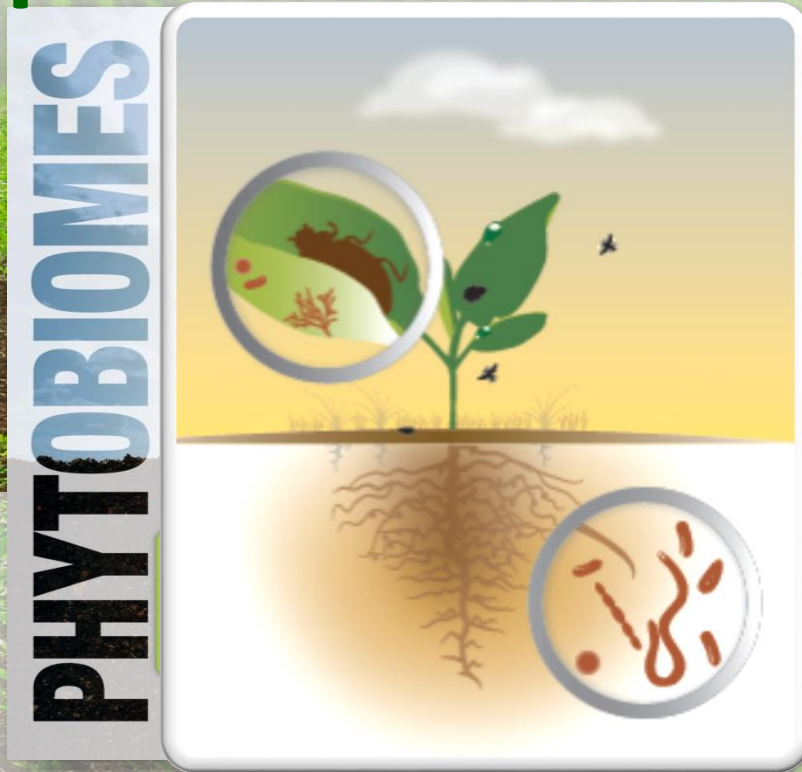


# Improving crop productivity through a comprehensive understanding of the phytobiome



*Mejorando la productividad de cultivos a través del conocimiento comprensivo del fitobioma*

**Jan E. Leach**  
Colorado State University

XIII IRCLAC  
Piura National University  
Piura, Peru  
May 2018



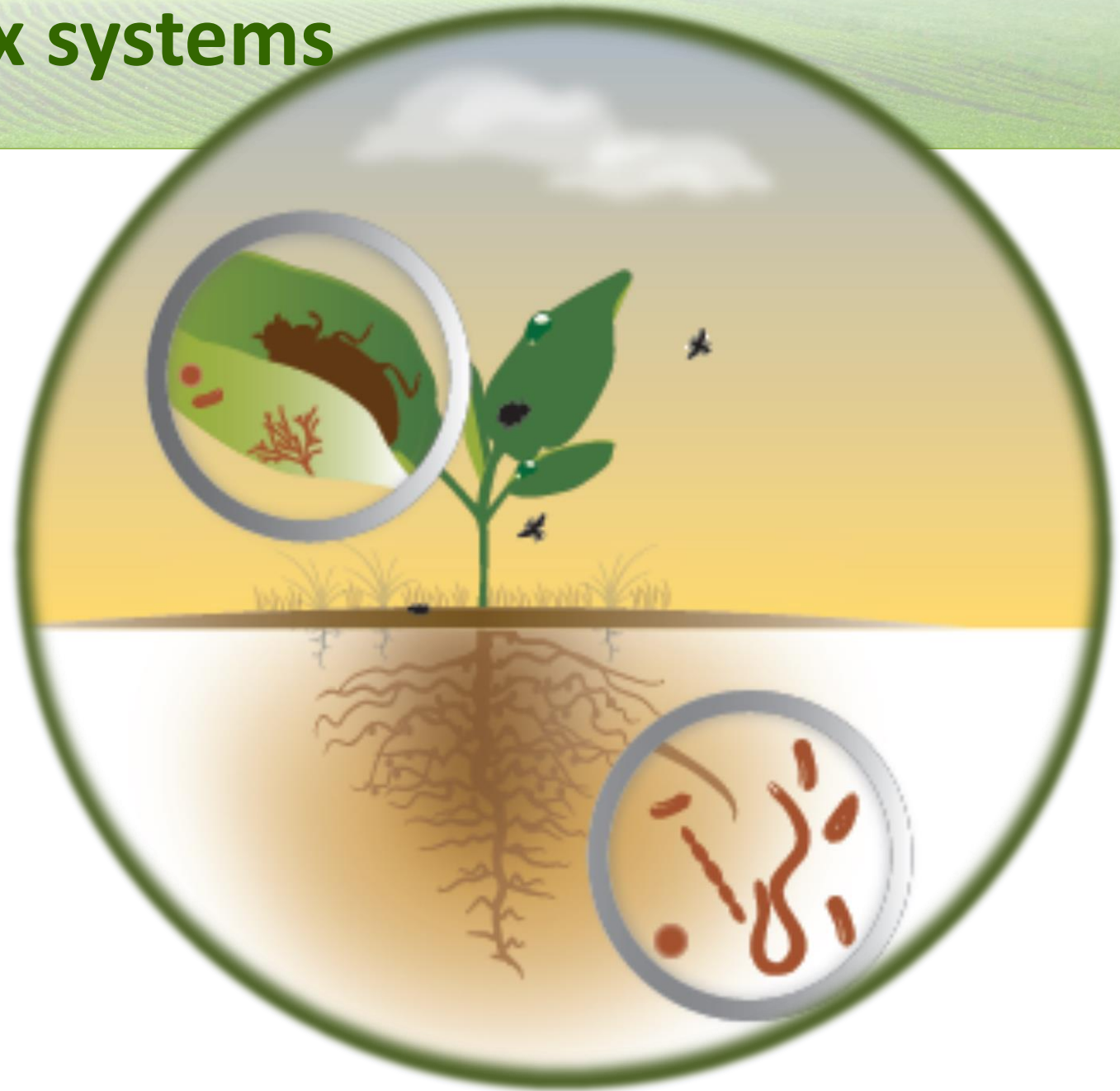
# Phytobiomes are complex systems

## Phytobiome:

- Interactions of the environment and living organisms that influence or are influenced by plants

