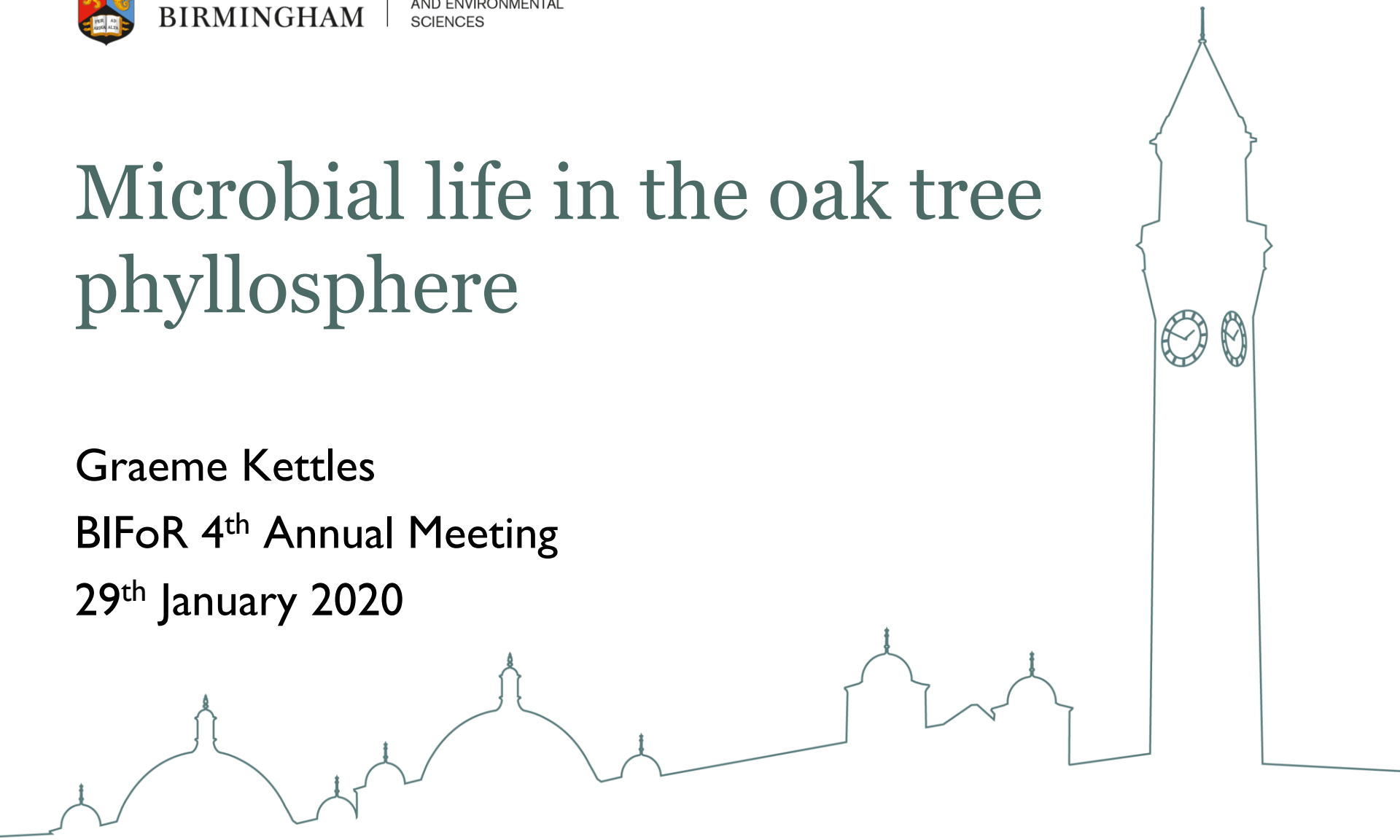
UNIVERSITY OF BIRMINGHAM | COLLEGE OF LIFE AND ENVIRONMENTAL SCIENCES

Microbial life in the oak tree phyllosphere

Graeme Kettles

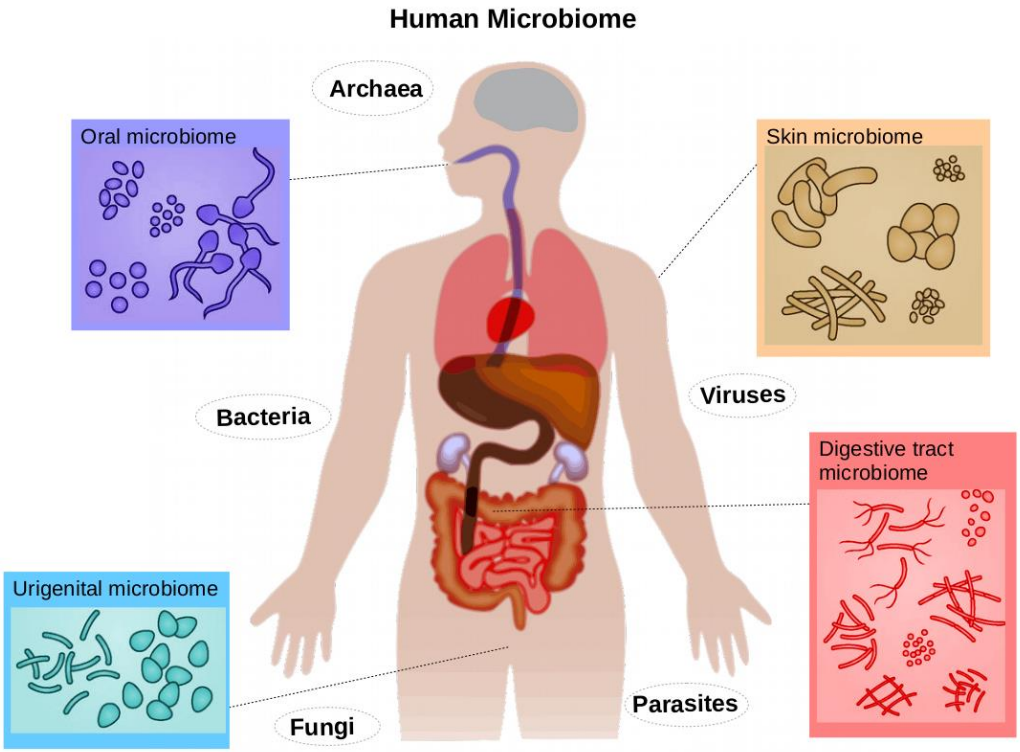
BIFoR 4th Annual Meeting

29th January 2020



