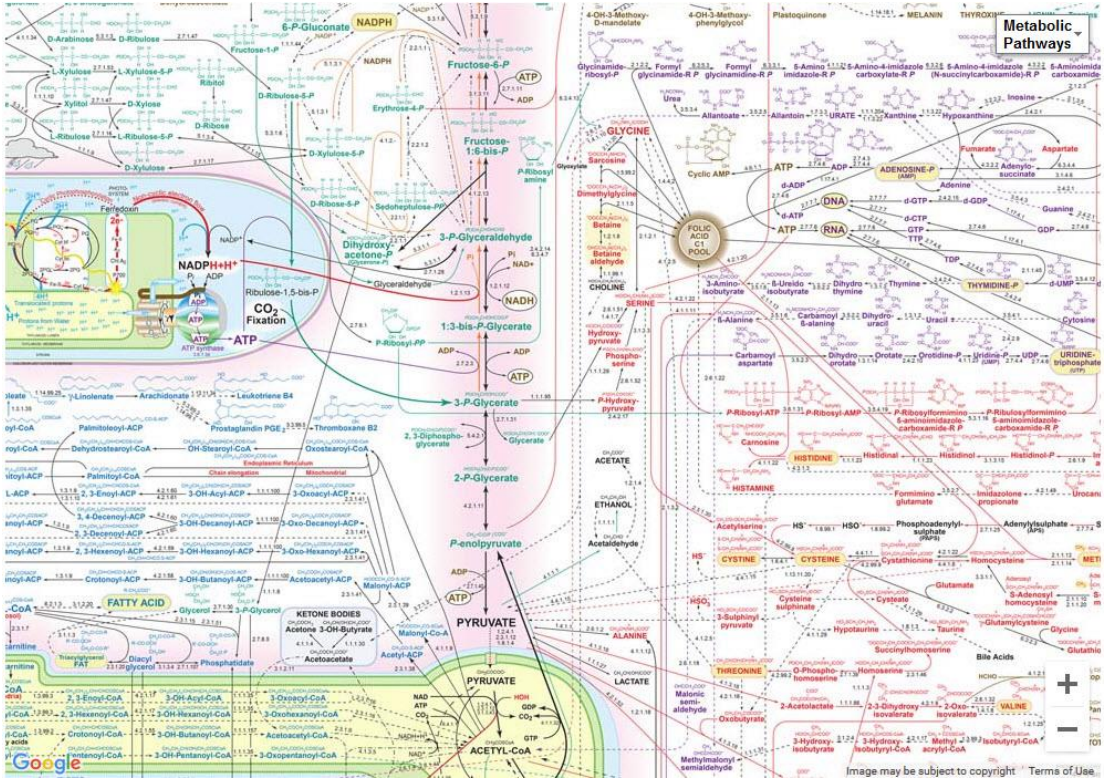
It involves interconversions of chemical compounds, *e.g. metabolites*

Metabolite precursors are transformed into end products
via many specific intermediates

METABOLISM ?

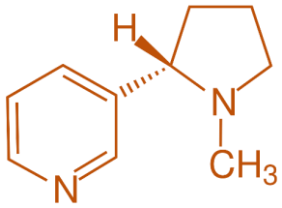
A network biochemical reactions, in living cells, well organised, integrated and regulated, and related to various metabolites and biomolecules:

- Primary (central) compounds
- Secondary (specialised) compounds in plants *(i.e.* natural products)…



PRIMARY *VS* SECONDARY METABOLITES

nicotine

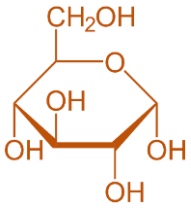


Secondary (specialised) metabolites

Terpenes
Phenolics
Alkaloids
Glucosinolates
…

Primary (central) metabolites

glucose



Carbohydrates
Organic acids
Amino acids
Lipids
Nucleotides
Nucleic acids
…

All other metabolites, typically involved in environmental interactions

Universal metabolites that originate from primary metabolism and ensuring vital processes

GENERAL ROLES OF SECONDARY METABOLITES

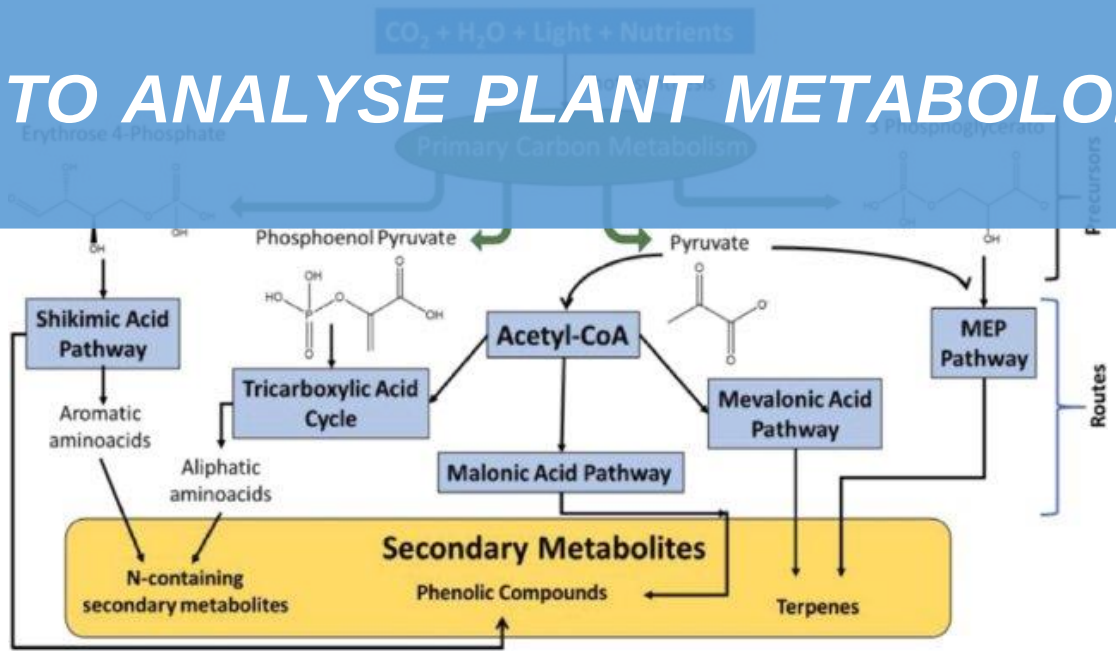
Plant defence

Plant reproduction

Abiotic factors

And sometimes… development!

HOW TO ANALYSE PLANT METABOLOMES?