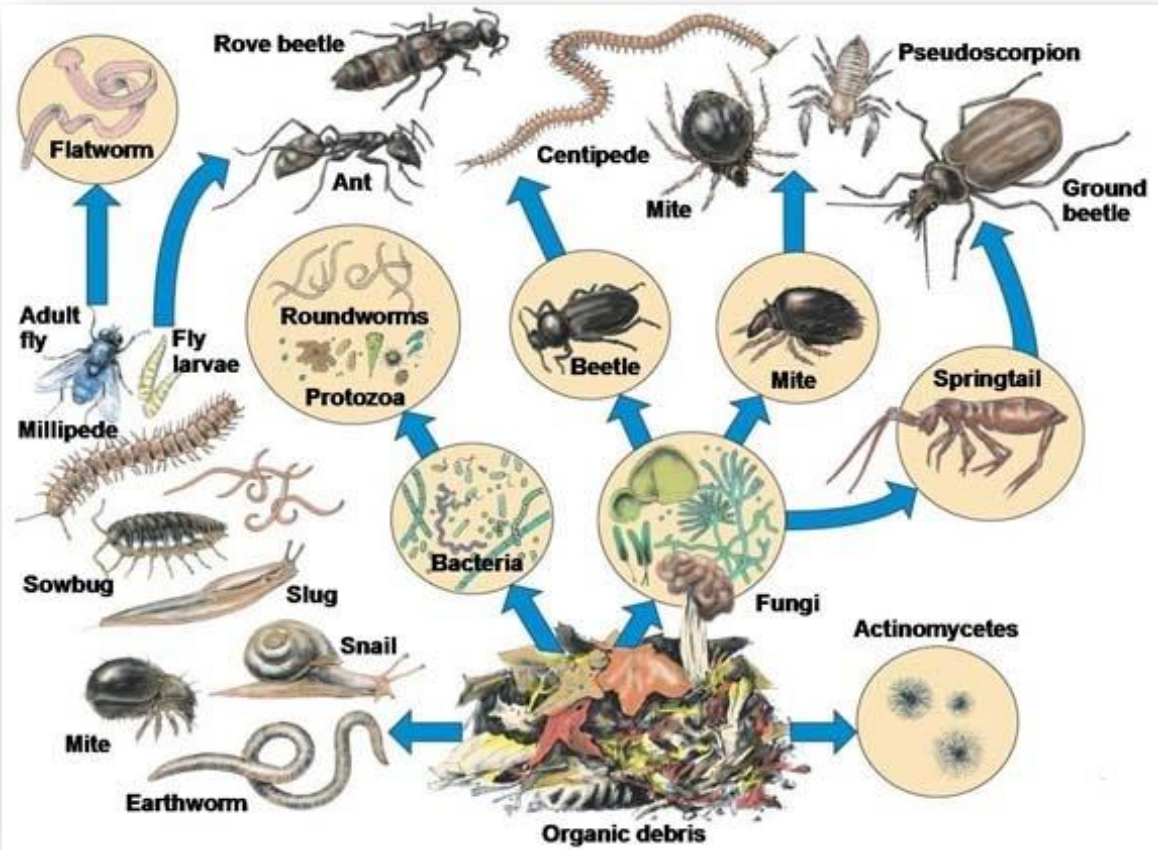
## Plant Microbiome:

