

DECODING THE HIDDEN SECRETS OF PLANT MICROBIOMES

Víctor J. Carrión Bravo

MY ROOTS



Málaga



2002-2007 BSc: Molecular Biology

2008-2010 MSc: Molecular and Celular Biology

2008-2012 PhD: Mangotoxin production in the plant pathogen *Pseudomonas syringae*



Universidad Pública de Navarra
Nafarroako Unibertsitate Publikoa



Phytopathology department

FAR AWAY FROM MY ROOTS



WAGENINGEN UR
For quality of life

Phytopathology department



Oct 2012-2013 Postdoc:

- Comparative genomics in *Pseudomonas syringae* and mutagenesis
- Mining the plant microbiome for novel traits and bioactive compounds (BE-Basic)



Microbial ecology department

2013-2018 Postdoc

Mining the plant microbiome for novel traits and bioactive compounds

Genome mining of the endophytic plant microbiome
Selection of beneficial *Burkholderia* spp.



Back to the Roots
Effect of plant domestication in the microbiome assembly



Universiteit Leiden

Assistant Professor
2018-



Guest researcher 2018-

BACK TO MY ROOTS



Universiteit Leiden

Assistant Professor
2018 - present



Guest researcher 2018 -
present



UNIVERSIDAD
DE MÁLAGA



CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Ramon y Cajal Fellow 2022 - present

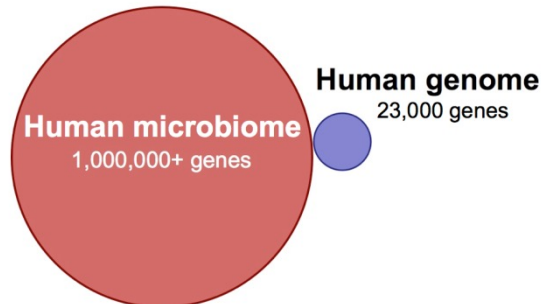
Microbiology & Crop Protection Dept.



WHAT IS A MICROBIOME?

‘the totality of microbes, their genomes and their interactions in a particular environment’

‘... the second genome of eukaryotes’



MODIFICANDO EL MICROBIOMA



PUEDEN TRANSPLANTARSE LOS MICROBIOMAS?

Hé, mijn oksel ruikt opeens zuur

De oksel Okselbacteriën van een familielid kunnen je van zweetgeur afhelpen. Dat zegt bio-ingenieur Chris Callewaert, **die Doctor Armpit wordt genoemd**.

INNE HESELMANS

Hij is geen dokter die ziekten geneest. Maar toch, als één persoon de titel *Doctor Armpit* verdient, is het wel de Gentse bio-ingenieur Chris Callewaert. Dokter Oksel. Igen zeggen begon het allemaal in wel heel vreemde ervaring. Op 1999 in 2009 werd hij wakker met ur die hij niet van zichzelf kende. urige, stinkende lucht", vertelt hij faculteit. „Terwijl ik nooit last van eur had!“ rijk om te melden is dat hij wakker een vreemd bed, van een meisje ij nooit eerder bij had geslapen. Nu j toen ook al wel dat een oksel vele en kan bevatten, aangepast aan i kieren. Maar verder had hij geen arom hij ineens die hinderlijke id. els weet Chris Callewaert (1986) de Corynebacteriën waren die die de Staphylococci wisten te overren, mogelijk met hulp van de

schillende proefpersonen hadden dezelfde ervaringen als Callewaert: ineens waren ze slechter gaan ruiken. Nadat ze in een vuil bed hadden geslapen, stress hadden ondergaan, of de pil of antibiotica waren gaan gebruiken. In één onderzoek liepen 185 deelnemers drie uur met een aan de oksel huid gekleefd katoenen propje. Een getraind panel van vier mannen en vier vrouwen beoordeelde de geur ervan op intensiteit en (on)aantrekkelijkheid (schaal -8 tot 8). Waarna Callewaert het genetisch materiaal in kaart bracht en bacteriën op kweek zetten om de groepen en soorten te karakteriseren. „Op een gegeven moment begonnen collega's me Mister Armpit te noemen", vertelt hij. DrArmpit.com is nu de naam van zijn site. Die bevat behalve toegankelijk geschreven onderzoeksverslagen ook een forum met ervaringen. Zoals van een jongen van zeventien die zich tevergeefs drie keer per dag wast. En van een vrouw die sinds een operatie aan haar linkerarm, worstelt met de geur van alleen die arm. „Ik kreeg steeds meer mensen die

Het aantal bacteriën in de oksel loopt in de honderden miljoenen - per vierkante centimeter

Staphylococci. Staphylococci weten namelijk in katoen te overleven; Corynebacteriën niet. Vanuit mijn vershirt hebben ze dus hun positie weer terug weten te veroveren.“ **Het is oorlog onder de oksels?** „Het is zeker oorlog. Staphylococci produceren voortdurend antimicrobiële eiwitten en andere componenten om de Corynebacteriën weg te concurreren en het zichzelf en hun vriendjes gemakkelijk te maken.“ Het aantal okselbacteriën loopt in de honderden miljoenen - per vierkante centimeter. Callewaert heeft zelf zo'n honderd verschillende soorten onder zijn oksels. Daarmee is dit ecosysteem diverser dan bijvoorbeeld zijn droge bovenarm, met maar een paar soorten. Maar minder divers dan zijn hand: die kan wel 200 soorten bevatten. De bio-ingenieur gebruikt geen antitranspirant, anders had hij wellicht een nog rijk ecosysteem gehad. Uit het een maand volgen van negen proefpersonen die afwisselend wel of geen oksel



KEY QUESTIONS IN MICROBIOME RESEARCH

Who?

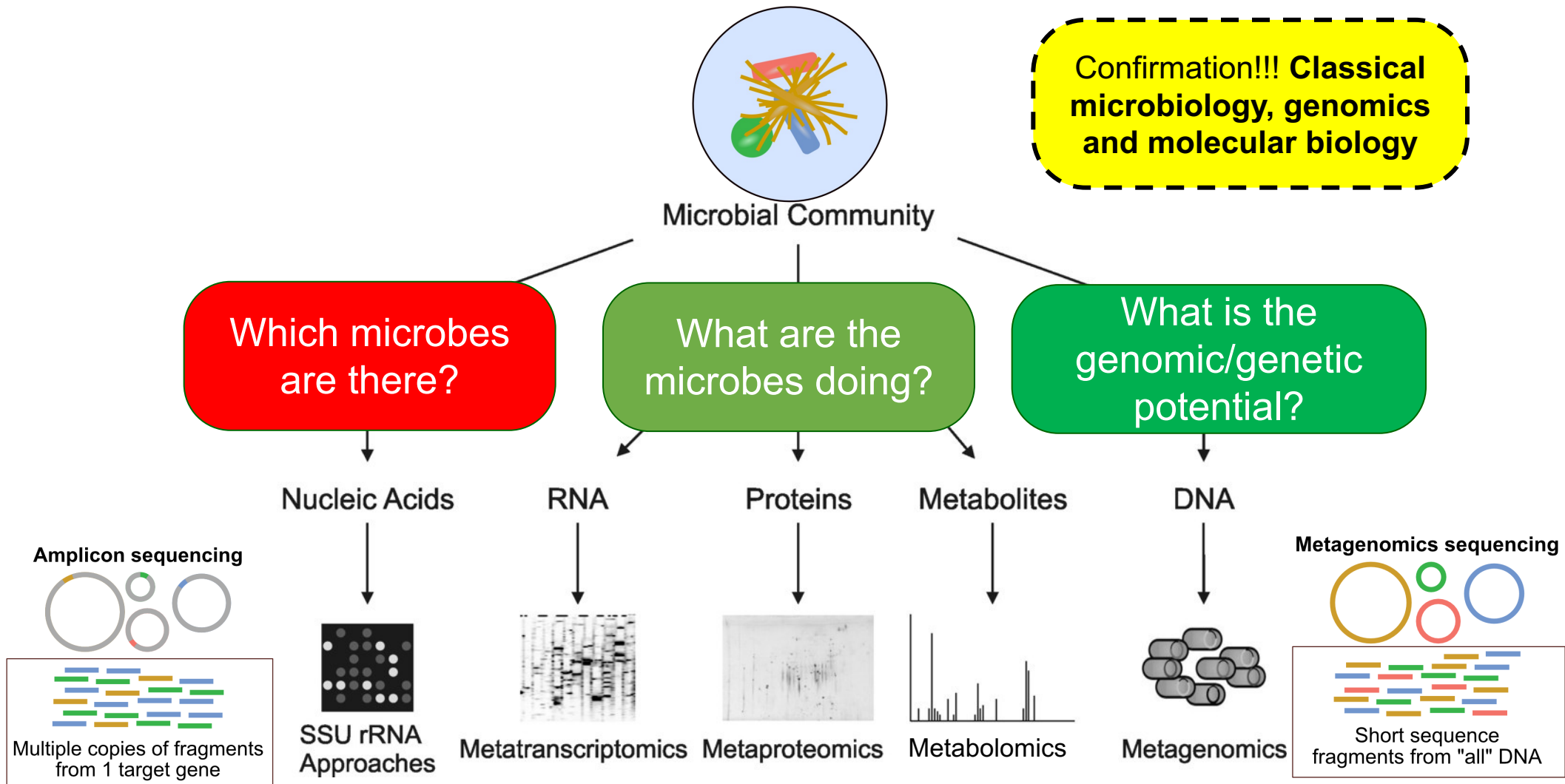
What?