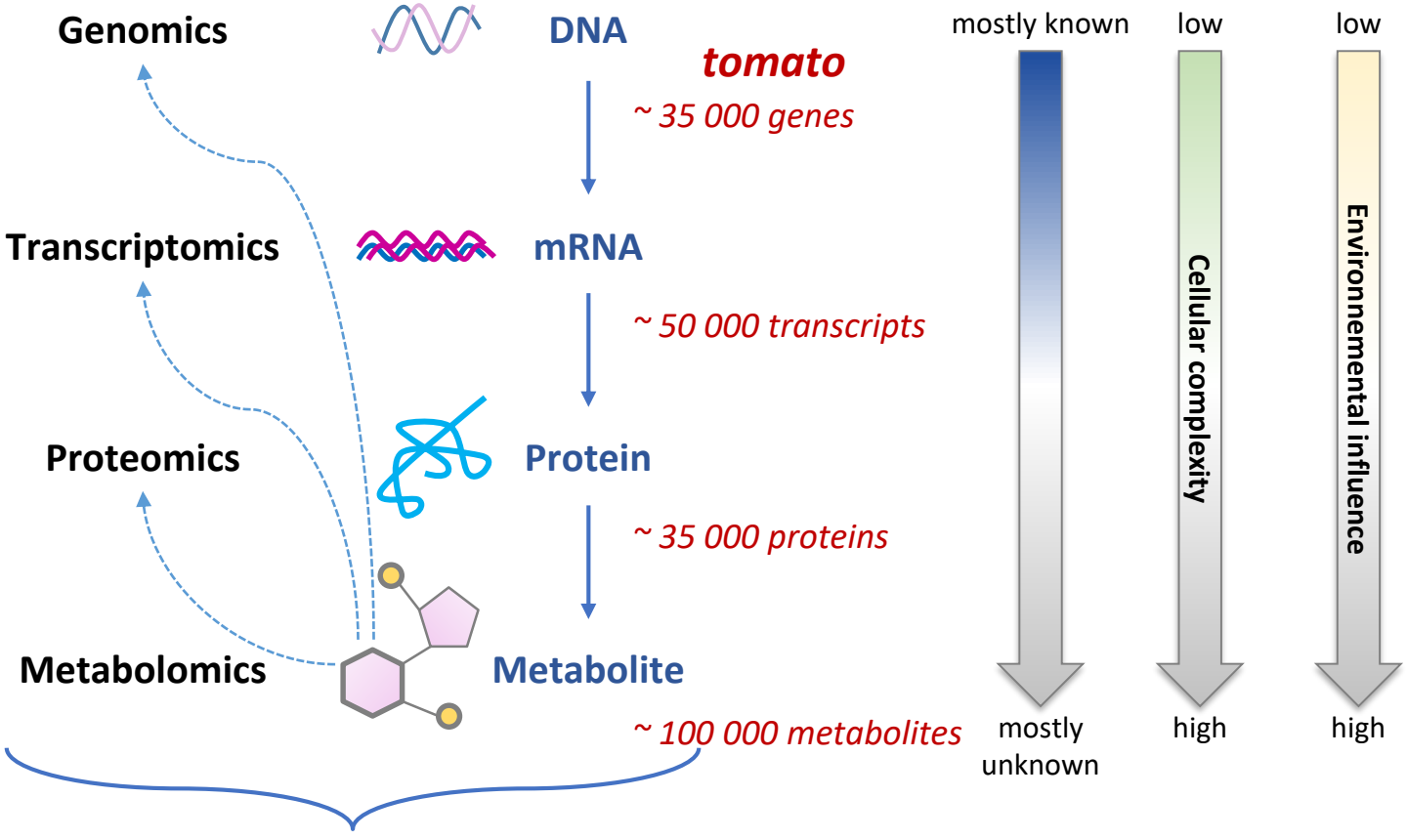


Rigobello-Masini and Masini, 2021

METABOLOMICS

Metabolomics = high-throughput analysis of metabolites, byproducts of the metabolism

Metabolomics is the **simultaneous** (“*multiparallel*”) measurement of **all cellular metabolites** (**a large number, typically several thousands**). Many of these are not identified (*e.g.* peaks in a profile, features).



Adapted from Rolin et al. (2021)

MTH-BORDEAUX: GENERAL PRESENTATION

Headed by
P. Pétriacq
& J. Valls

Open facility for metabolome studies

Supported by 4 Research Units

- ***UMR1332 BFP*** *(INRAE, UBx)*
- ***UMR5200 LBM*** *(CNRS, UBx)*
- ***UMR1366 Œnologie*** *(INRAE, UBx)*
- ***UR EABX*** *(INRAE)*

And 3 Institutes

- ***INRAE***
- ***Uni. Bordeaux***
- ***CNRS***

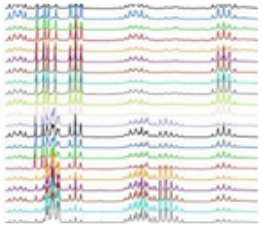
Local and national recognitions

IBiSA 2008 *(audit 2020)*
INRA 2008, 2013
ISC INRAE 2018 *(audit 2020)*
FED Uni. Bordeaux (2019, 2023)
ISO 9001:2015 *(2023)*

Part of Uni. Bordeaux Facility Core (32 facilities)
Node of MetaboHUB National Infrastructure (MetaboHUB-Bordeaux)
Member of PHENOME-EMPHASIS

Bordeaux Metabolome Facility

Bordeaux Metabolome Facility provides equipments and expertise for **the study of metabolome, lipidome and metabolic fluxes**. The facility is mostly dedicated to the study of plant or plant-derived products.



Aims

Bordeaux Metabolome Facility, supported by **three Institutes** (INRAE, CNRS and Bordeaux University), gathers equipments and expertise for the study of metabolism and make them available to the scientific community.

The Facility performs **adaptations and technological developments** and designs and implements analytical strategies and bioinformatics tools for metabolomics, metabolic phenotyping, lipidomics and fluxomics.

The Facility supports studies of **plant** functional genomics, genetics, pathology, ecophysiology and systems biology for regional, national and international research programs. It is also used for the study of **plant-derived products** and for **pharmacological approaches**.

https://metabolome.u-bordeaux.fr/
http://www.metabohub.fr/

METABOHUB 2.0 MetEx+

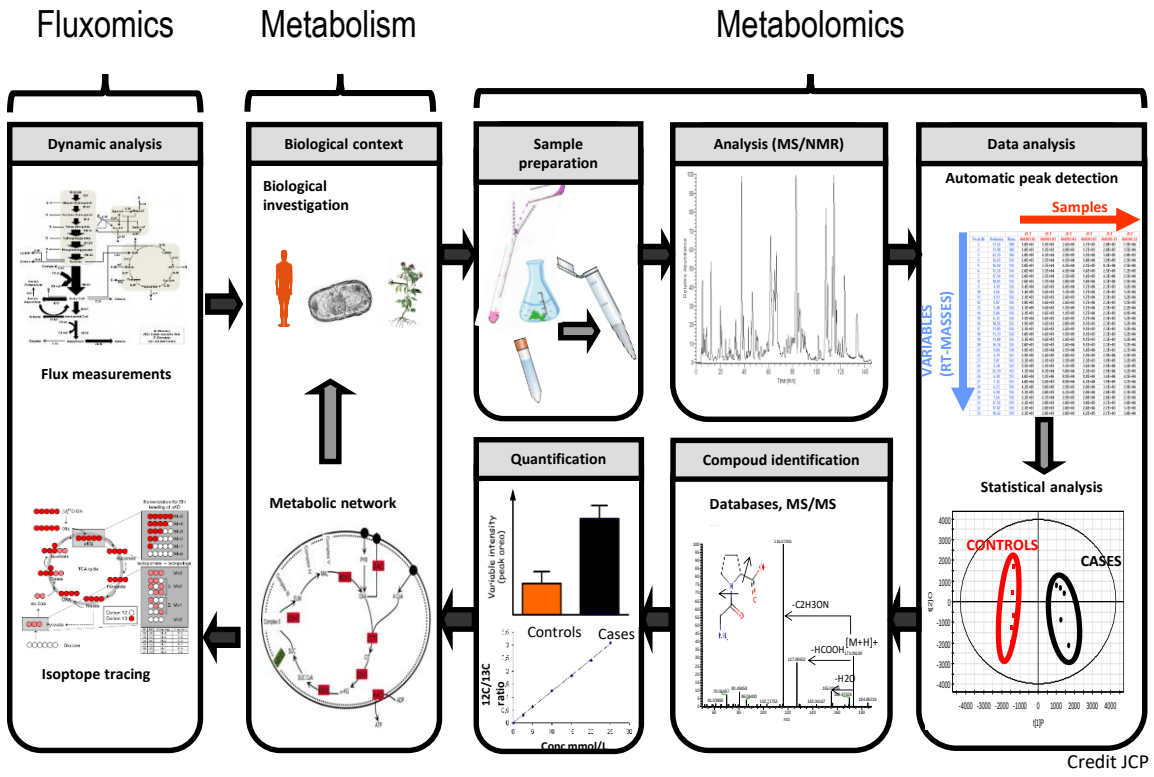
METABOHUB

Bordeaux METABOLOME

Distributed & coordinated infrastructure for metabolomics & fluxomics Devoted to **innovation, training and technology transfer**

ANR-11-INBS-0010

Dir: Fabien Jourdan,
Floriant Bellvert,
François Fenaille



Challenges:

- **Coverage of the metabolome**: need for complementary analytical approaches
- **Quantification**: measurement requiring the use of labelled standards
- **Sensitivity**: R&D development to reduce the need for sample volumes
- **Scalability**: moving from cellular to organism level fluxes
- **Interoperability**: data and methods to apply large-scale studies over time

MetaboHUB objective: To develop generic methods for the production and analysis of metabolomics & fluxomics data to answer research questions on the metabolism of organisms: from cell to population.