- The dynamic community of microbes associated with plants





# Phytobiome members in the soil



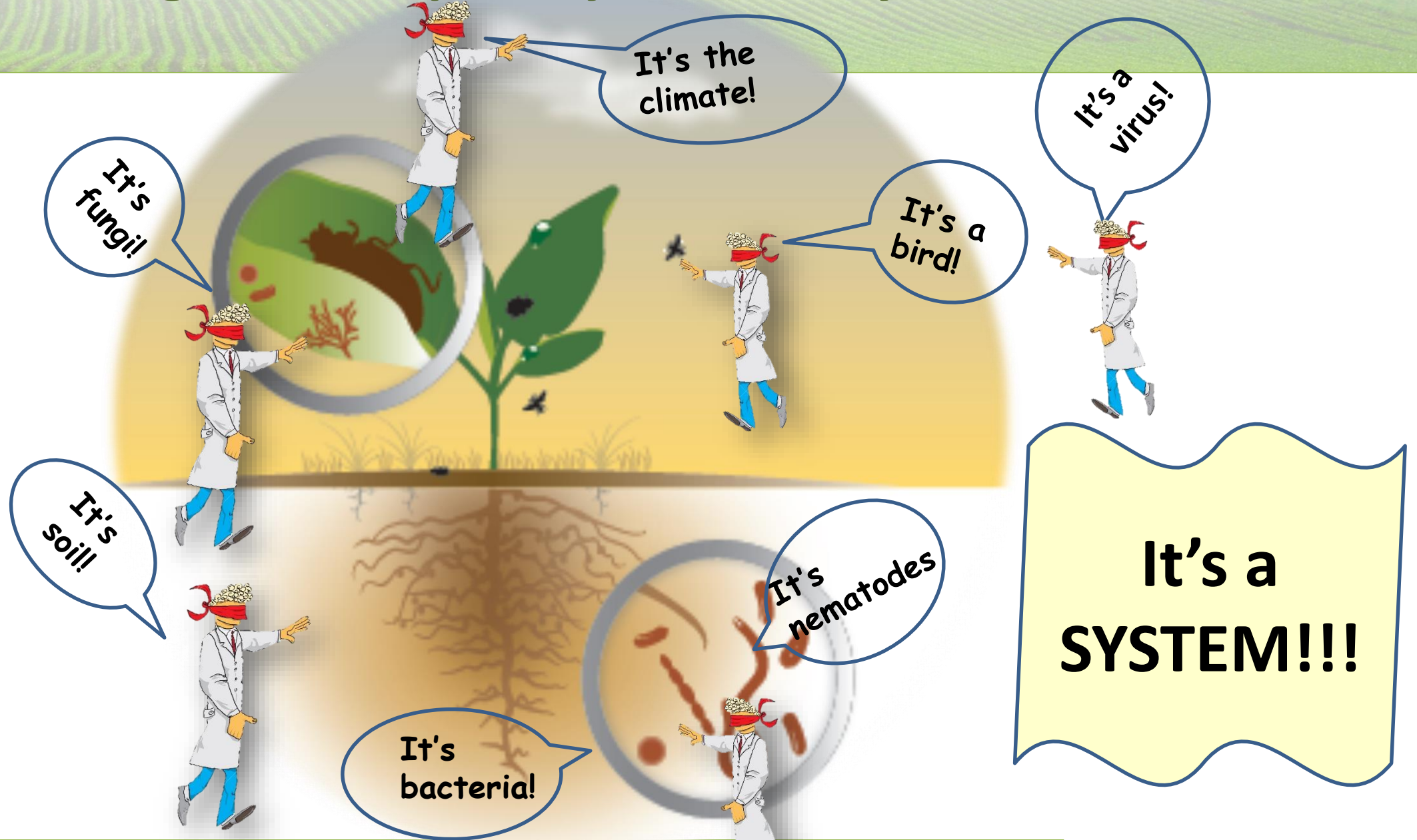
## In 1 g soil:

- \*1 billion **bacteria**
- \*100 million **virus**
- \*100 thousand **fungi & microalgae**
- \*10's of thousands of **protozoa**
- \*hundreds of **nematodes**





# Embracing the complexity of the Phytoboime!





The New York Times Magazine

May 18, 2015

THE  
SECRET  
LIVES  
OF

# Germ

WHAT WE CAN LEARN FROM OUR MICROBIOME. BY MICHAEL POLLAN

## Gut bacteria could predict asthma in kids

Sarah Williams, SCIENCE Sept 30, 2015

## When Gut Bacteria Changes Brain Function

....the microbiome may play a role in regulating how people think and feel.