How?

- to what extent do microbiomes influence (eco)system functions?
- what factors, mechanisms drive microbiome assembly & activity?
- are there general patterns in microbiome dynamics & functioning?

→ **systems approach** to study & engineer microbiomes

THE TOOLBOX ...

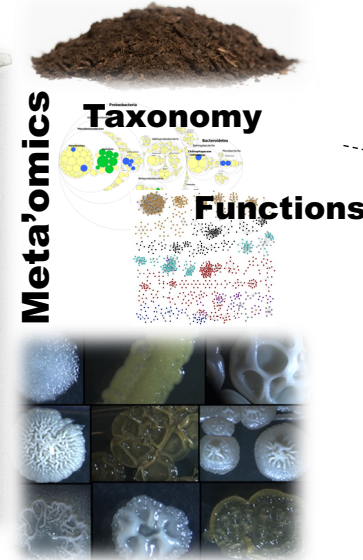
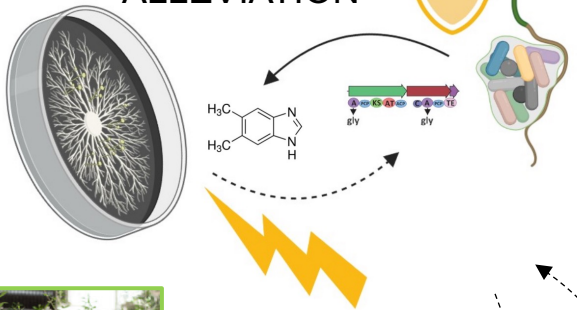


FUNCTIONAL UNDERSTANDING OF PLANT MICROBIOMES

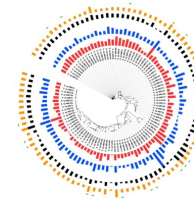


OUR MICROBIAL SOURCES

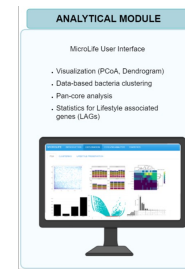
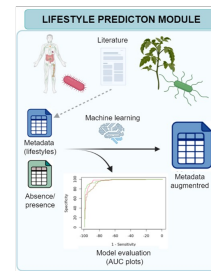
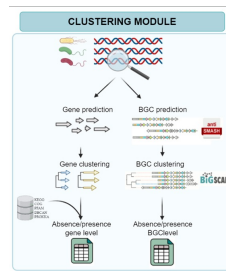
BIOTIC STRESS ALLEVIATION



ABIOTIC STRESS ALLEVIATION



BIOINFORMATICS, COMPARATIVE GENOMICS & LIFESTYLE PREDICTION



Postdocs

PhDs

MScs

BScs



MICROBIOME-MEDIATED PLANT PROTECTION

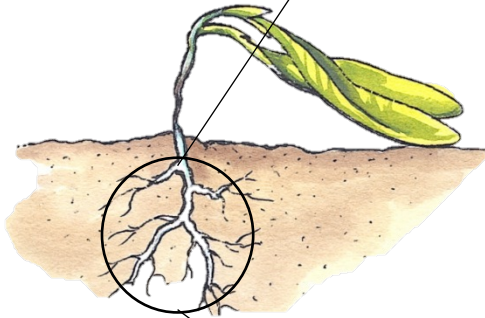
- Disease suppressive soils
- Soils in which plants do not get diseased or only little
- Found worldwide
- Described for pathogenic fungi, bacteria, nematodes, ...
- Eliminated by heat treatment; transplanted to conducive soils