Cross-sectional approach

Plant sciences - Biotech. – Nutrition - Personalized medicine

MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR, DE LA RECHERCHE ET DE L'INNOVATION
FRANCE 2030

MTH-BORDEAUX: GENERAL PRESENTATION

Equipment

- 1 NMR
- 10 MS
- 4 Robots
- 2 Microfluidics systems

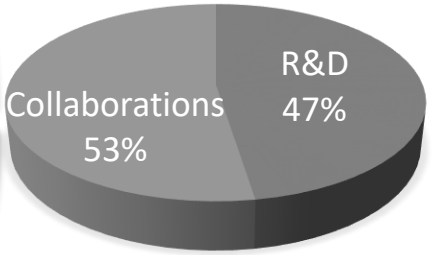


Training and diffusion

- **~ 25-40 publications/year**
- 1 patent (2018)
- > 80 users
- > 50 people trained to facility techniques: (under)grads, PhDs, Postdocs, visiting scientists…) and B2AS Master

https://metabolome.u-bordeaux.fr/

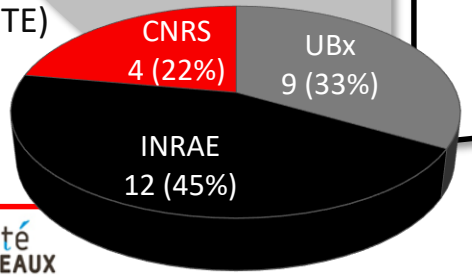
Functioning budget
~ 300 k€
55 % institute funds
45 % contracts
& servicing



Transfer units

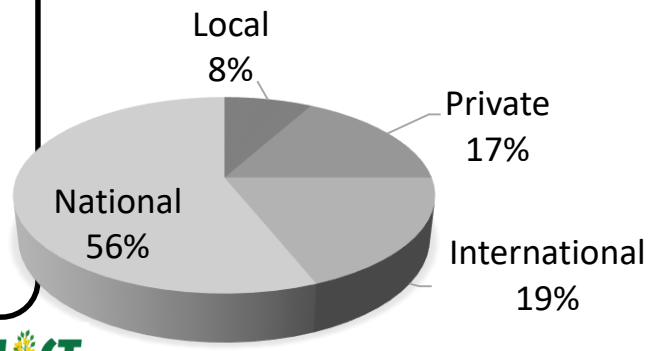
Human resources (2024)

- 4 activities/ 4 sites
- 29 permanent staff (~ 10 FTE)
- 2 CDD MTH
- 7 PhDs



Projects

- ~ 70-100 projects /year
- ~ 200 000 samples /year
- 5 EU, 17 ANR projects…



MTH-BORDEAUX: ANALYTICAL DOMAINS

METABOLOMICS (MET) *P. Pétriacq (BFP, EABX)*

untargeted
targeted

Response & predictive biomarkers of plant performance (growth & stress)
Breeding, Screening of genetic resources (**modelling**, **functional genomics)**
Microbial Ecosystems responses to global changes (e.g. periphyton)

BIOCHEMICAL PHENOTYPING (HITME) *Y. Gibon (BFP)*

biomass
quantitative

Metabolic modelling (metabolites & enzymes)
Plant systems biology
Microfluidics (R&D)

PHENOLICS ANALYSES (POL) *J. Valls & T. Richard (Oeno)*

targeted
quantitative

Composition & effect characterisation of **processed products** (wine, vine…)
Wine/Food **authenticity**

LIPIDOMICS (LIP) *L. Fouillen (LBM, EABX)*

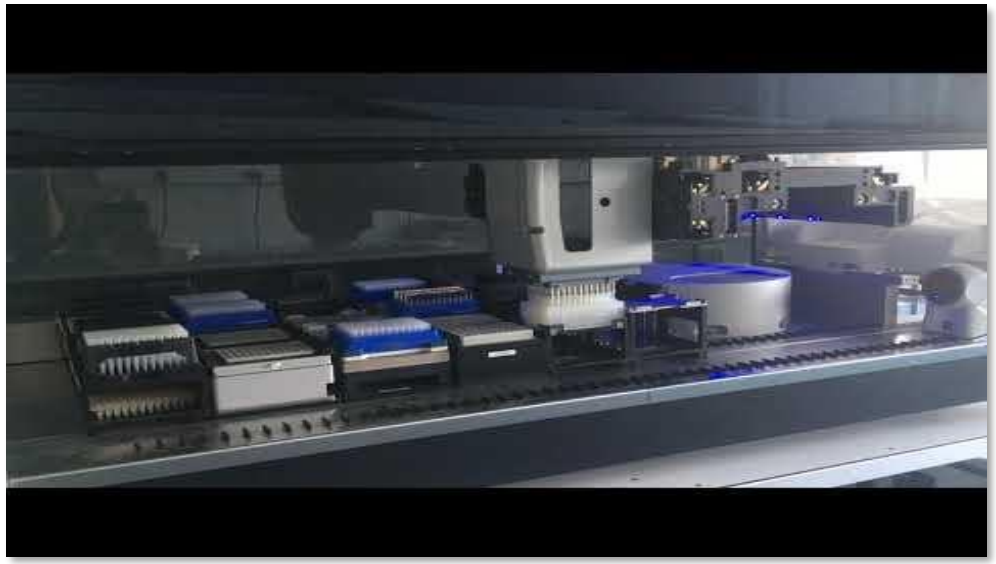
targeted

Lipid metabolism, signalling & storage

Mostly for plant sciences & plant-derived products

Large omic datasets are analysed by AI

MTH-BORDEAUX: ROBOTISED PLATFORM



For **high-throughput extraction**
before **LC-MS**
or NMR metabolomic profiling

For **targeted determination of major compounds** & metabolic markers
of **oxidative metabolism**

For measurement of **enzyme activities**
of **central** & **redox metabolisms**

Microfluidics too !

MTH-BORDEAUX: EQUIPMENT

GCMS

PYROLYSIS

IBISA + DISC

2022

MICROFLUIDICS

WHITE ROOM, 3D PRINTER

PHOTOLITHOGRAPHY

EQUIPEX+

2023

M. Maucourt C. Marais

TRIBRID

uHRMS

EQUIPEX+

2024

QTOF MS

IMAGING,

ION MOBILITY

CPER UBx

2024

GCMS

LIPIDOMICS

FED, DISC

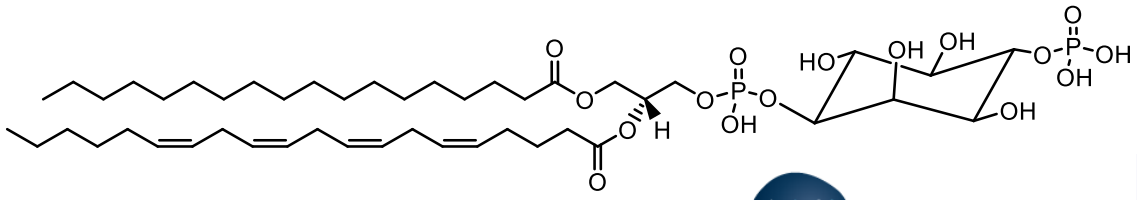
2024

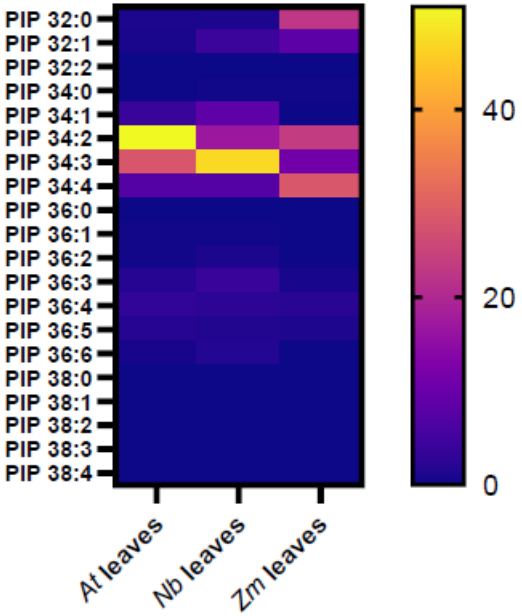
Increase analytical capacities:
throughput, metabolome coverage, annotation, imaging…