David Kohn *The Atlantic* June 24, 2015



## Wherever You Go, Your Personal Cloud Of Microbes Follows

ROB STEIN, NPR

SEPTEMBER 22, 2015 8:38 AM ET



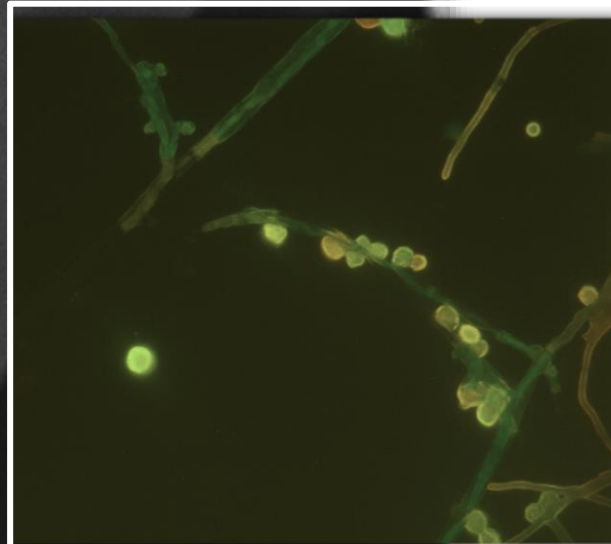
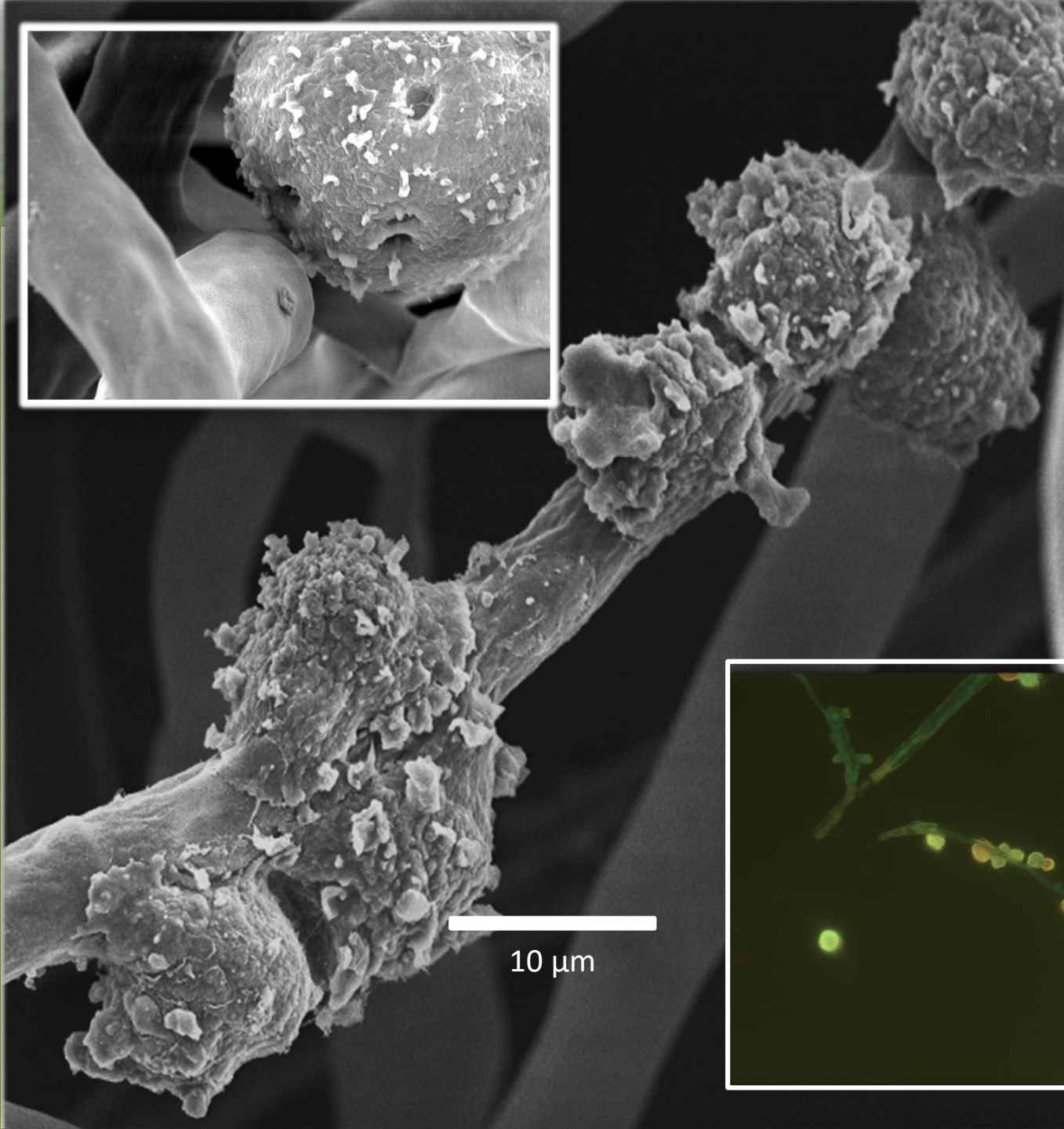
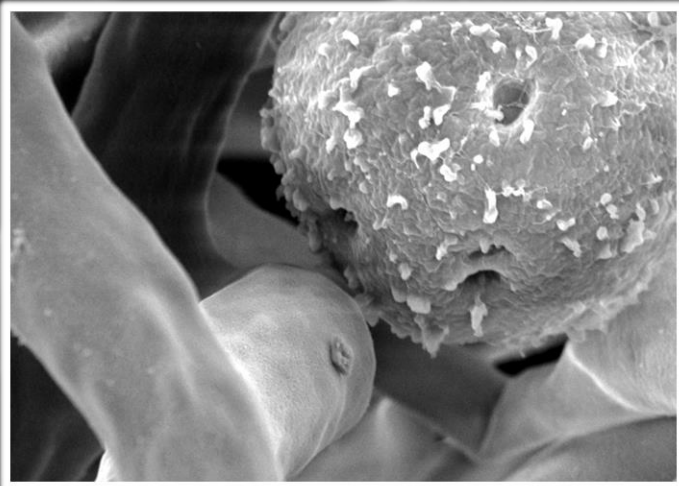


# Grazers & predators: important phytobiome members

e.g., *Vermamoeba vermiformis* attach to *Rhizoctonia solani* mycelia, consume mycelial contents, and encyst.

- What is the net impact of predators & grazers on the microbiome?
- Can these be manipulated to enhance plant health, quality and productivity?

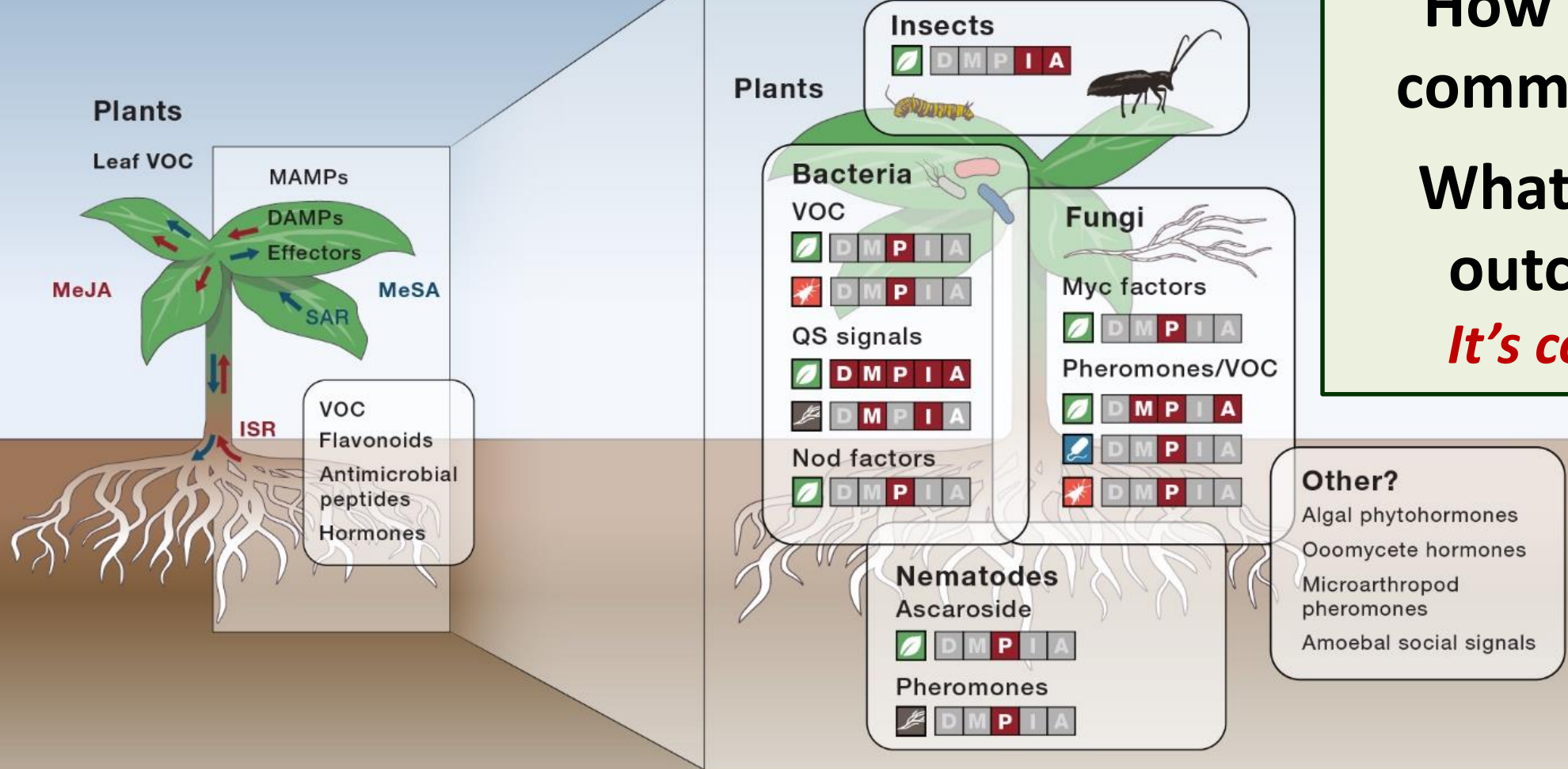
John Long et al. unpubl.