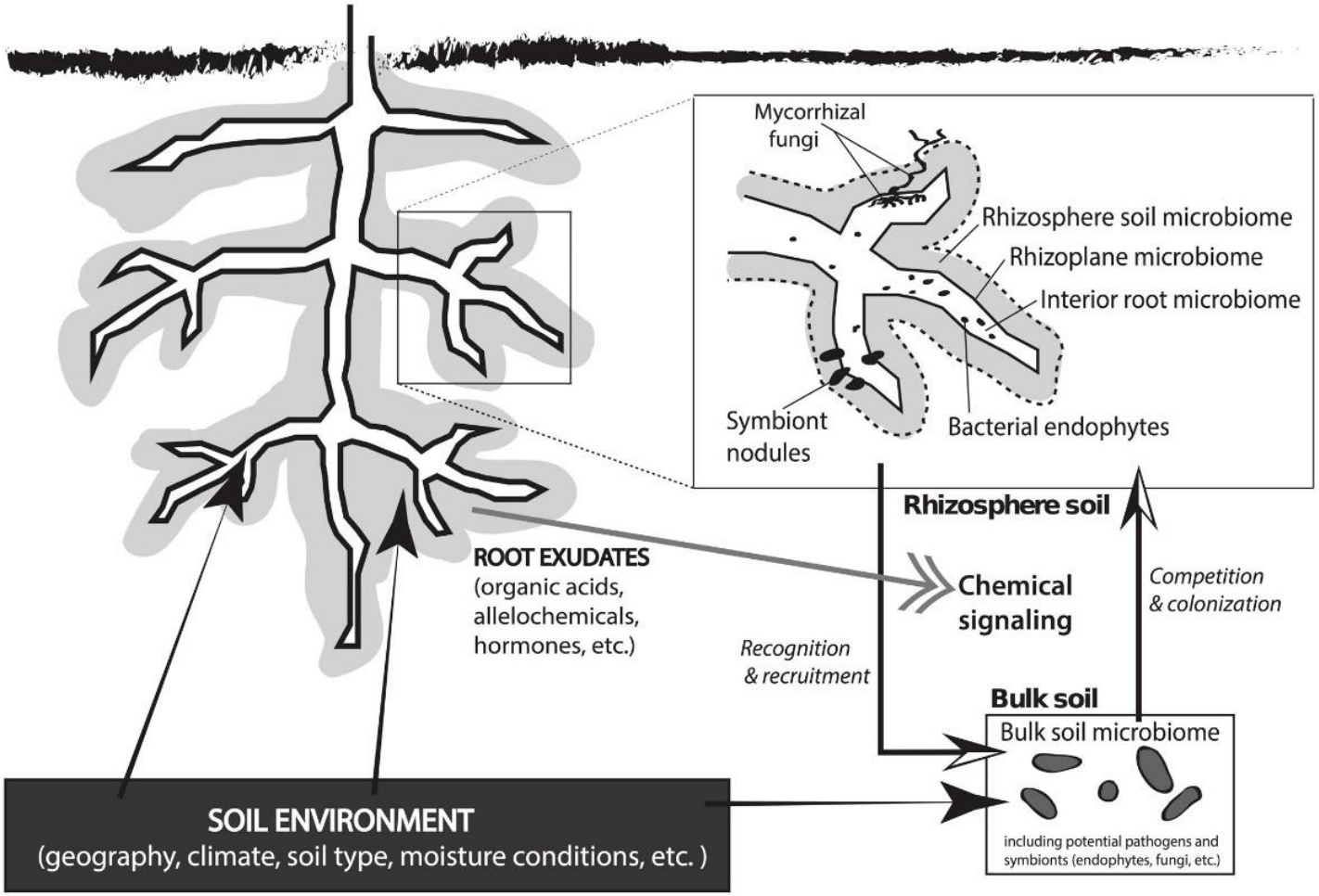
@GraemeKettles

Human microbiomes



Perturbation of the microbiome has been linked to numerous diseases and adverse health conditions

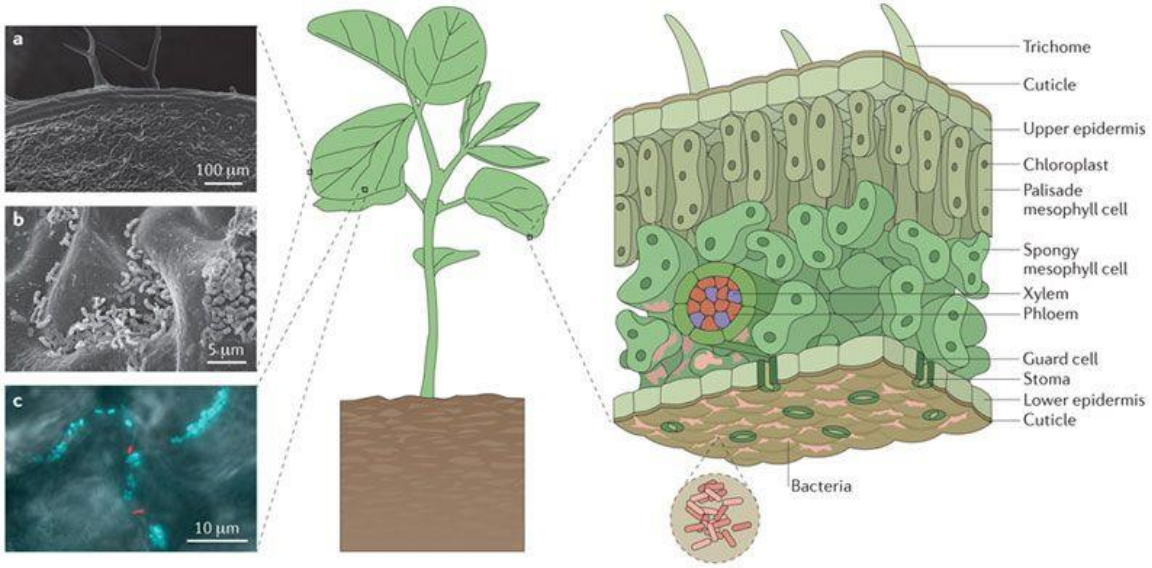
Plant microbiomes



Coats & Rumpho (2014) Front Microbiol. 23;5:368.

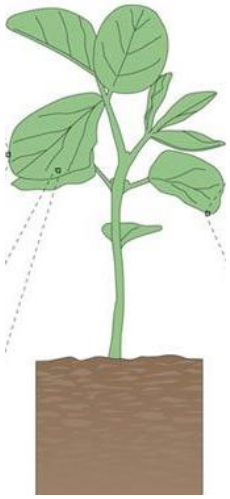
The phyllosphere microbiome

- Aerial (above-ground) parts of plants eg. leaves, stems, flowers
- Global leaf area ~1bn km^2
- Up to 10^6-10^7 bacteria/cm^2 of leaf
- Bacteria dominate, tend to form aggregates
- Fewer fungi in phyllosphere