MTH-BORDEAUX: HIGHLIGHTS

- **First method for simultaneous profiling of anionic phospholipids (PA, PS, PI, PIP and PIP2) in plants**

Laboratoire de
BIOGENÈSE MEMBRANAIRE

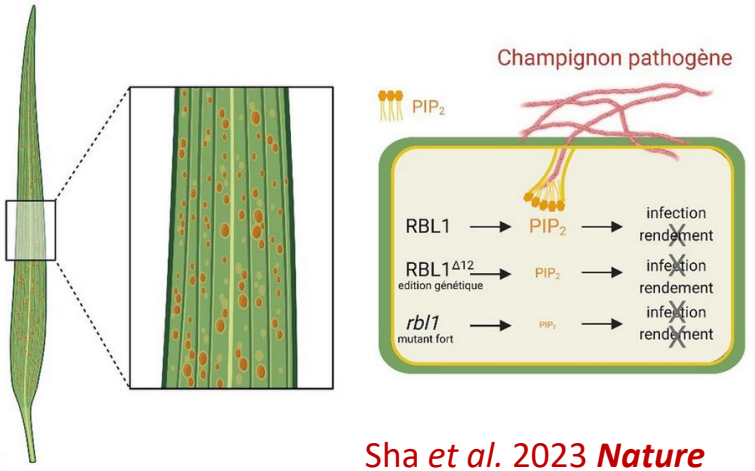




Genva *et al.* 2023 ***Plant J***

Accueil › Actualités

Sécurité alimentaire : l'édition du génome permet d'obtenir du riz résistant à de multiple pathogènes

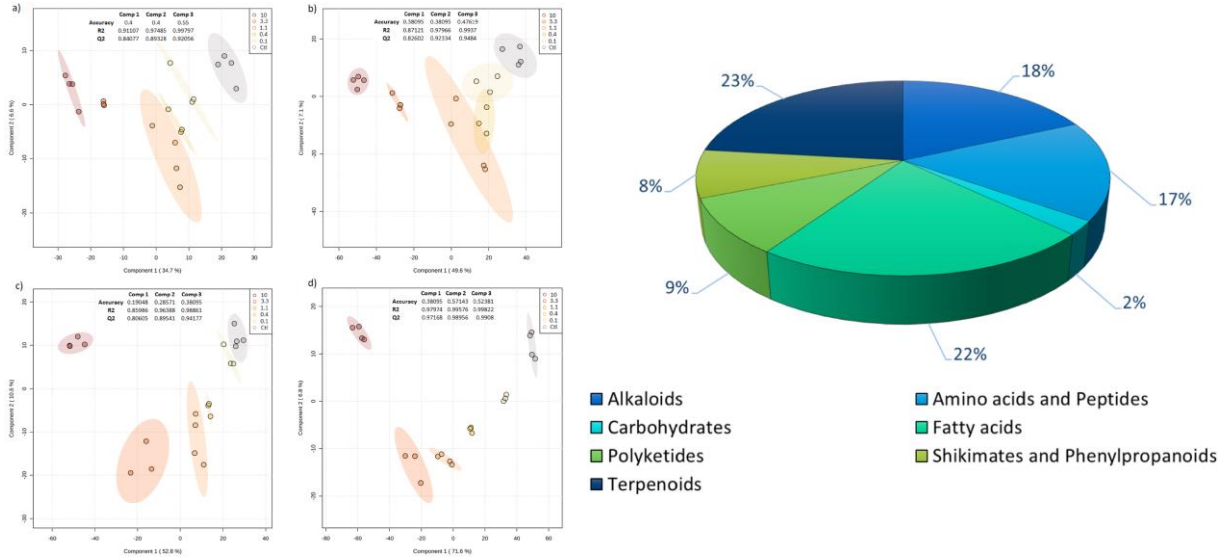


Sha *et al.* 2023 ***Nature***

MTH-BORDEAUX: HIGHLIGHTS

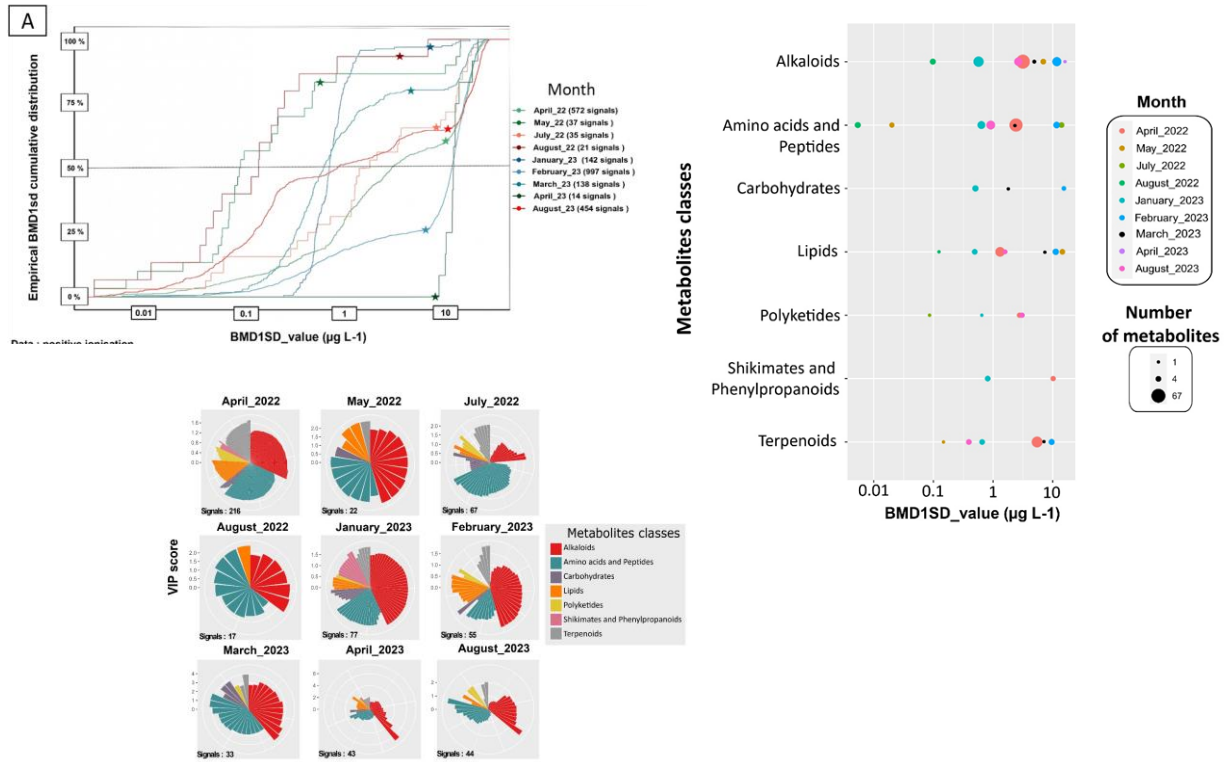
○ Metabolomics approaches towards aquatic chemical ecology & ecotoxicology

Metabolomic uncovering of allelopathic interaction between invasive macrophytes and cyanobacteria blooms in freshwater ecosystems