DISEASE SUPPRESSIVE MICROBIOME | *STUDY SYSTEM*



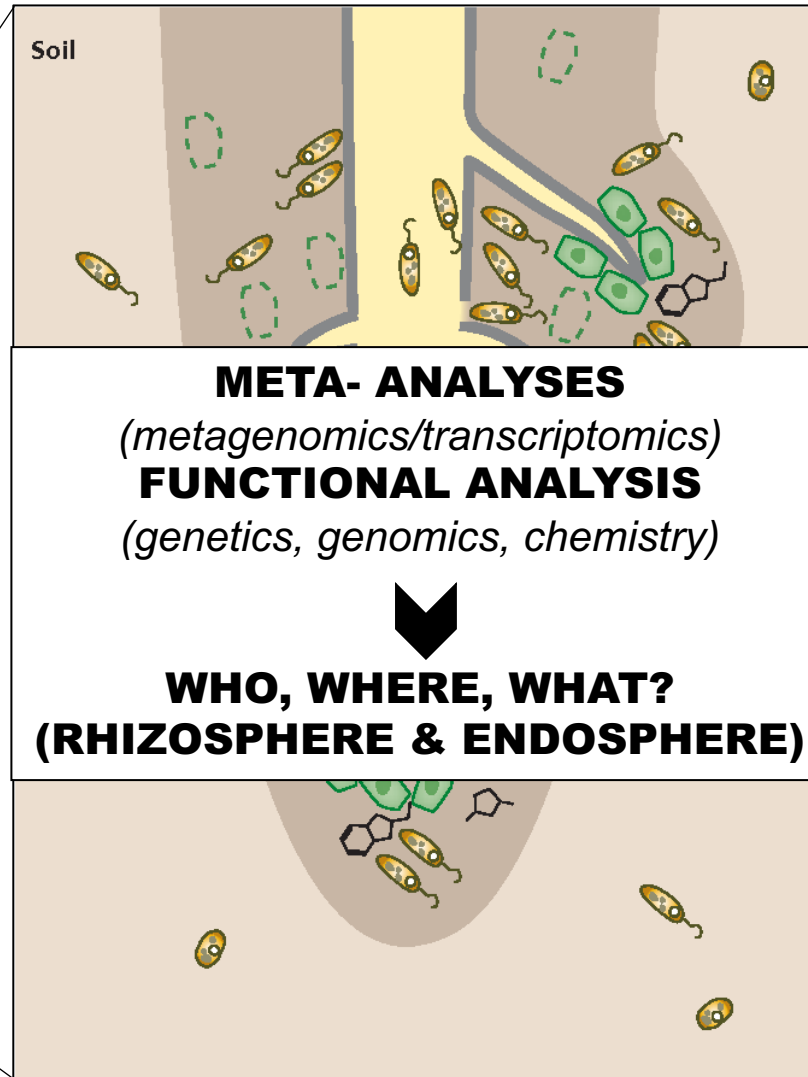
Sugar beet



Damping off



Rhizoctonia solani



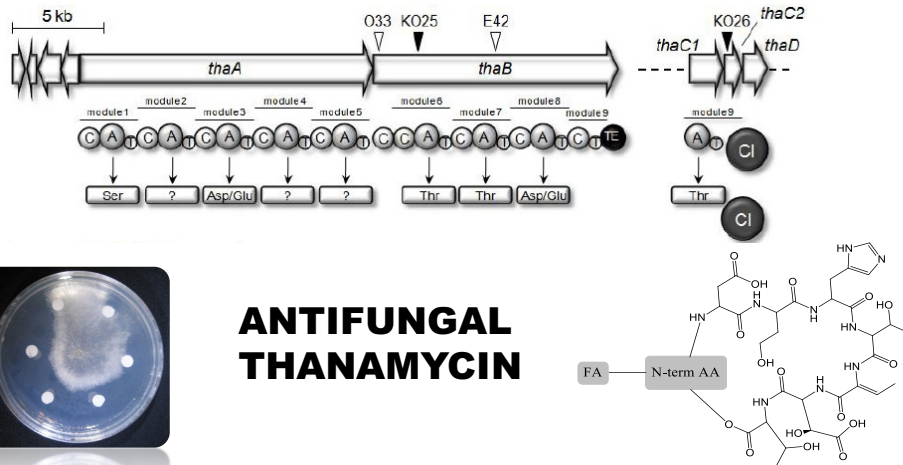
conductive soil



suppressive soil

RHIZOSPHERE MICROBIOME

y-Proteobacteria – *Pseudomonas* & *Lysobacter*

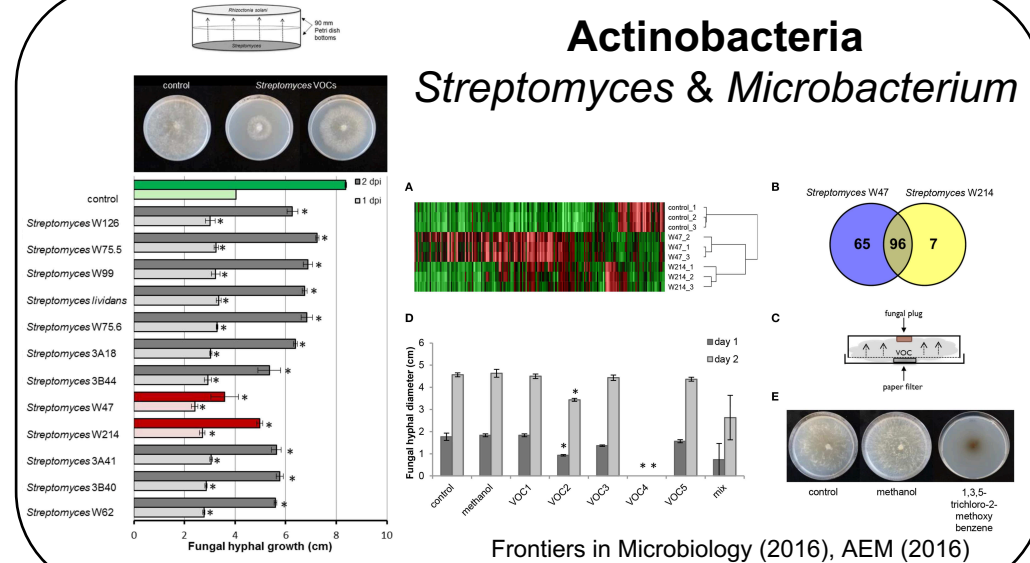


ANTIFUNGAL THANAMYCIN

Science (2011); PNAS (2012); ChemBioChem (2014); Nature Microbiology (2015)

Actinobacteria

Streptomyces & *Microbacterium*

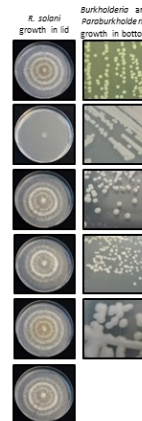
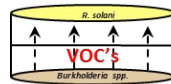


Frontiers in Microbiology (2016), AEM (2016)

β-Proteobacteria - *Paraburkholderia*

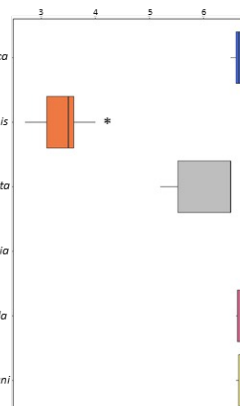


In vivo

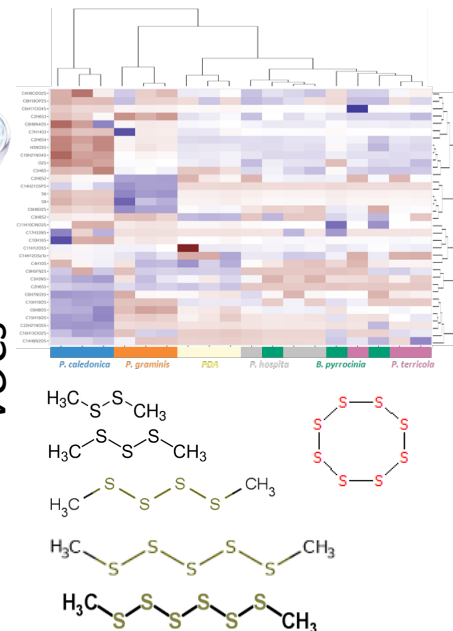


In vitro

Fungal hyphal growth (cm)

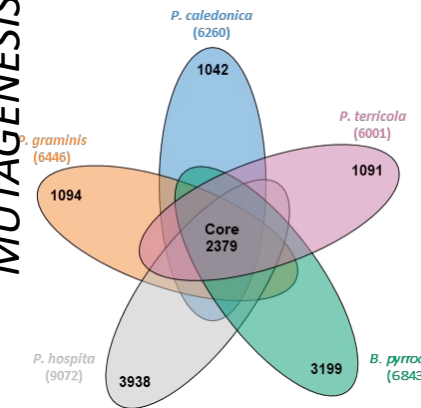


VOCs



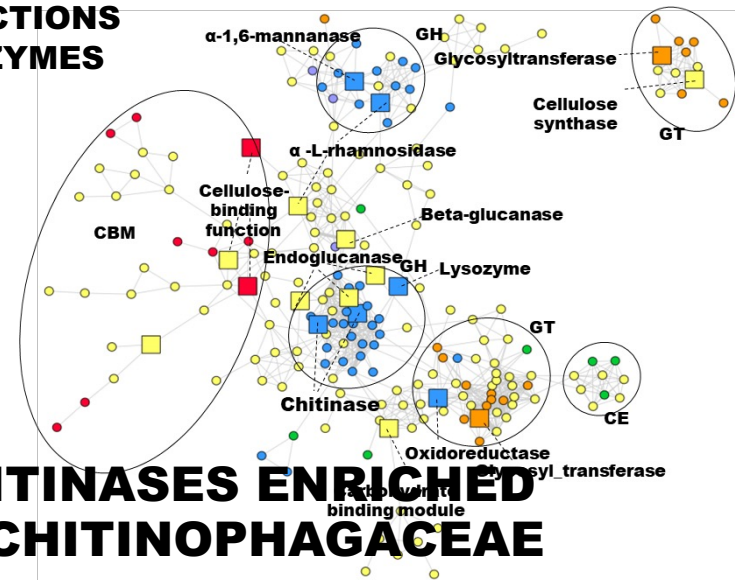
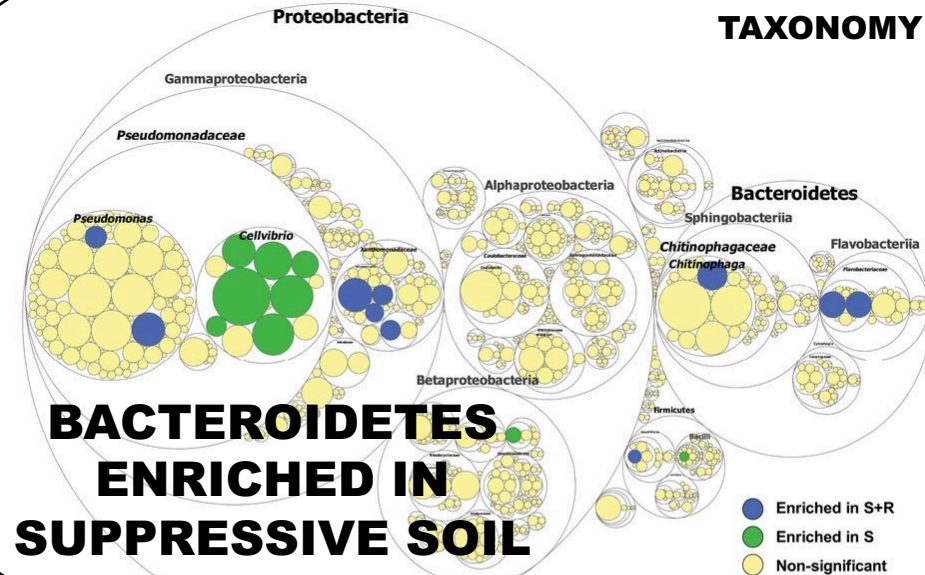
COMPARATIVE GENOMICS & MUTAGENESIS