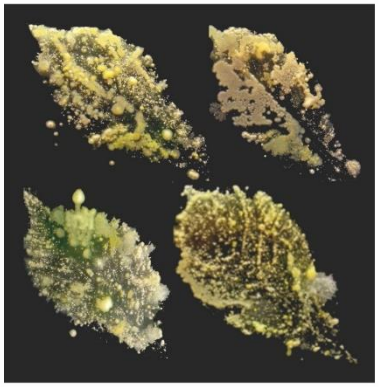


Vorholt JA (2012) Nature Reviews Microbiology 10: 828–840

The phyllosphere microbiome

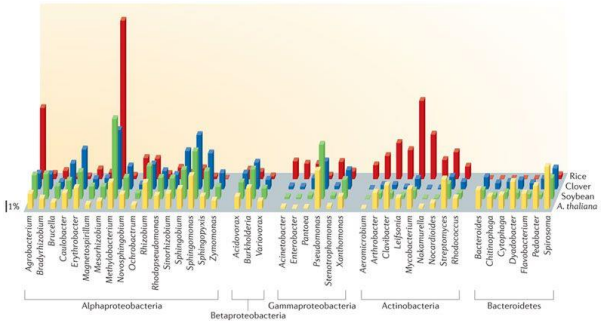


Culture dependent techniques

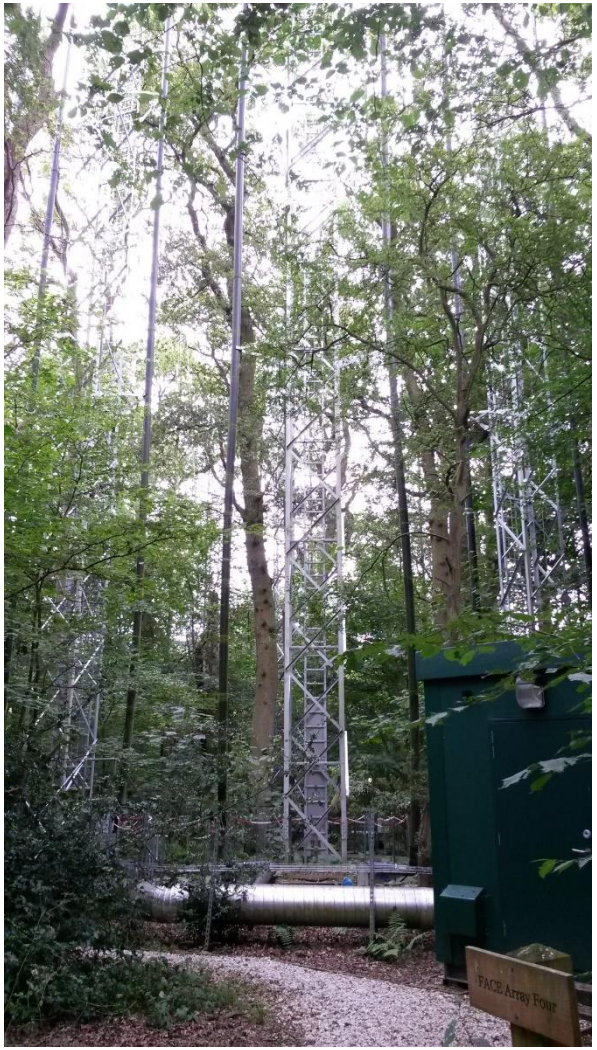


Microbes cultured from the surface of horse chestnut tree leaves

Culture independent techniques



A library of tree microbiomes



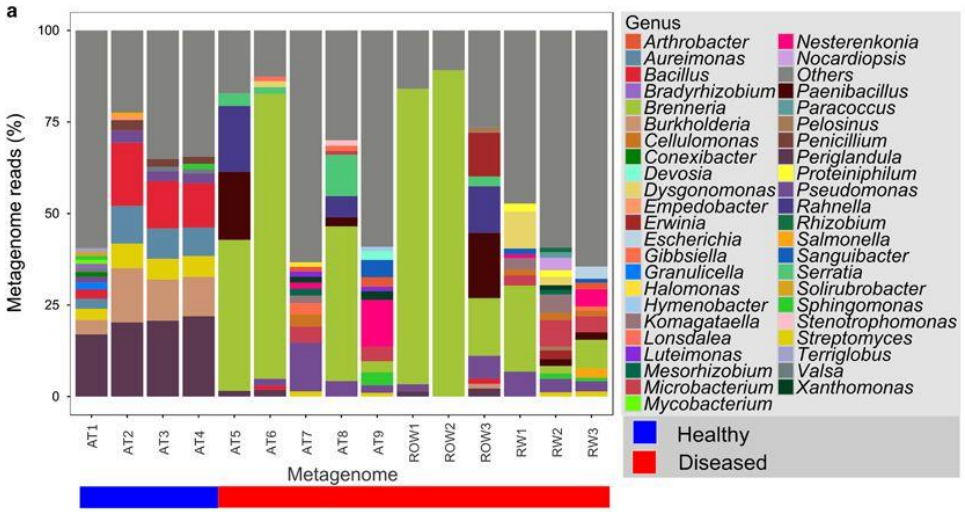
BIFOR

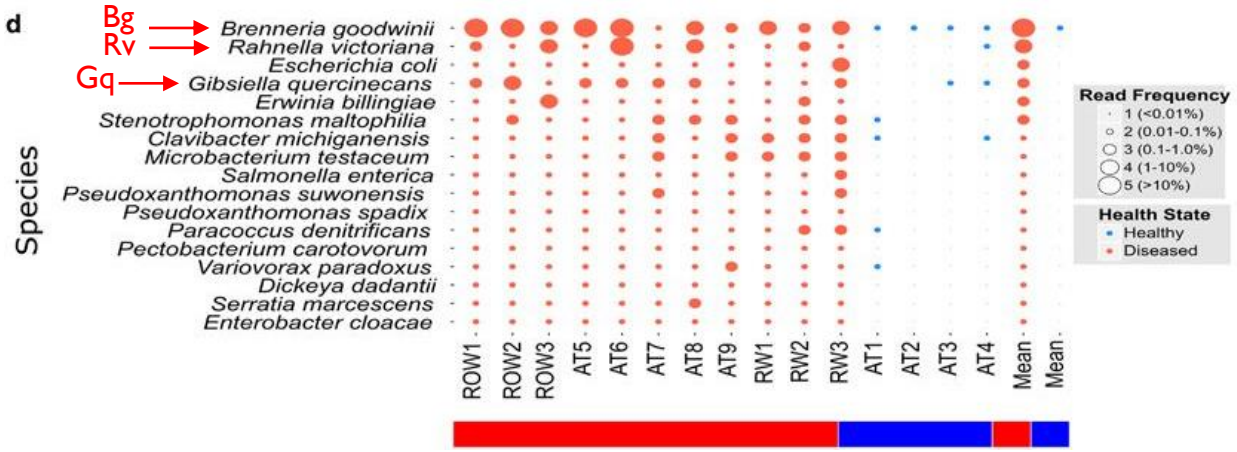
BIRMINGHAM INSTITUTE OF FOREST RESEARCH

The acute oak decline (AOD) pathosystem