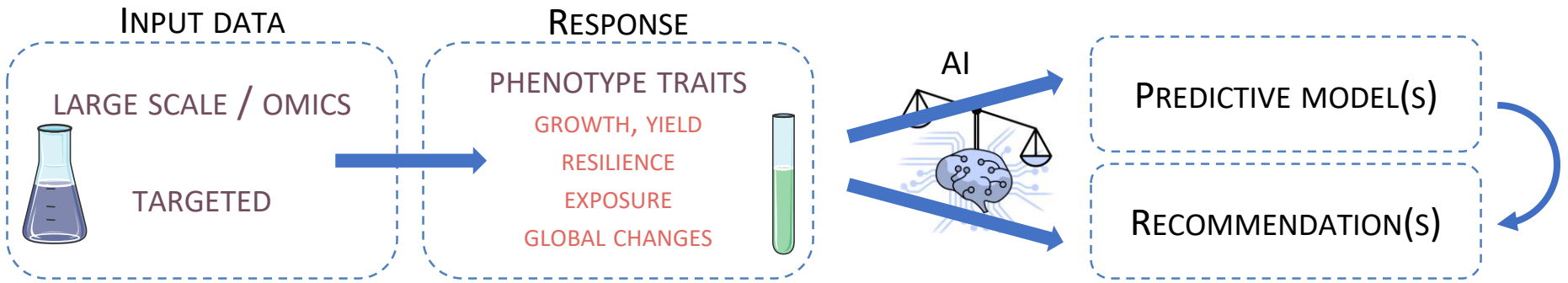
Tison-Rosebery *et al.* 2023 ***Comptes Rendus Ac Sci***

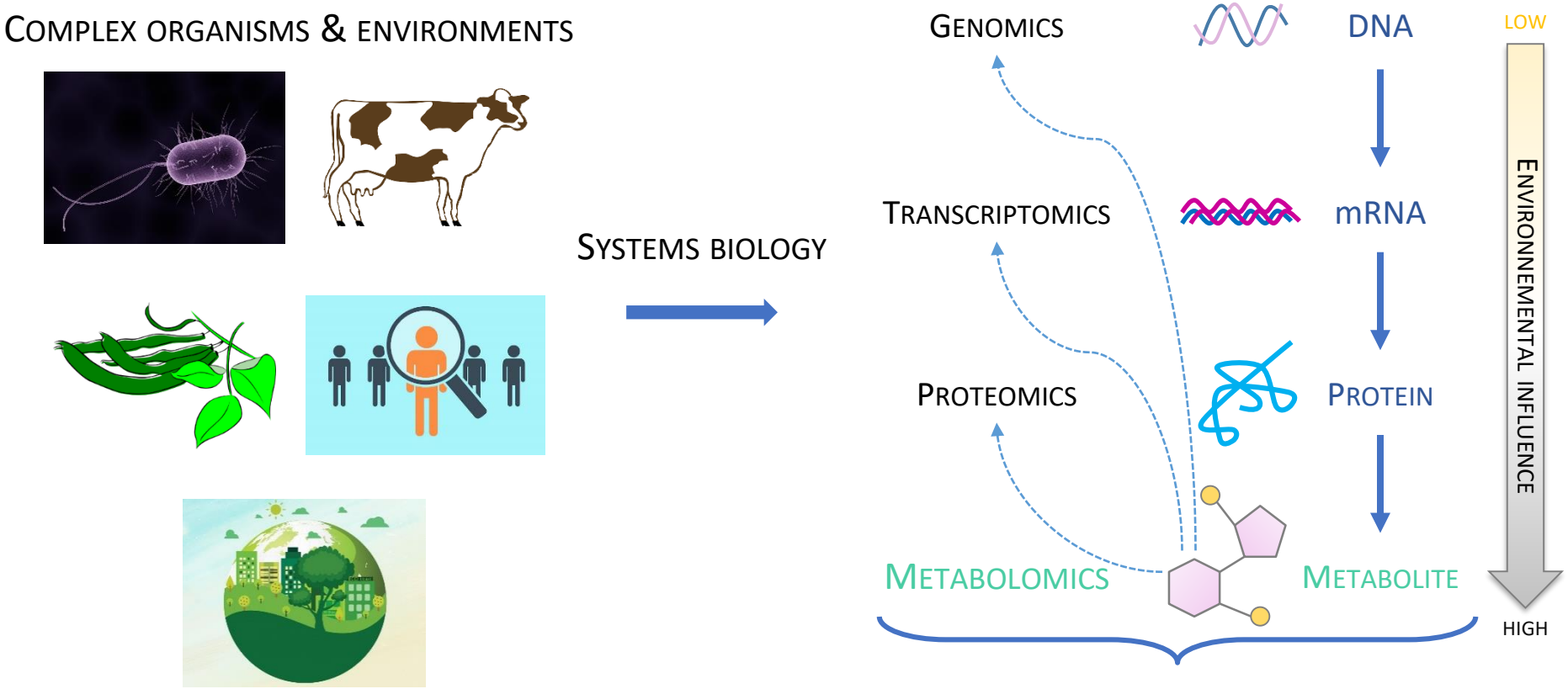
Sensitivity shift of the meta-metabolome and photosynthesis to the chemical stress in periphyton between months along one year and a half period



Medina *et al.* 2024 ***Sciences of the Total Environement***

PREDICTIVE BIOLOGY

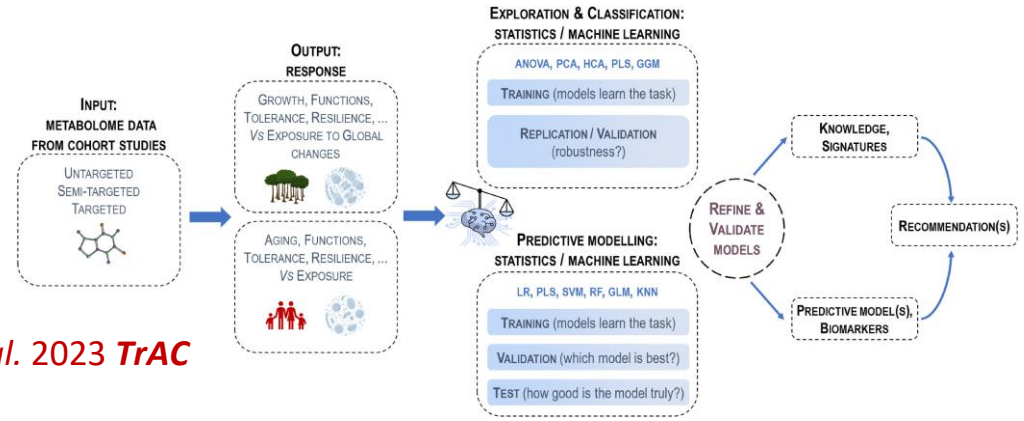




MTH-BORDEAUX: HIGHLIGHTS

- **Metabolome modelling to decipher plant performance**
- Machine learning of metabolome data to predict phenotype traits