GENES INVOLVED IN THE BIOSYNTHESIS OF SULFUROUS VOCs

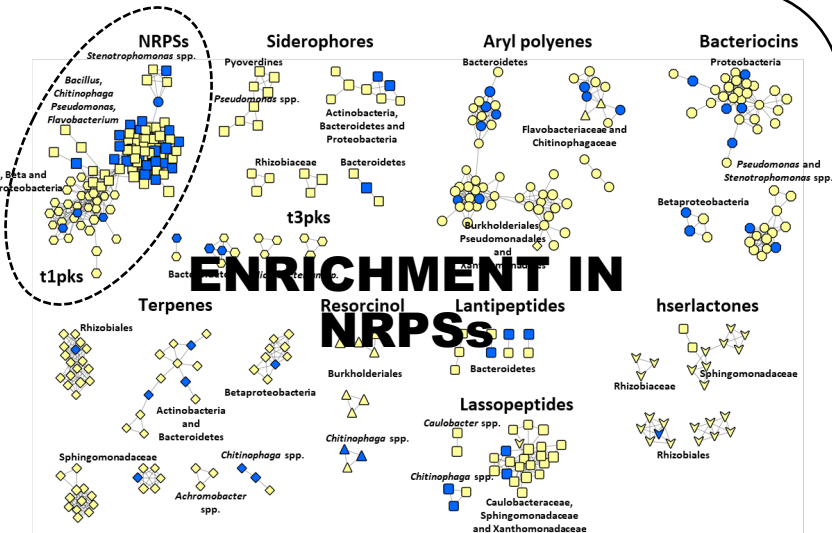
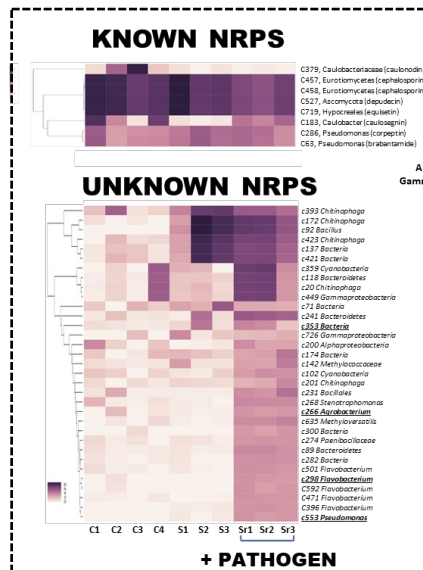
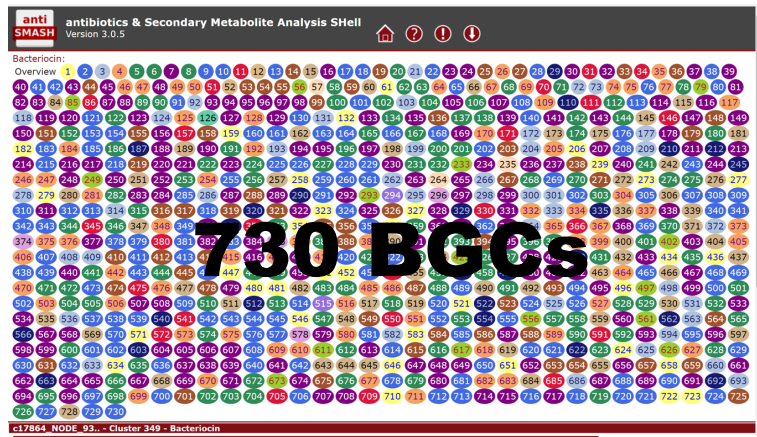


Carrion et al., 2018 (ISME J)

ENDOSPHERE MICROBIOME



FUNCTIONS - NATURAL PRODUCTS



Carrion et al. 2019 (Science)

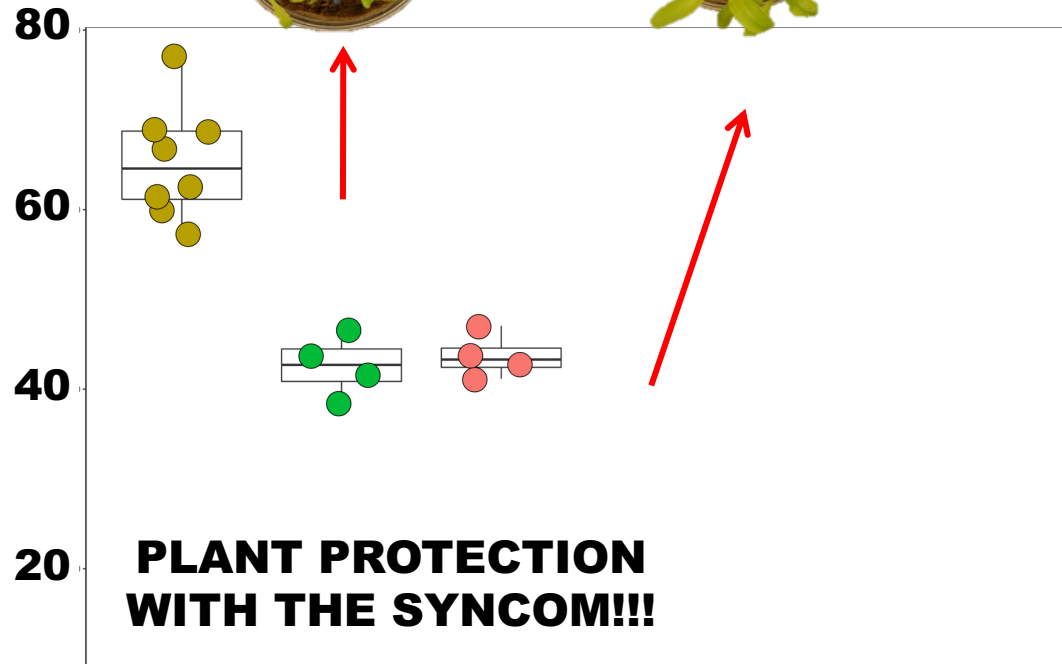
FROM METAGENOME TO MICROBE

> *IN VIVO* ACTIVITY, COLONIZATION & *IN VIVO* BGC/CHITINASE EXPRESSION

PLANTS INOCULATED
WITH INDIVIDUAL
BACTERIA

PLANTS INOCULATED
WITH SYNCOM

Disease incidence (%)



PLANT PROTECTION
WITH THE SYNCOM!!!

Diseased
plants

Flavobacterium sp.

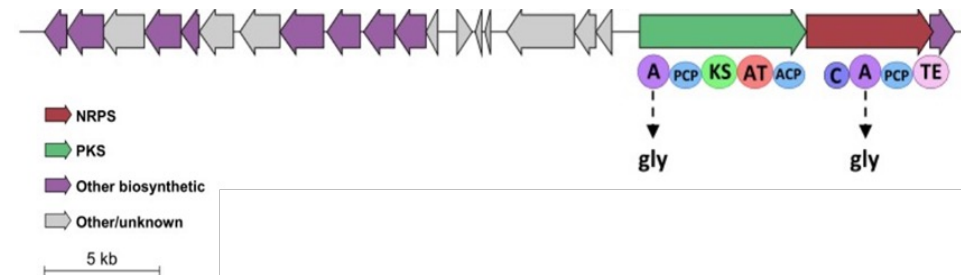
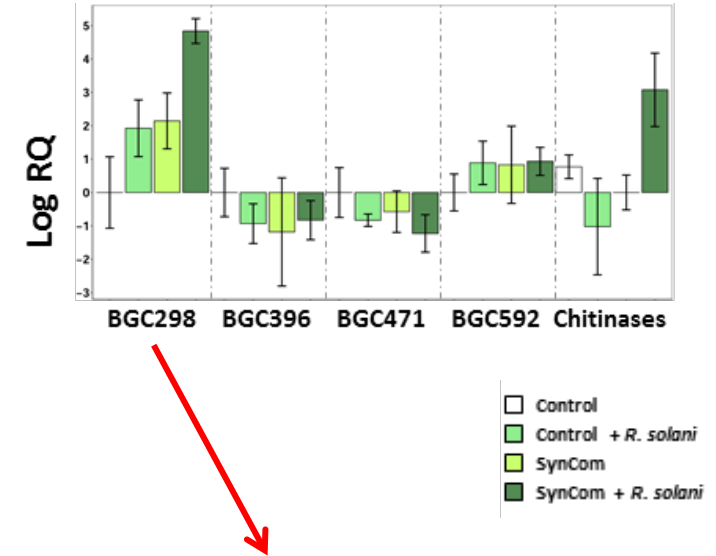
Chitinophaga sp.