Brady *et al.* (2017) World J Microbiol Biotechnol. 33(7):143
Brown *et al.* (2015) Forestry 88:1 53-63

The acute oak decline (AOD) pathosystem

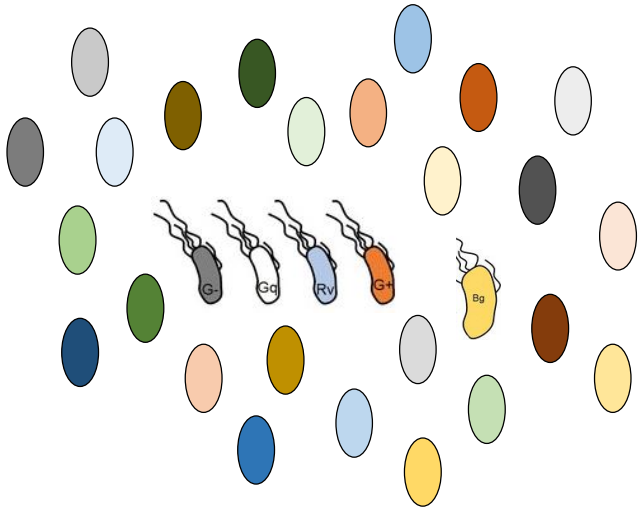




Denman *et al.* (2017) ISME J 12, 386–399

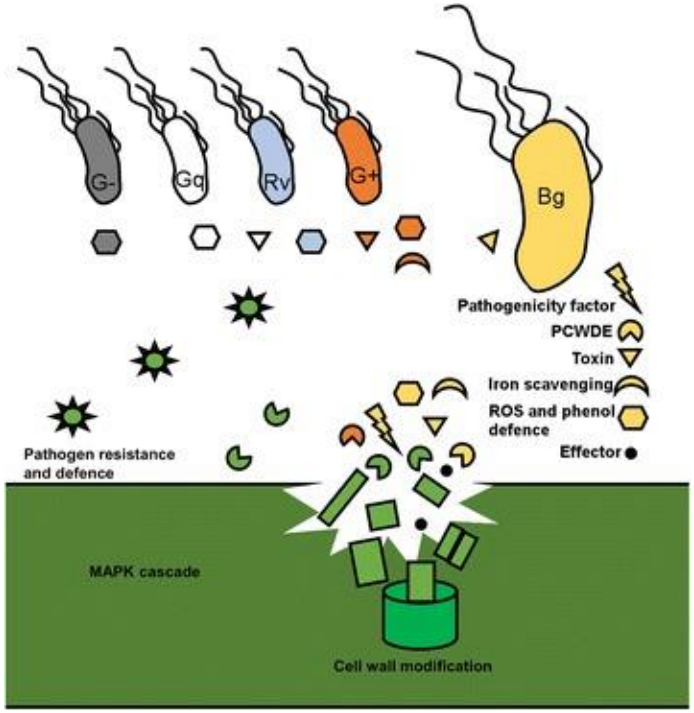
AOD is a multispecies bacterial complex

Healthy microbiome



Healthy host plant

pathobiome



Diseased host plant

Adapted from Broberg *et al.* (2018) Microbiome 30;6(1):21

How does a “healthy microbiome” transition to a diseased pathobiome?