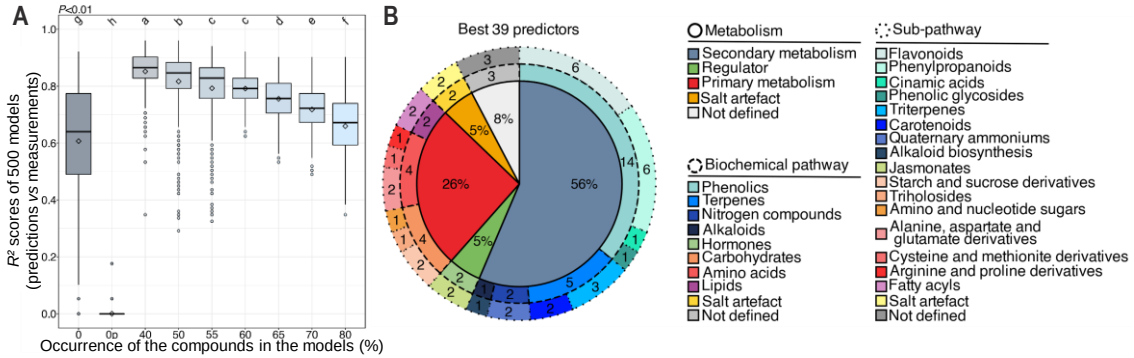
Plant cohort metabolomic studies



Hajjar*et al.* 2023 ***TrAC***

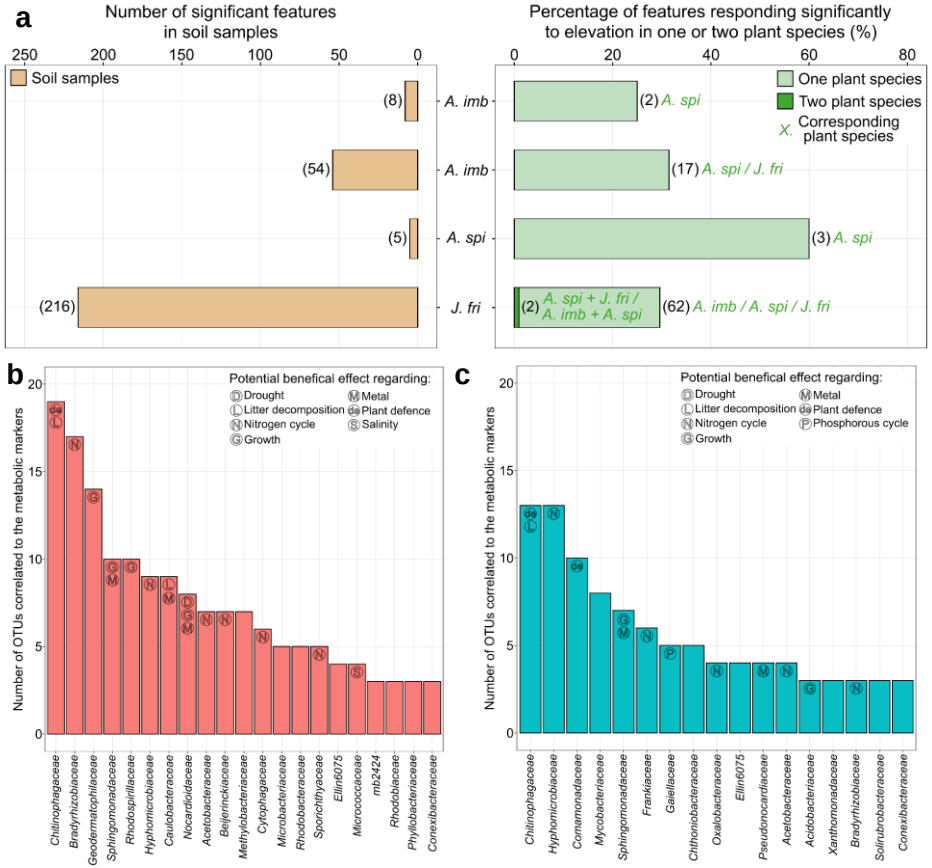
Phytochemical diversity *vs* extreme habitats

of 24 extremophiles (+ 11 crops)



Dussarrat *et al.* 2022 ***New Phytol***

Rhizochemistry and soil bacterial community

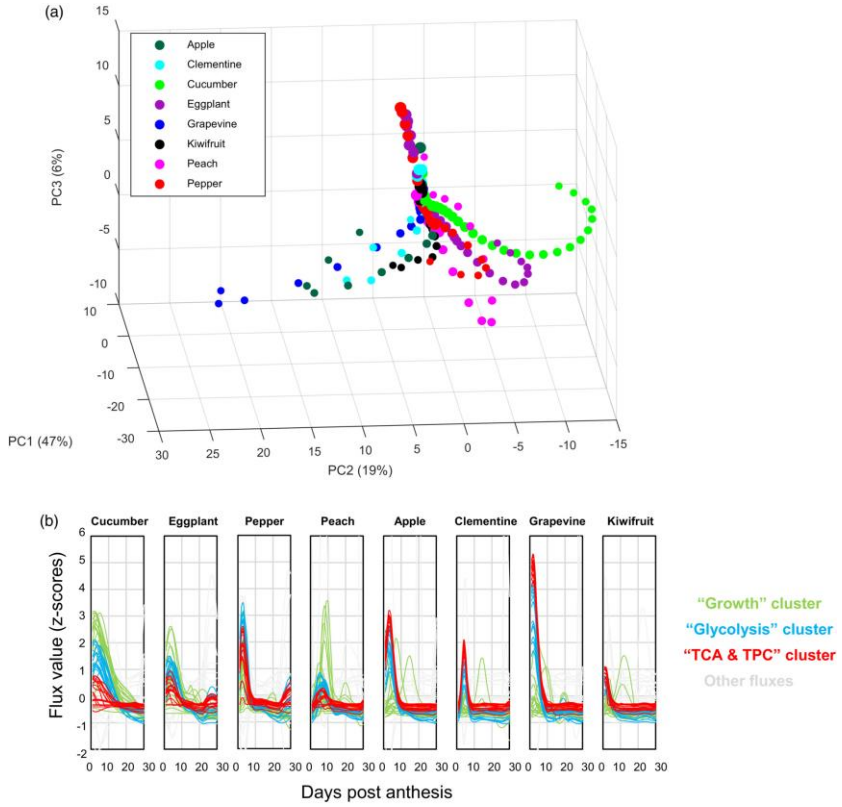


Dussarrat *et al.* 2025 ***Soil Biol Biochem***

MTH-BORDEAUX: HIGHLIGHTS

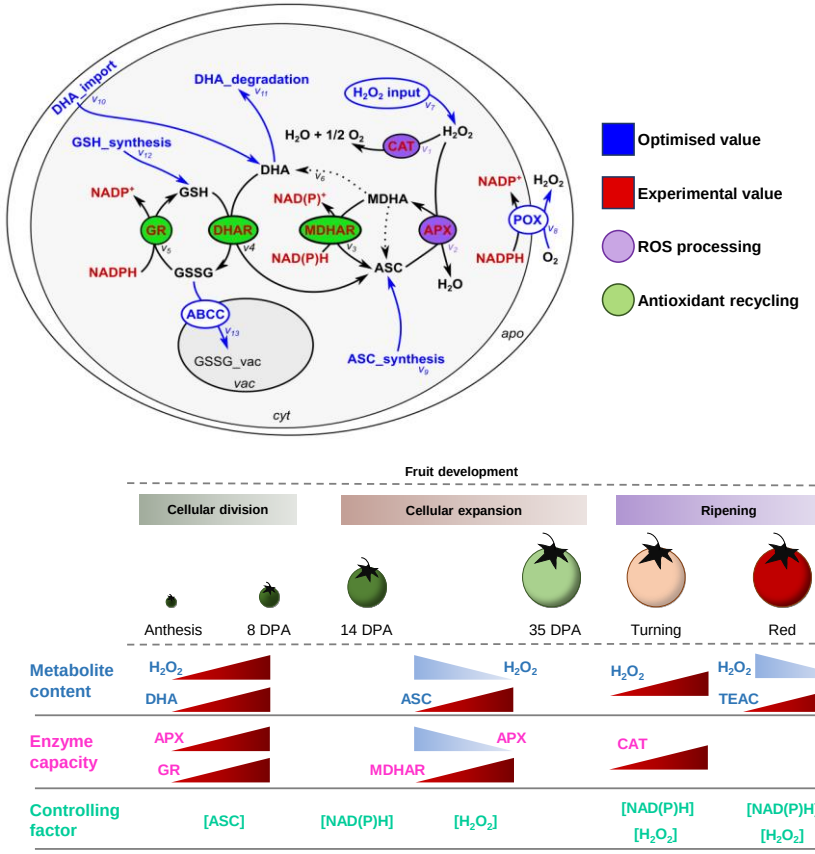
- **Metabolome modelling to decipher plant performance**
- Metabolic modelling for flux calculation