SynCom

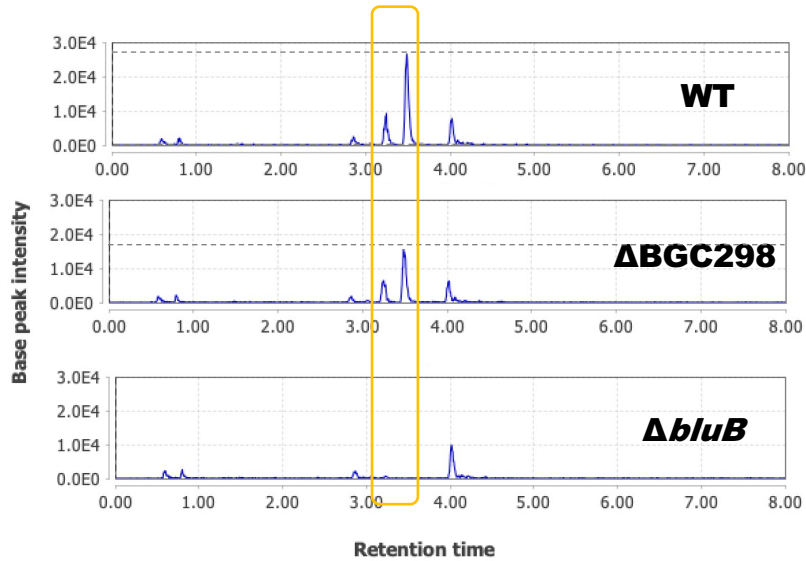
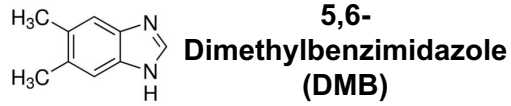
SynCom2-
ANRPS298

Flavobacterium
sp. ANRPS298

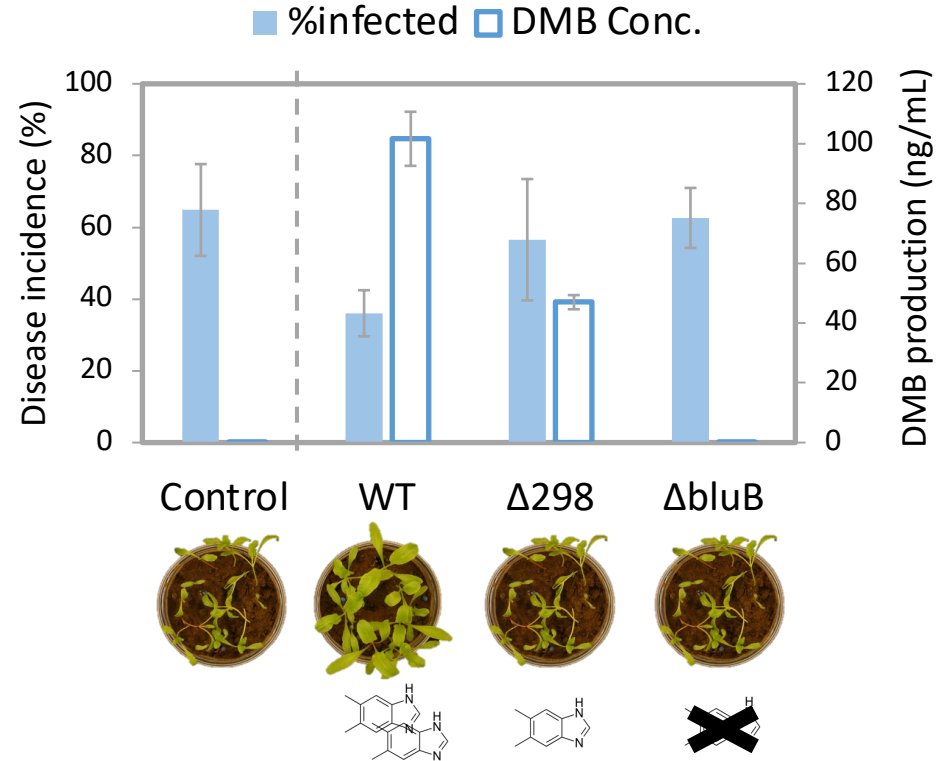
> PATHOGEN-INDUCED EXPRESSION
(BGC-298, CHITINASES)



COMPARATIVE METABOLOMICS *FLAVOBACTERIUM* WT VS. MUTANTS



DMB is less abundant in *Flavobacterium* Δ BGC298, and absent in Δ bluB



Xinya Pan

- *Flavobacterium* unlocks inner power by producing DMB
- (Ongoing) activation by root exudates, O₂?

SOIL IMMUNE RESPONSE | RHIZOSPHERE & ENDOSPHERE



RHIZOSPHERE

- Antifungal peptides: thanamycin, brabantamide > *Pseudomonas*
- Antifungal VOCs: *Streptomyces*, *Paraburkholderia*
- Unknown mechanisms/metabolites: *Microbacterium*, *Planctomyces*, *Bacilli*

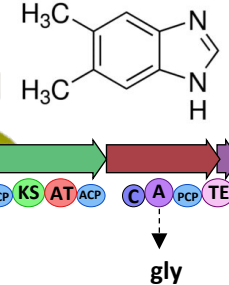
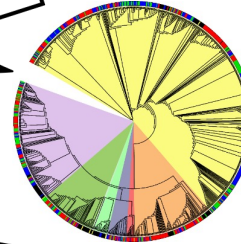
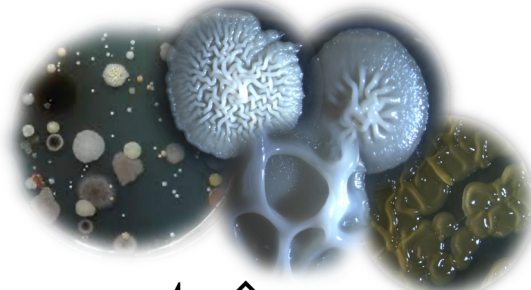
ENDOSPHERE

- Enrichment Bacteroidetes
- Pathogen-induced expression of chitinases and specific BGCs in endophytic Bacteroidetes
- DMB associated with protective endophytic *Flavobacterium*
 - overexpression, *chemistry*, *genetics* – ongoing (Xinya & Brandon)

CLASSICAL MICROBIOLOGY

FUNCTIONAL ANALYSIS

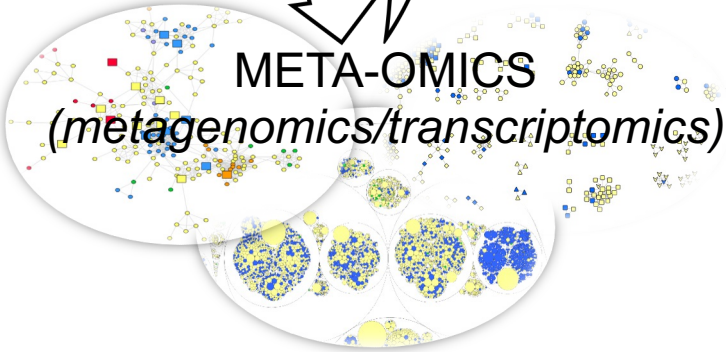
(genetics, genomics, chemistry)



Mendes et al. (2011) *Science*; Watrous et al. (2012) *PNAS*; Cordovez et al. (2015) *Front. Microbiol.*; Van der Voort et al. (2016) *Ecology letters*; Chapelle et al. (2016) *ISME Journal*; Carrion et al. (2018) *ISME Journal*; Carrion et al. (2019) *Science*; Pan et al. (2023) *TIM*; Mendes et al. (2023) *Env Micro*; Pan et al. (2024) *in prep*

META-OMICS

(metagenomics/transcriptomics)



Genes involved in beneficial activities?

New virulence factors?

What makes an endophyte an endophyte?

Can we predict lifestyle based on (meta)genomic content?