Oak leaves are rich in culturable microbes

Adriana Iamandi

Imprint of oak leaf from Biosciences glasshouse

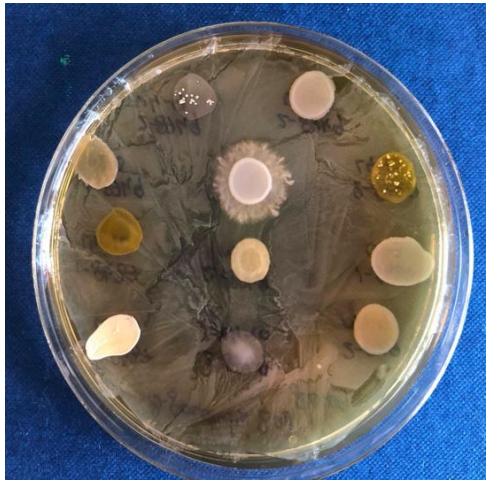
Imprint of oak leaf from BIFoR-FACE

A culture collection of oak phyllosphere isolates

Adriana Iamandi

Imprints of 144 leaves from upper, middle and lower canopies of 12 oaks at BIFoR-FACE

Restreaking to produce a 360 isolate collection

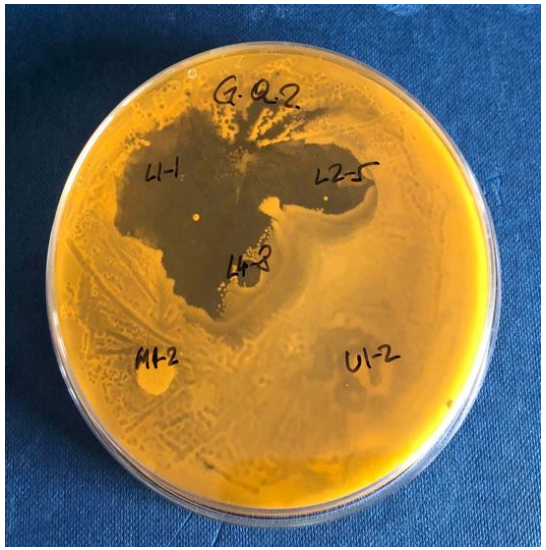


<u>AOD assay</u>
Bacterial lawn of AOD-associated bacteria. Phyllosphere isolates spotted on top

Antagonism is common in the oak phyllosphere

Adriana Iamandi

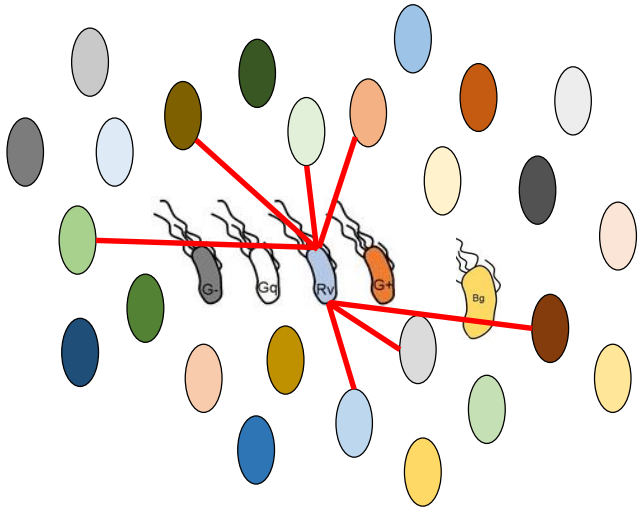
Of 120 phyllosphere isolates, growth of 34 (~28%) was compromised by one of the AOD bacteria.



Of 120 phyllosphere isolates, 4 inhibited growth of one or more of the AOD bacteria.