# Phytobiome members communicate!

Leach et al. 2017 Cell



How do they communicate?

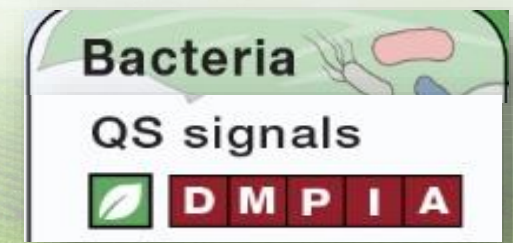
What are the outcomes?

*It's complex!*



# Interkingdom communications: Quorum sensing (QS)

Leach et al. 2017 Cell



- Bacteria and plants communicate through chemical signals
- *Can we manipulate production of signals to increase plant disease resistance?*

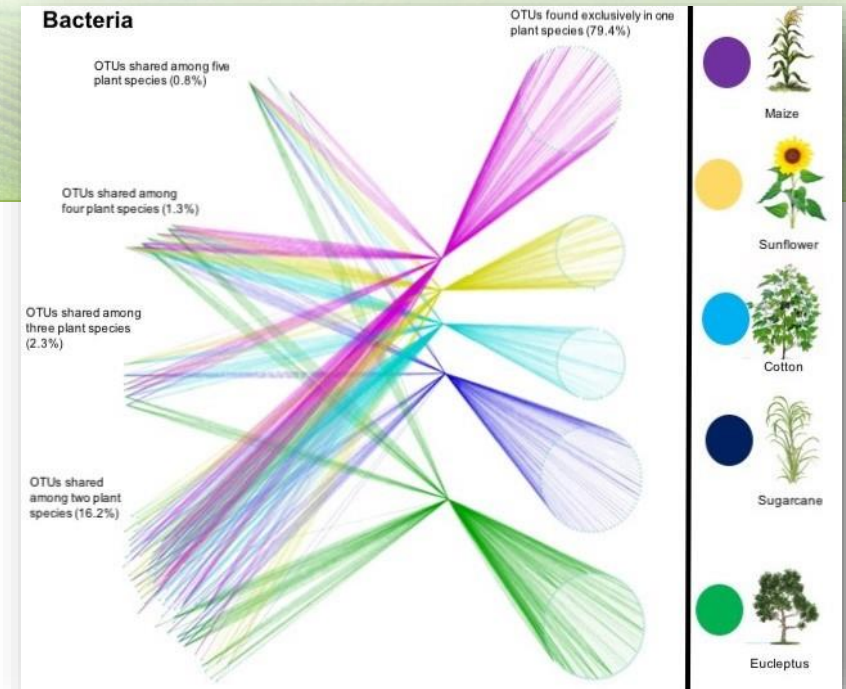


# Plants control their microbiome composition/diversity

- Plant signals attract/enrich specific microbes in the rhizosphere
- Plants regulate the entry of microbes to fine-tune the internalized microbial communities



Johnston-Montje et al, 2014. BMC Plant Biol



Trivedi in Leach et al. 2017. Cell

- Plants can transmit bacterial endophytes from generation to generation through seed
- Geographically distinct soils contribute taxonomically similar sources of bacterial endophytes