+



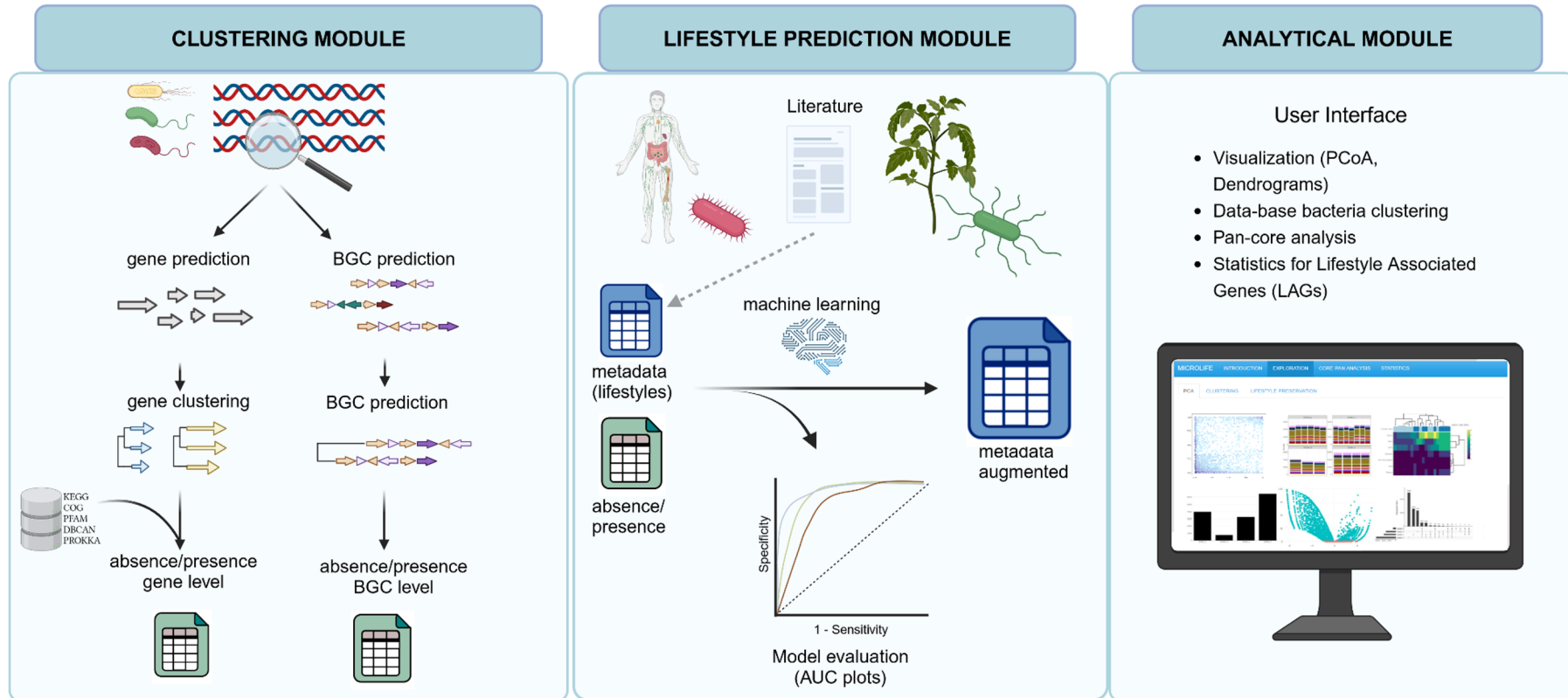
MetaData



THE TOOL: bacLIFE



Guillermo
Guerrero



Guerrero-Egido et al. 2024 (Nat. Comms.)

MARBL

Harnessing marine microbes for drug discovery and sustainable production of fish and crops

MARBL is a €7.5 million, 5-year EU-funded project to develop methods for the sustainable collection and use of biodiversity from marine environments and assess their commercial potential.



LEARNING FROM NATURE: MICROBIOMES TO COPE WITH SALINITY

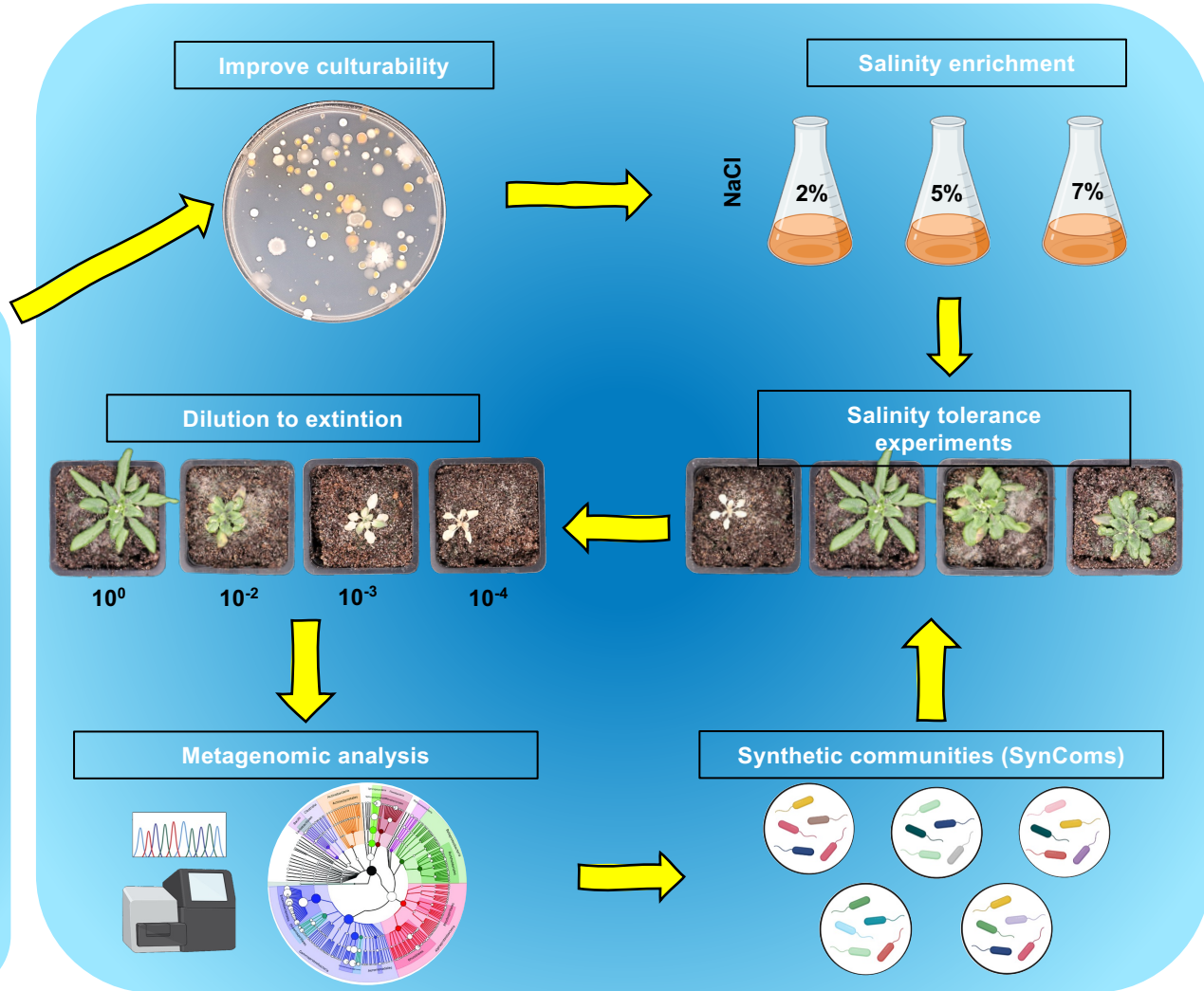
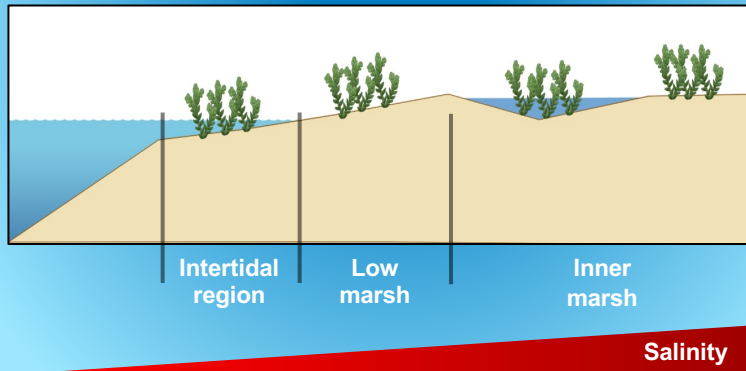
Ters



LEARNING FROM NATURE: MICROBIOMES TO COPE WITH SALINITY



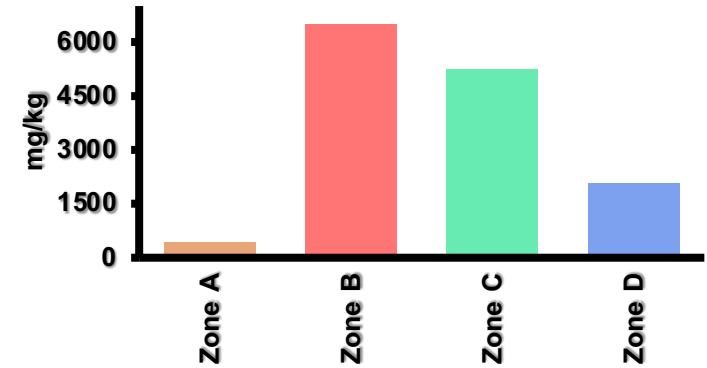
Glasswort
(*Salicornia europaea*)