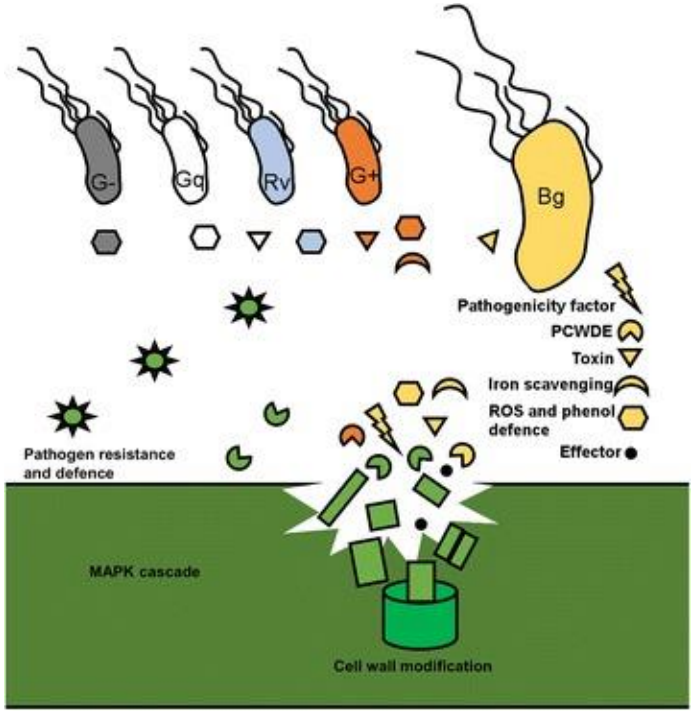
How does the AOD pathobiome develop?

Healthy microbiome



Healthy host plant

pathobiome

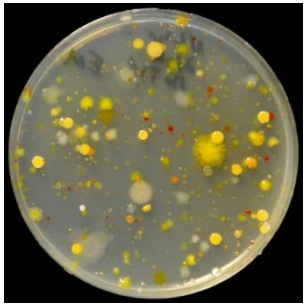


Diseased host plant

Adapted from Broberg *et al.* (2018) Microbiome 30;6(1):21

Can microbial communities protect plants from pathogens?

Leaves of field-grown tomato plants are rich in microbes



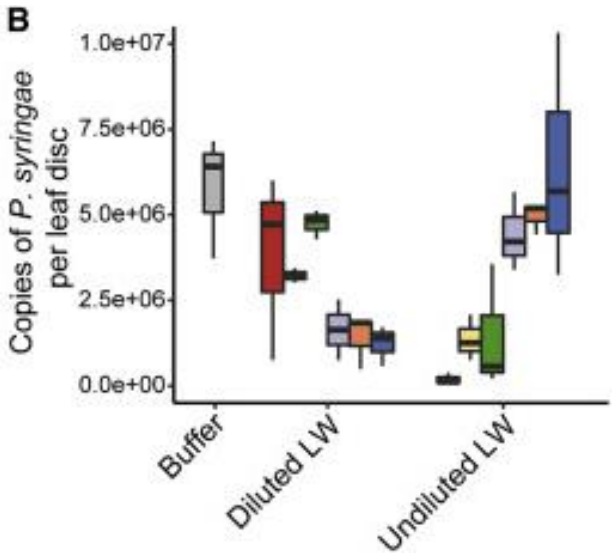
Prepare leaf washes from field-grown plants

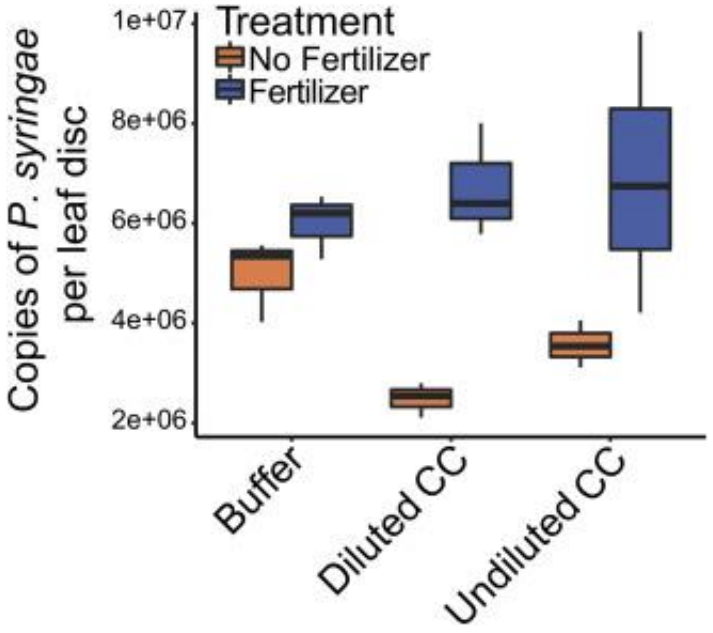
Spray lab-grown plants with leaf wash
+leaf speck pathogen
P. syringae