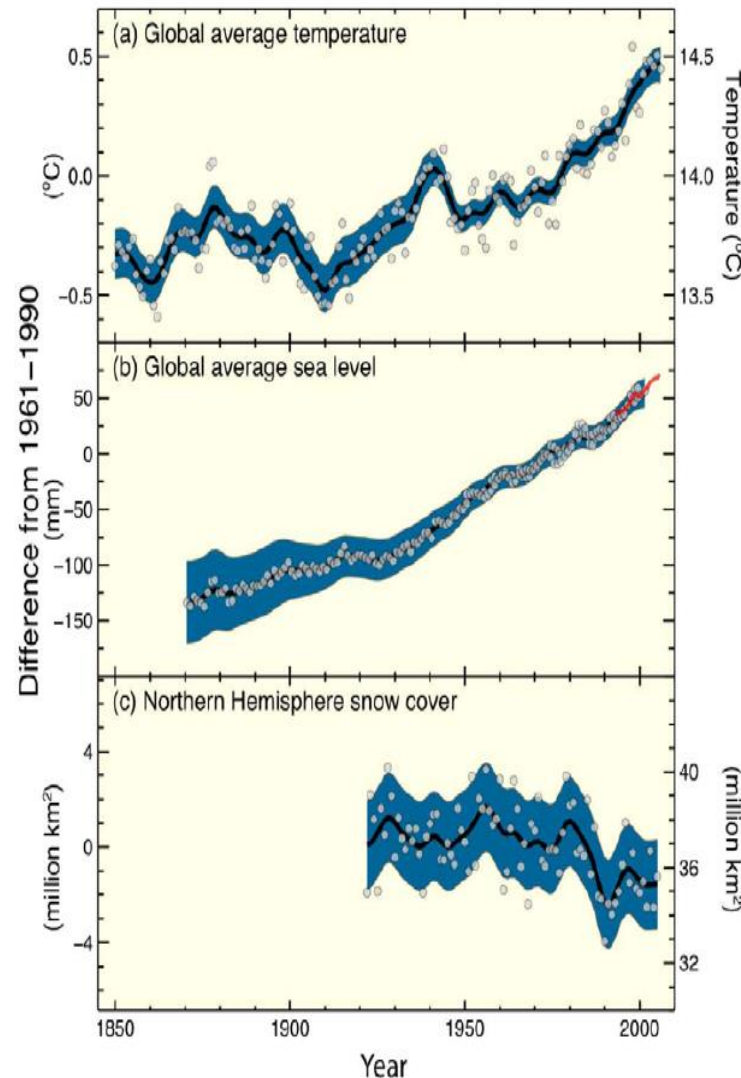
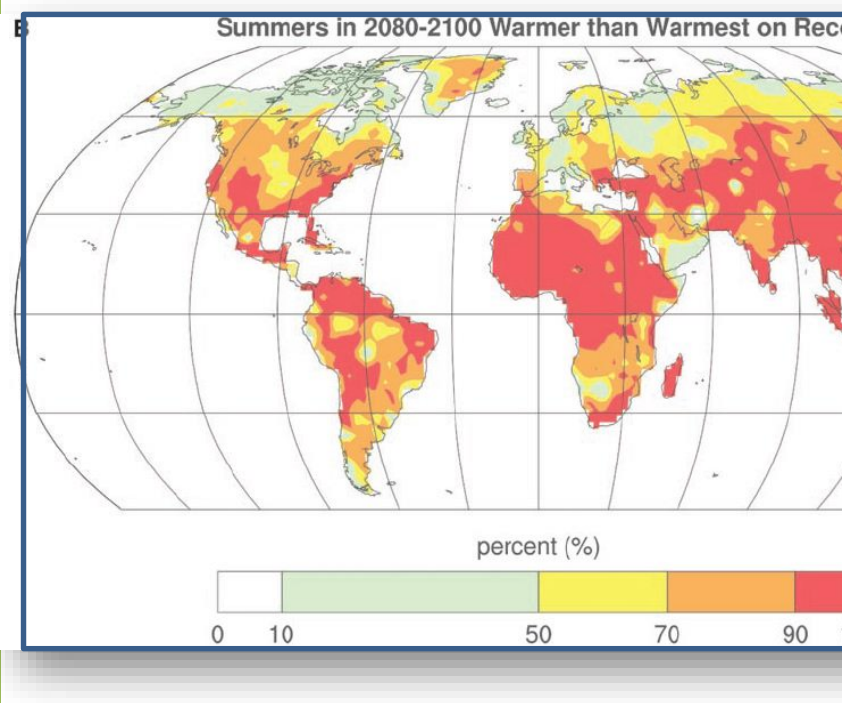
# Exploiting knowledge of the phytobiome

## What guides plant microbiome composition and dynamics?

- *Can we exploit that information to improve crop health and productivity?*
- *Can we **breed** for plants that select for 'healthy' or 'useful' microbiomes?*
- *Can we develop/engineer microbial mixes that establish/restore a 'healthy' microbiome?*



# Environmental impacts on phytobiome interactions




*“Warming in the climate system is unequivocal...”*

International Panel on Climate Change 2007, *Climate Change Synthesis Report*

Battisti and Naylor, 2009. Science





***“For the major crops (wheat, rice, and maize) in tropical and temperate regions, climate change without adaptation is projected to negatively impact production ....”***