Comparative constraint-based modelling of fruit development



Colombié *et al.* 2023 ***Plant J***

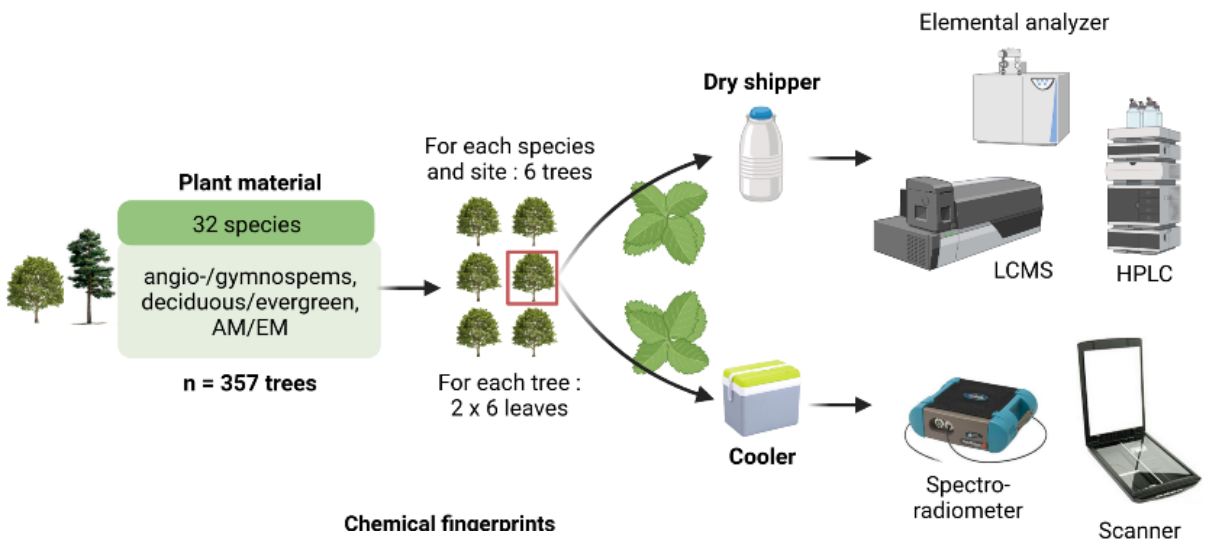
Kinetic model of redox fluxes in the growing tomato fruit



Decros et al. 2023 ***New Phytol***

MTH-BORDEAUX: HIGHLIGHTS

- **Metabolome modelling to decipher plant performance**
- Protocol developed to investigate the relationship between plant metabolomes and mycorrhizal symbiosis



Chemical composition

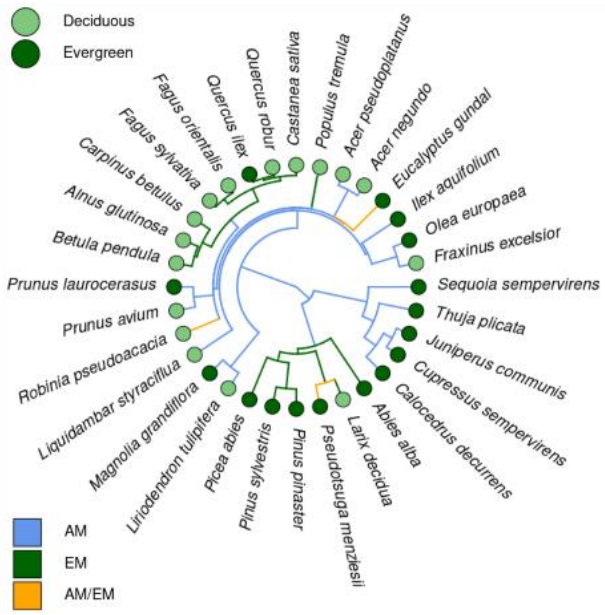
Targeted
Elemental content, Primary metabolites, Phenolic composition

Untargeted
Metabolomics

Spectral properties

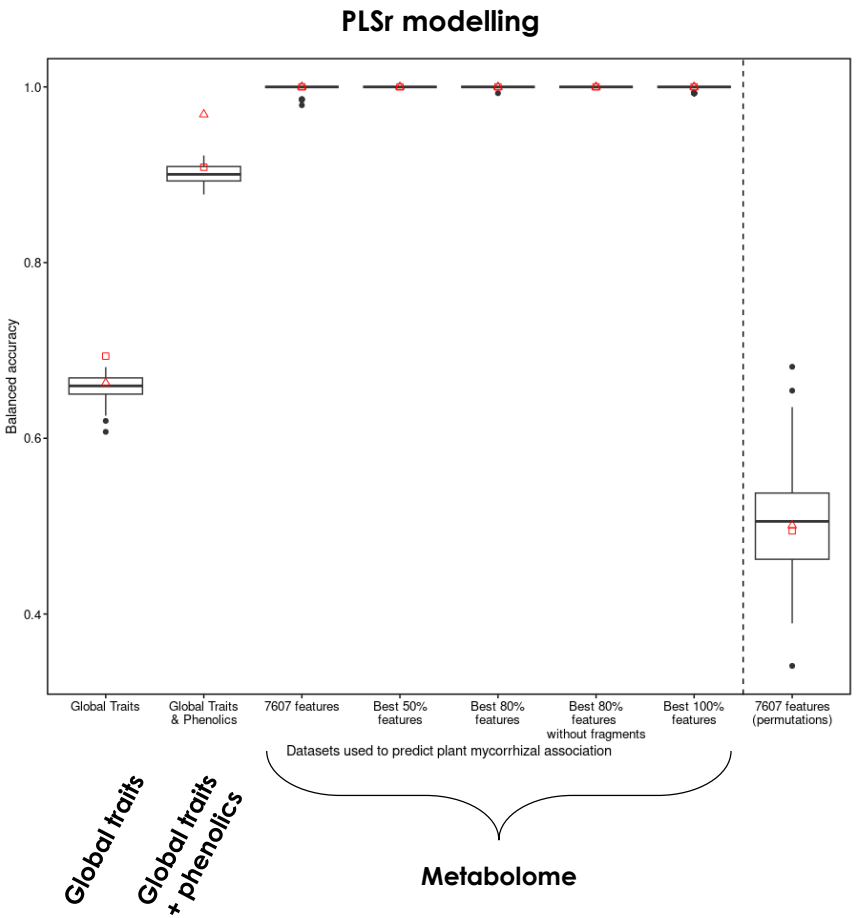
Reflectance
Spectro-radiometer (400-2400 nm)