Monitor disease levels

UC Berkeley News, Berg & Koskella (2018) Current Biology 28:15 2487-2492

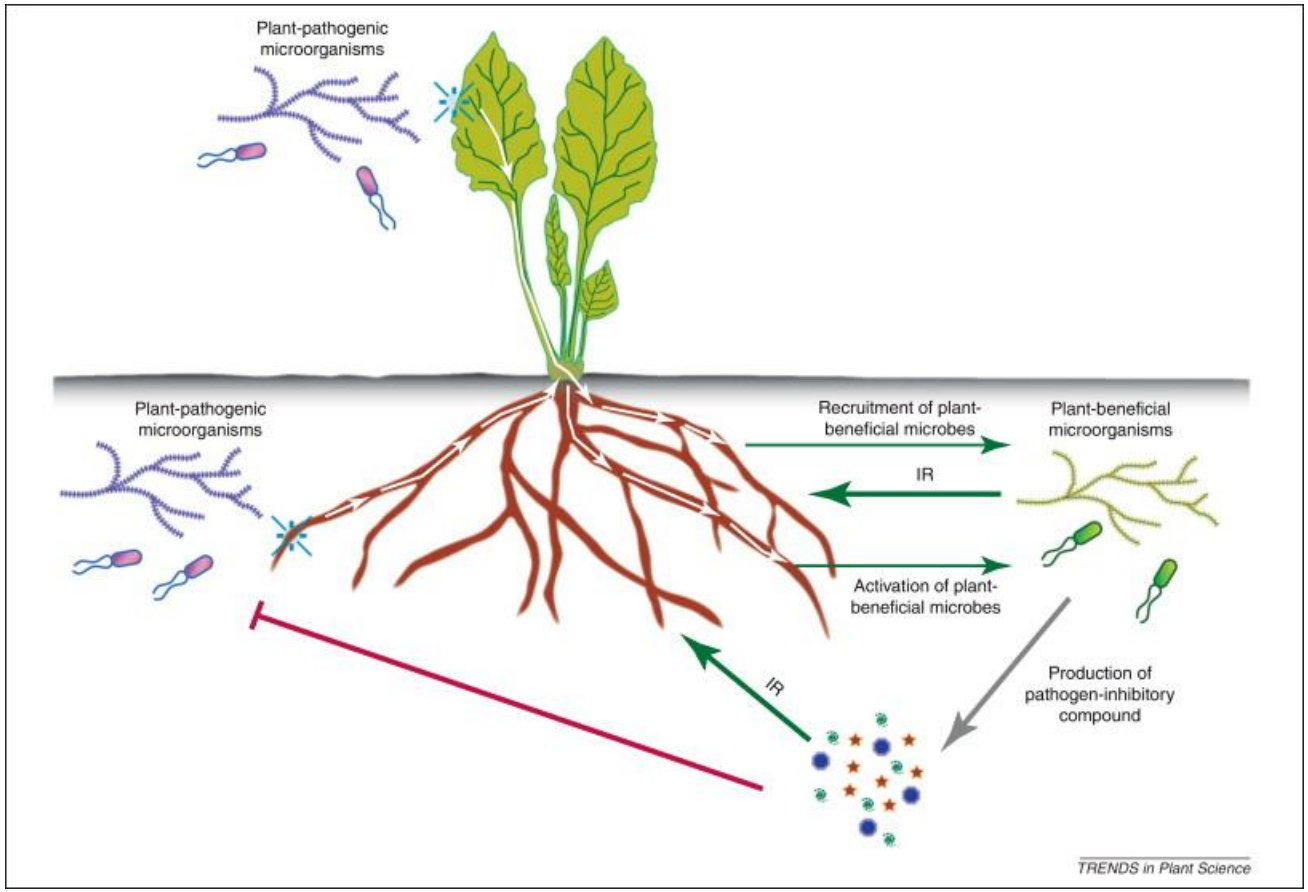
Phyllosphere microbiomes can protect plants from pathogens





Berg & Koskella (2018) Current Biology 28:15 2487-2492

Plant-microbiome interactions are complex



Berendsen *et al.* (2012) Trends in Plant Science 17:8 478-486

Summary

- Leaves of oak trees are (surprisingly) rich in culturable microbes
- AOD is a complex bacterial-driven decline of oak trees
- Some AOD bacteria suppress growth of phyllosphere isolates
- Conversely, other phyllosphere isolates can suppress growth of AOD bacteria

How does the phyllosphere microbiome impact overall tree health?
How does the eCO2 environment at BIFoR-FACE impact the microbiome?
What mechanisms mediate microbe-microbe and plant-microbe interactions in oak tree diseases?

Acknowledgements

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