**IPCC, 2014**

**(<http://www.ipcc.ch/report/ar5/>)**



# Members of the phytobiome and their interactions are impacted by the environment

## Abiotic Stresses

Temperature Stress

Drought

Salinity

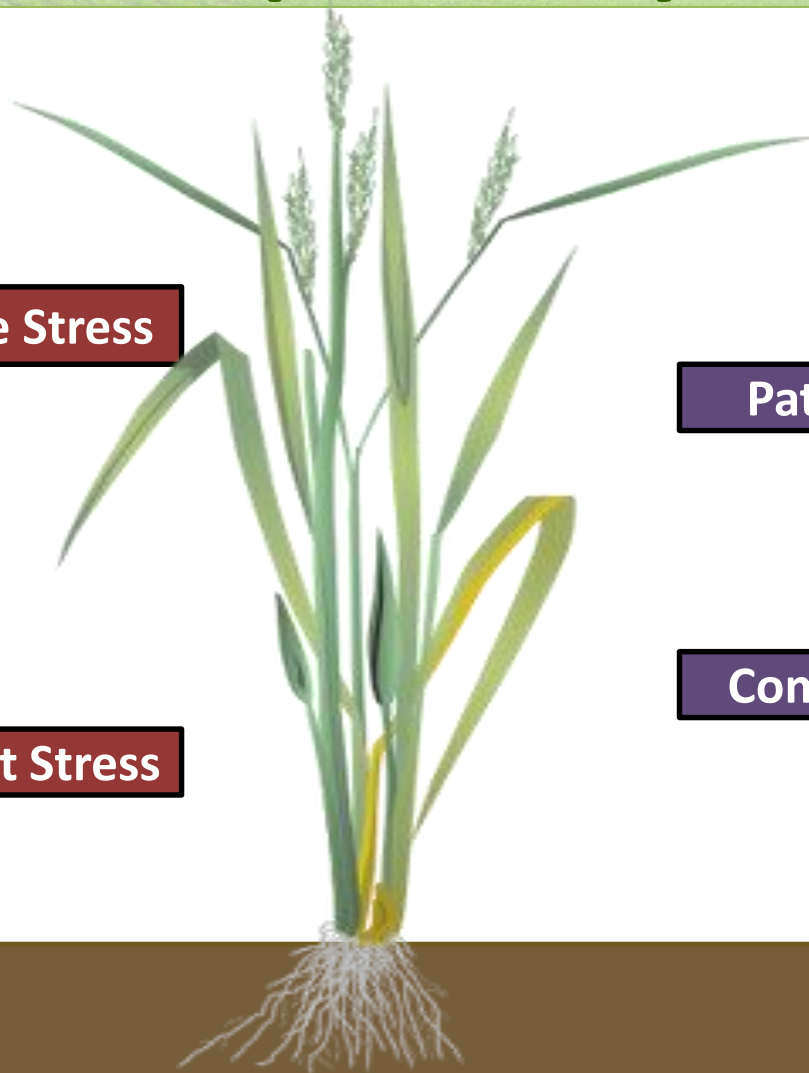
Nutrient Stress

## Biotic Stresses

Pathogen Attack

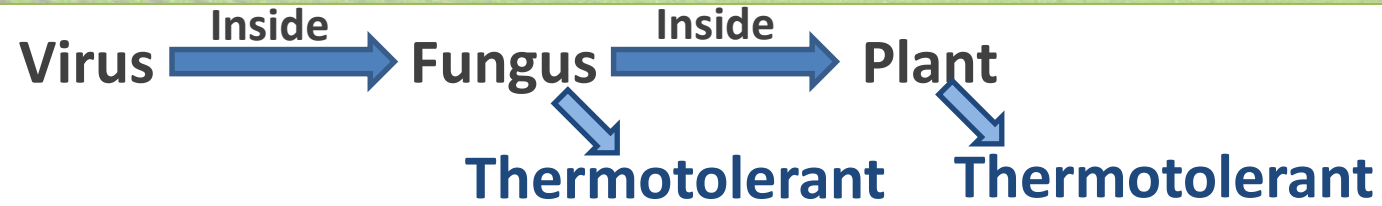
Pest Attack

Competition

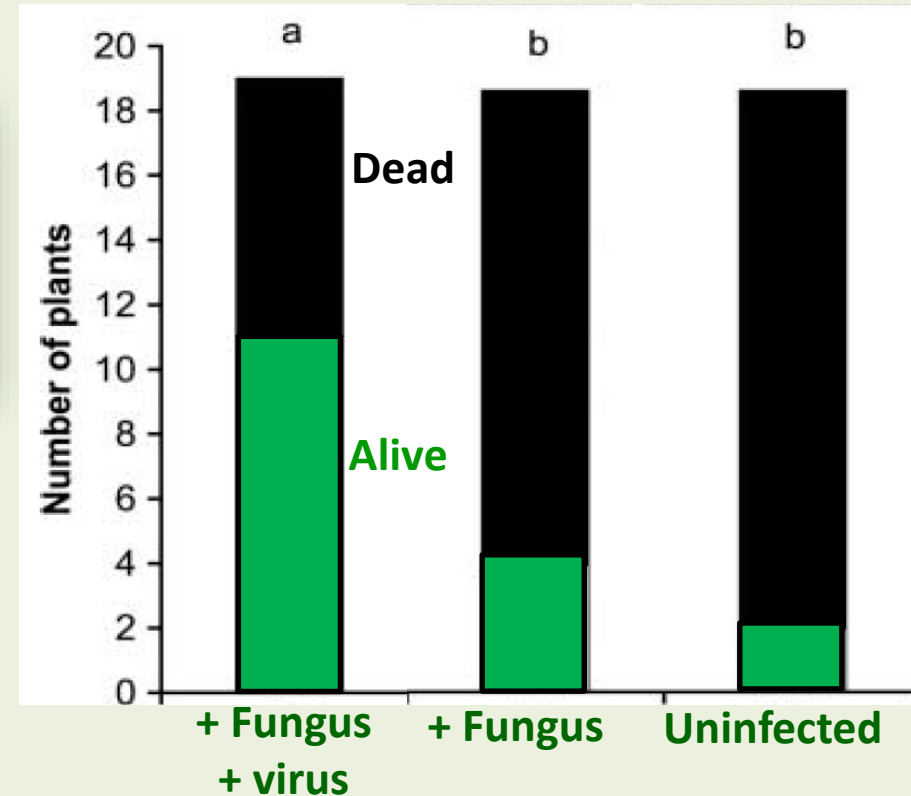
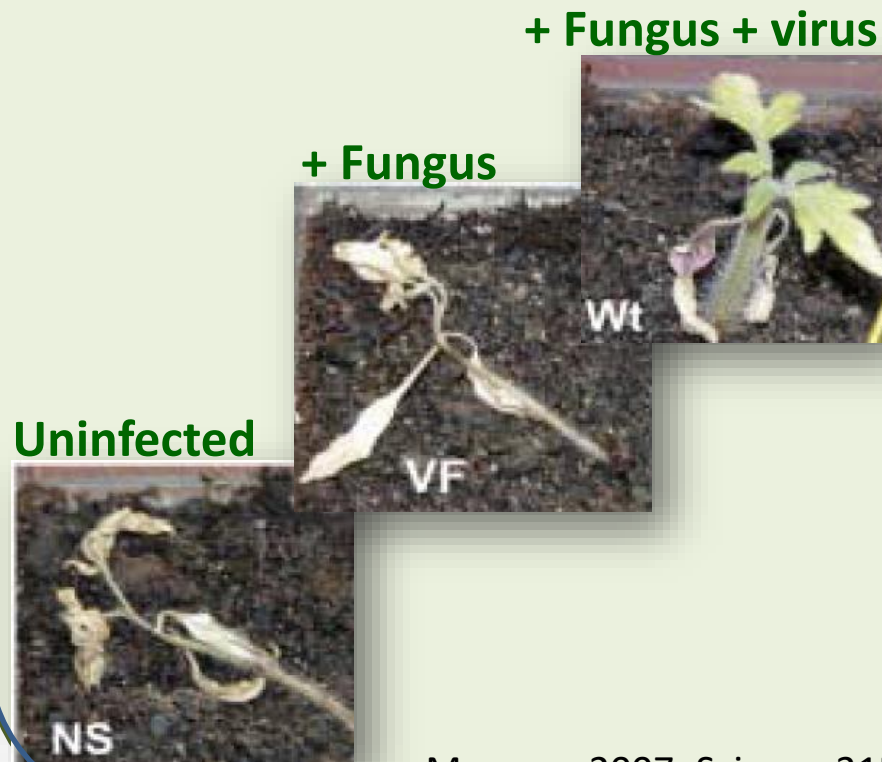