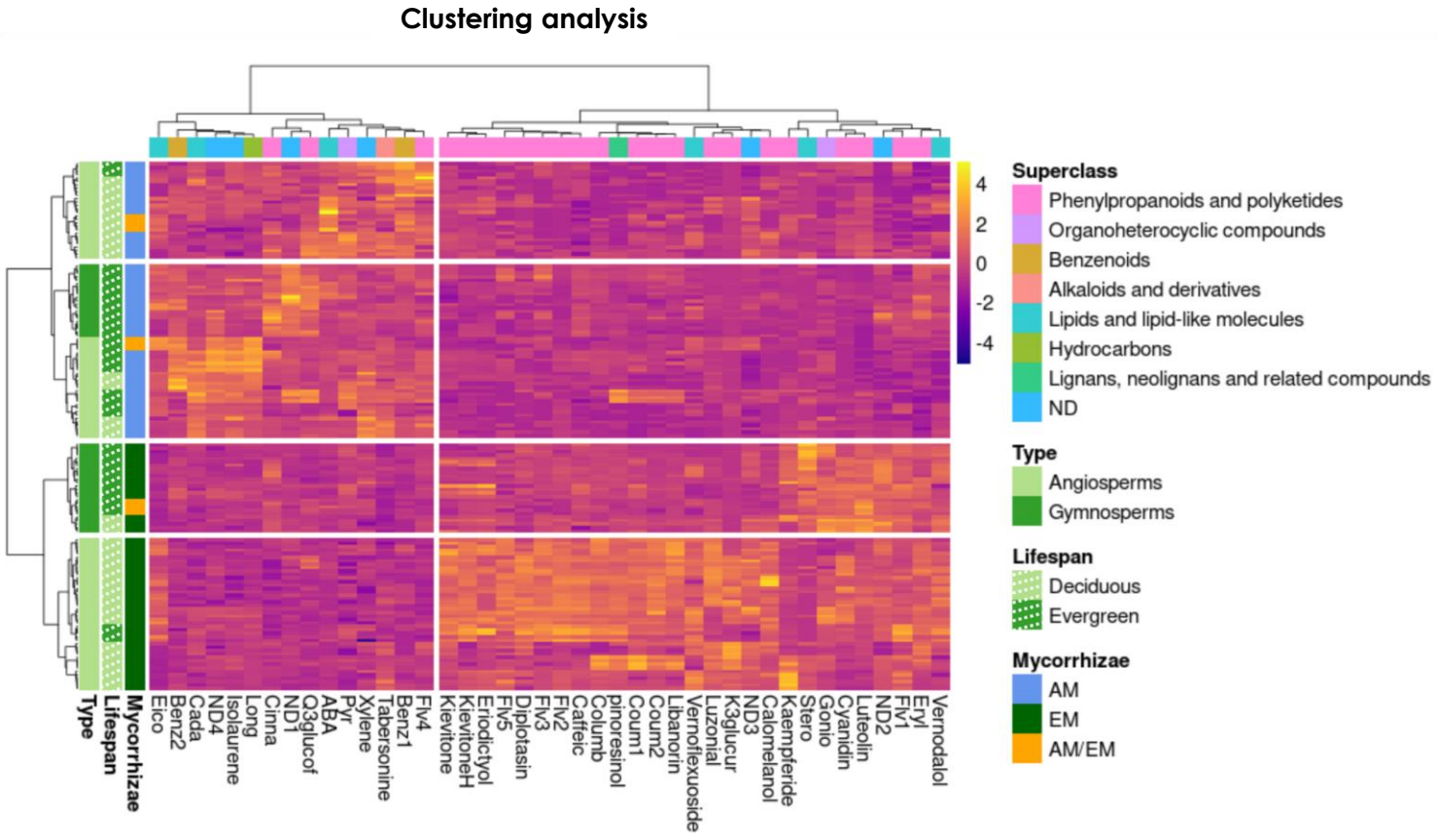
Leaf colour
RGB chromatic coordinate



MTH-BORDEAUX: HIGHLIGHTS

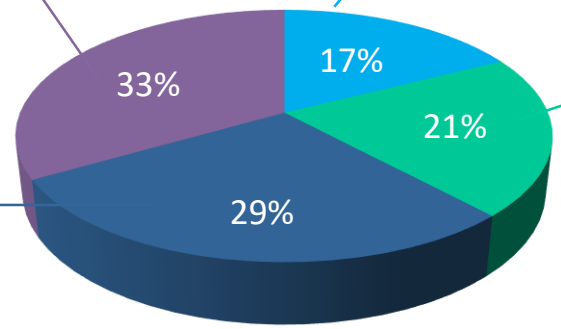
- **Metabolome modelling to decipher plant performance**
- Leaf metabolome is highly predictive of plant traits including mycorrhizal partnerships

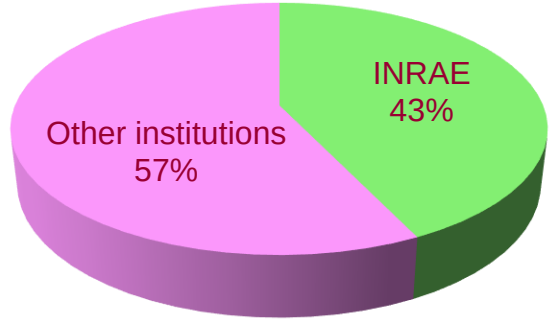




CONCLUSIONS

- *Bordeaux Metabolome* supports numerous academic and private projects
- These projects operate at different levels (~ 43% including INRAE)
- Successful combination of MetaboHUB-PHENOME for a unique & useful tool devoted to predictive metabolomics

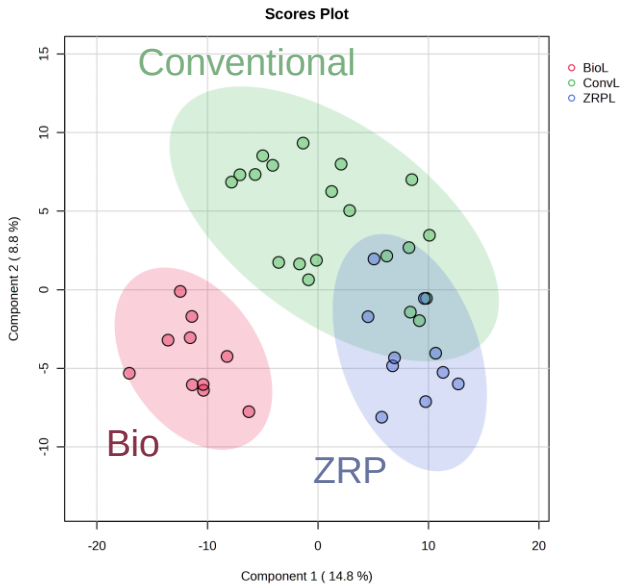


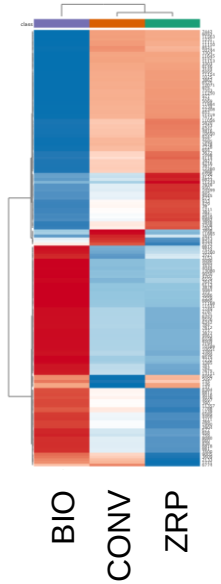


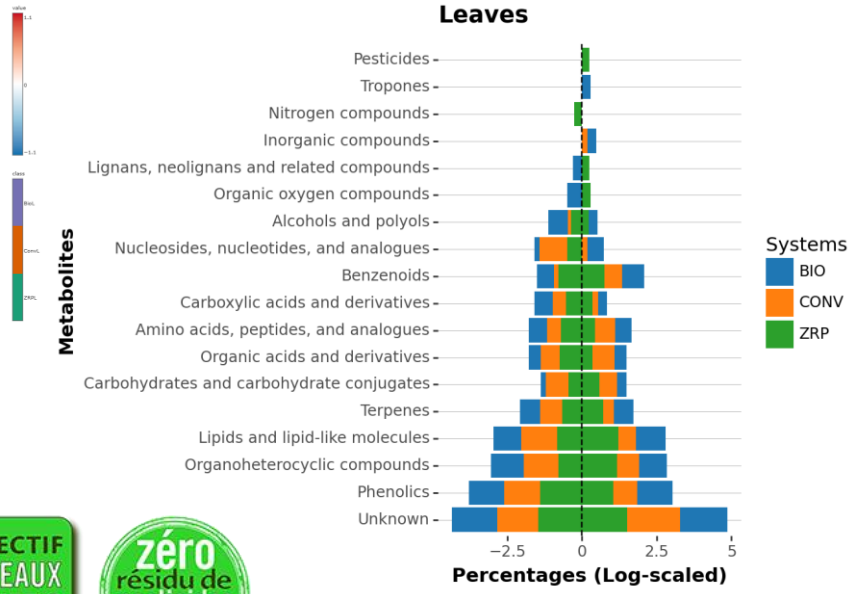
PERSPECTIVES

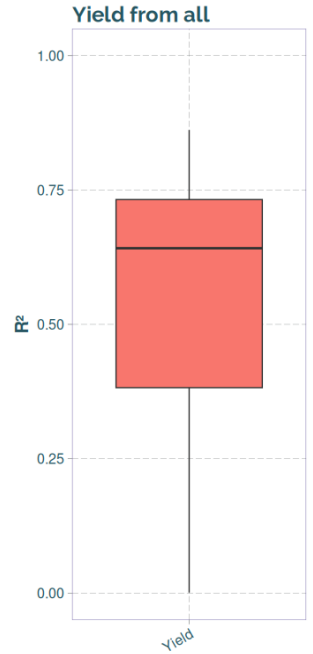
- **Build-up MetaboHUB3.0 towards EU recognition**
  - Pursue method developments for Cohort studies, Microfluidics/imaging, Fluxomics and Metabolome annotation
  - Integrate novel sampling devices for high-throughput metabolic profiling in phenotyping facilities (EU-Met)

- **Deploy predictive metabolomics to predict ecosystem services in complex agroecosystems**
  - **Multiscale**: integrate heterogeneous data to enhance modelling capacities (GLOMICAVE, MetaboHUB…)
  - **Multispecies**: profile biodiversity to uncover generic mechanisms underlying agroecosystem functioning
  - **Multicompartments**: combine plant, soil and water to study complex genotype-phenotype relationships









GIP-TRIAD M2 student 2025 (A. Mallouki)

MTH-BORDEAUX

BFP juniors

RFMF days
in Saint Malo (2024)

This year in Paris
10-13 June 2025