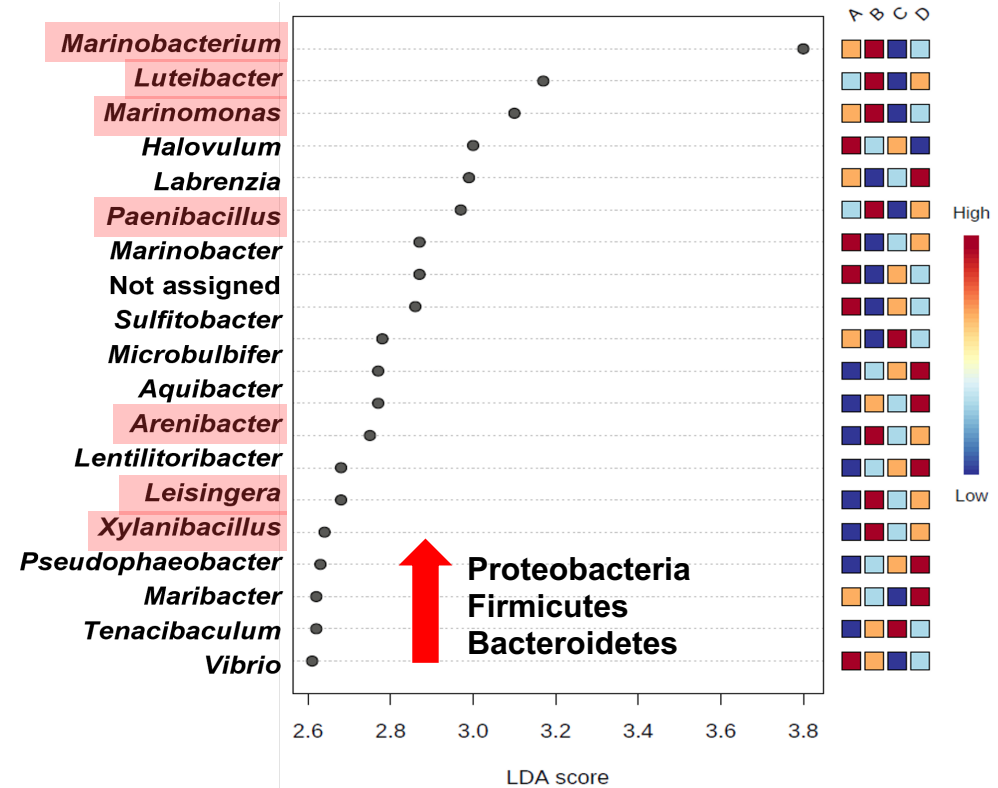
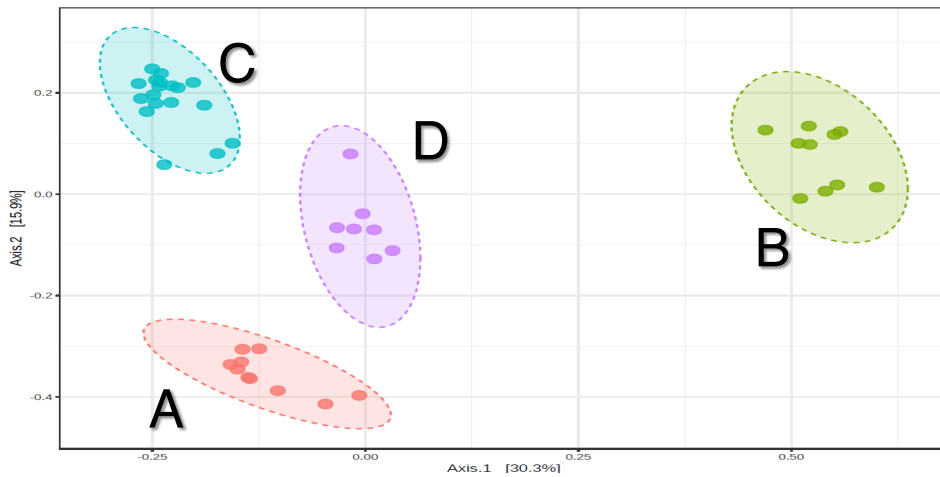
Terschelling island



Plant available Na⁺



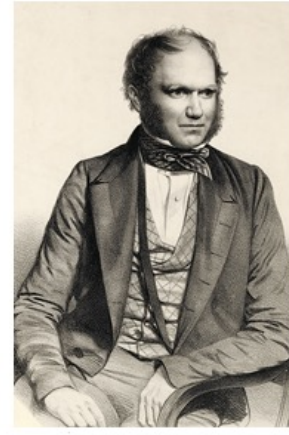
Microbiome





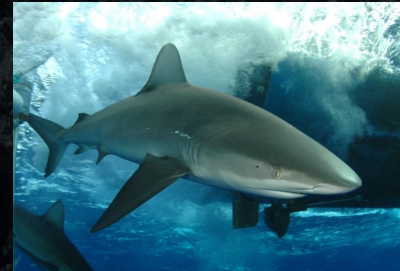
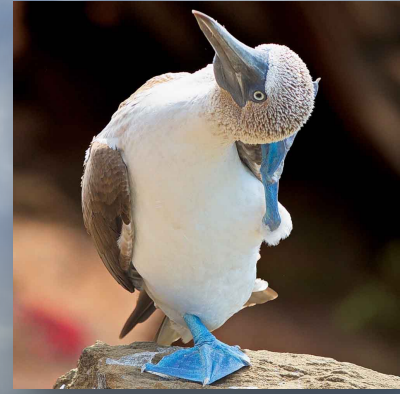
HMS Beagle

© Omikron/Science Source



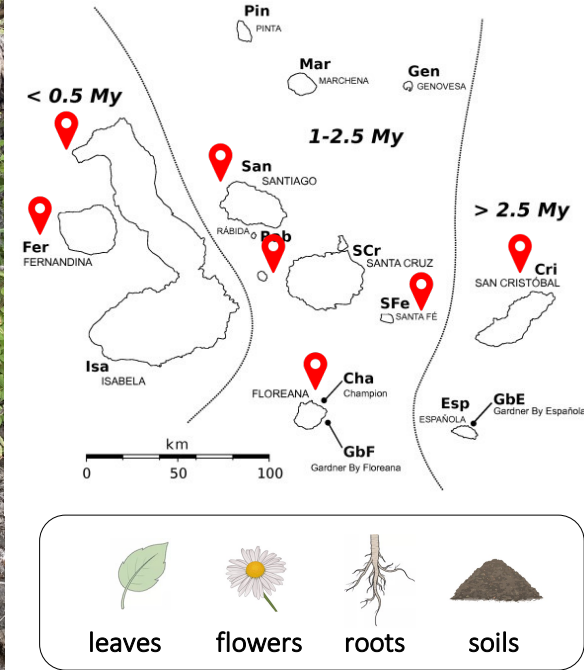
Charles Darwin

The Natural History Museum/Alamy Stock Photo



GALÁPAGOS MICROBIOME EXPEDITION: UNCOVERING
THE MICROBIAL WORLD THAT DARWIN NEVER SAW

SAMPLING OF SCALEZIA



SAMPLING OF SCALESIA



Video by Wilson Cabrera & Haig Balian

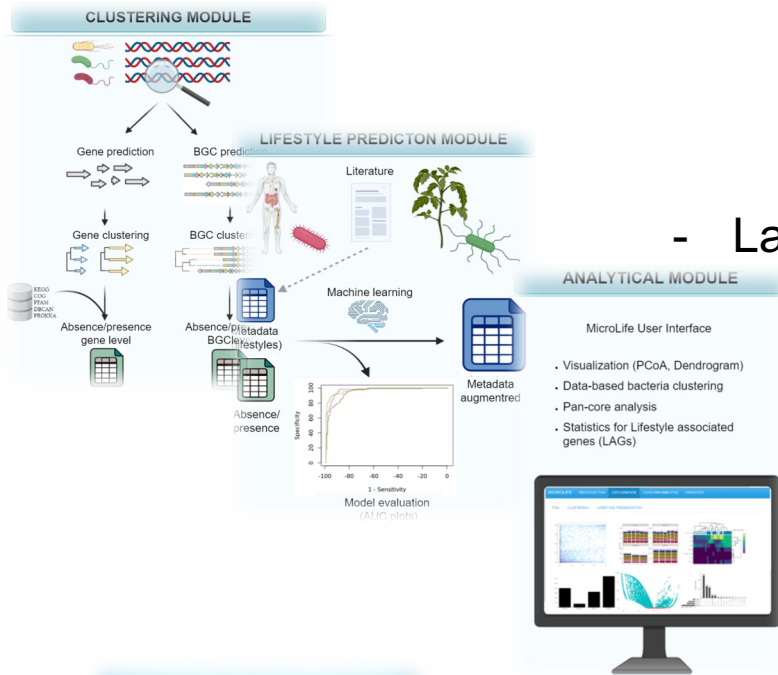
Outcomes

isms on and inside

and processes of
es

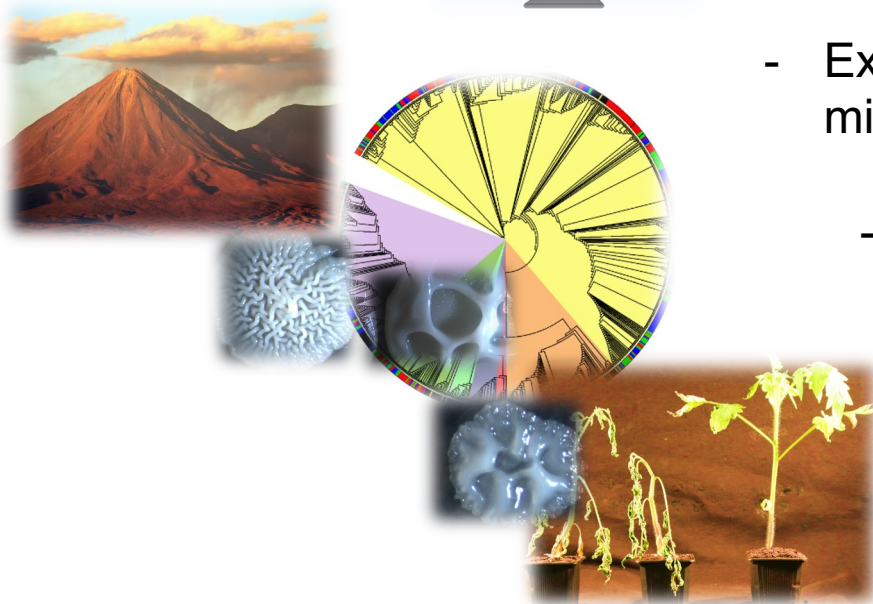
on the ecology of
(with, survival)

TAKE HOME SMS



- Large-scale comparative (meta)genomics.
- Understanding
- Enhancement

- Extreme environments: a goldmine of microbes for biotech applications
- Mechanisms are yet not discovered



THE CARRION RESEARCH GROUP



PHD STUDENTS

- Guillermo Guerrero (LU, UMA)
- Pascal Nuijten (NIOO, LU, UMA)
- Xinya Pan (NIOO, LU, UMA)
- Marcos Pedraza (UMA)
- Belen Delgado (UMA)
- Kevin Bretscher (NIOO, LU, UMA)

BSC & MSC STUDENTS

- Cristina Sarmiento
- José María Urquizu

POSTDOCS

- Hugo Pantigoso (LU)
- Miguel Rodriguez (NIOO, LU)
- Adam Ossowicki (UMA)

NL COLLABORATORS

- **JOS M. RAAIJMAKERS & TEAM (NIOO, LU)**
- GILLES VAN WEZEL & TEAM (IBL, LU)
- **MARNIX MEDEMA & TEAM (WUR)**
- SALMA BALAZADEH & TEAM (LU)
- HERMAN SPAINK (LU)
- DENNIS CLAESSEN (LU)

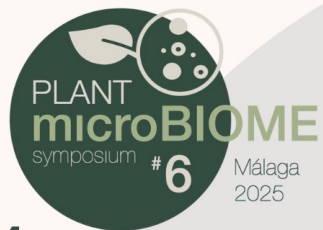
INTERNATIONAL COLLABORATORS

- **ALEXANDRA STOLL (CHILE, CEAZA)**
- **IOANNIS STRINGLIS (GREECE, AUA)**
- **SILVIA PRIOETTI (ITALY, UNITUS)**
- XU CHENG (CHINA, AGIS)
- XIAOGANG LI (CHINA, NFU)
- JUAN PEREZ-JARAMILLO (COLOMBIA, NATIONAL UNIVERSITY)
- RODRIGO MENDES & TEAM (BRASIL, EMBRAPA)
- LUCAS MENDES & TEAM (BRASIL, USP)
- PIETER VAN 'T HOF (ECUADOR, USFQ)
- LEO EBERL & TEAM (SWITZERLAND, ZURICH UNIVERSITY)
- JOSEPH N PAULSON (USA, HARVARD UNIVERSITY)
- PAOLA DURÁN & TEAM (CHILE, FRONTERA UNIVERSITY)



Horizon2020
European Union Funding
for Research & Innovation





6th Plant Microbiome Symposium

3-7 November 2025
 Antequera, Málaga, Spain

**Registration
 deadline:**
April 2025

Program outline:

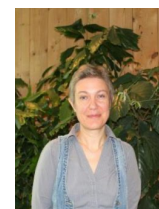
- International keynote speakers
- Poster sessions
- Networking
- Joint dinners and excursions

Topics

- Plant-Microbiome communication
- Computational biology & Microbiomes
- Plant-microbiome interactions for sustainable agriculture
- Microbial interactions & Plant health
- Microbiome mediated stress alleviation

Registration open now at:

6thplantmicrobiomesymposium2025.com



Paolina Garbeva



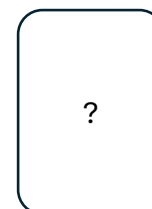
Manuel Delgado Baquerizo



Maria J. Pozo



Julia Vorholt



Viviane Cordovez



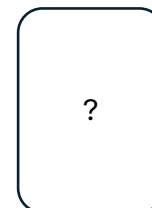
Juan Esteban Pérez-Jaramillo



Akos T. Kovács



Lucas William Mendes



Ainhoa Martínez Medina



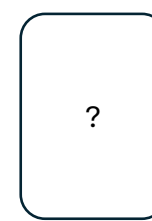
Ioannis Stringlis



Francisco Dini Andreote



Angela Sessitch



EPSO 6th Workshop on Plants and Microbiomes



ANGELA SESSITSCH



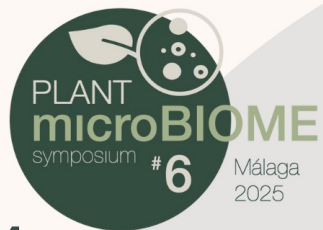
PAUL SCHULZE-LEFERT



CORNÉ PIETERSE



KARIN METZLAUFF



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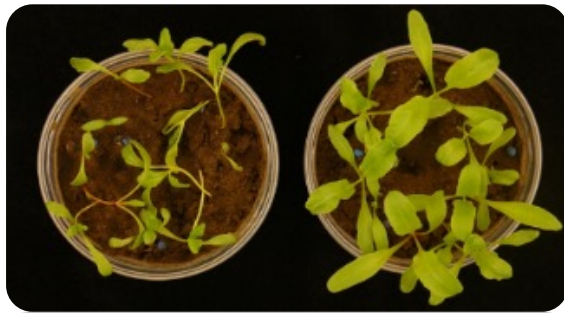
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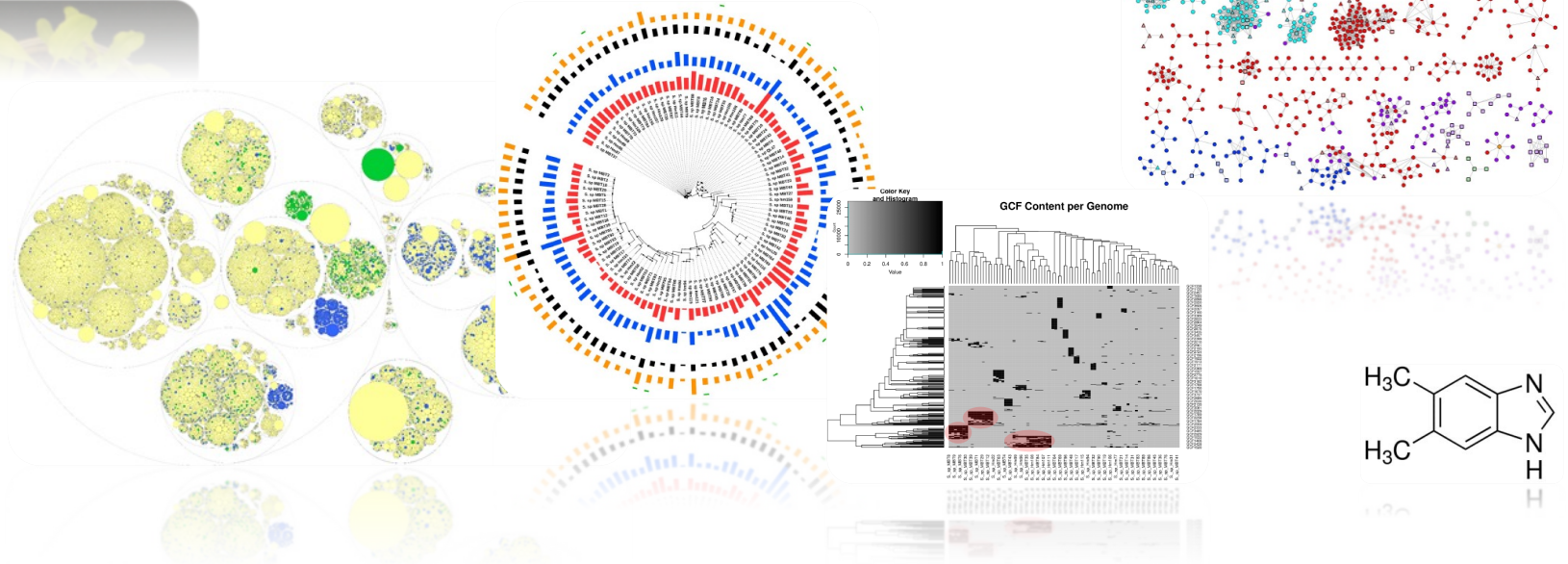


Abstract submissions open now!





Thanks for your attention



DECODING THE HIDDEN SECRETS OF PLANT MICROBIOMES

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