# Microbes confer heat tolerance to plants

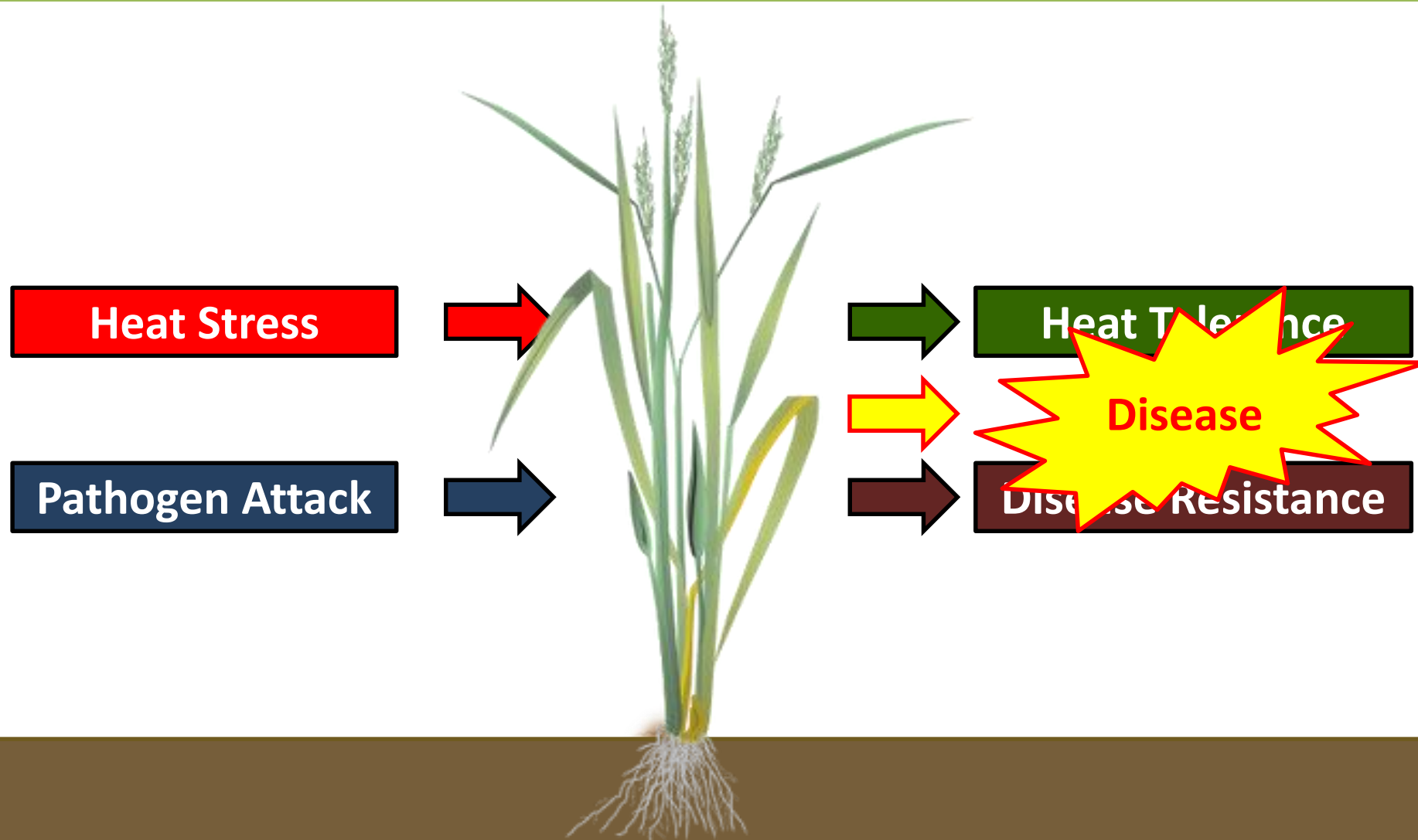


## Heat-treated tomato plants





# Abiotic and biotic stresses are usually simultaneous

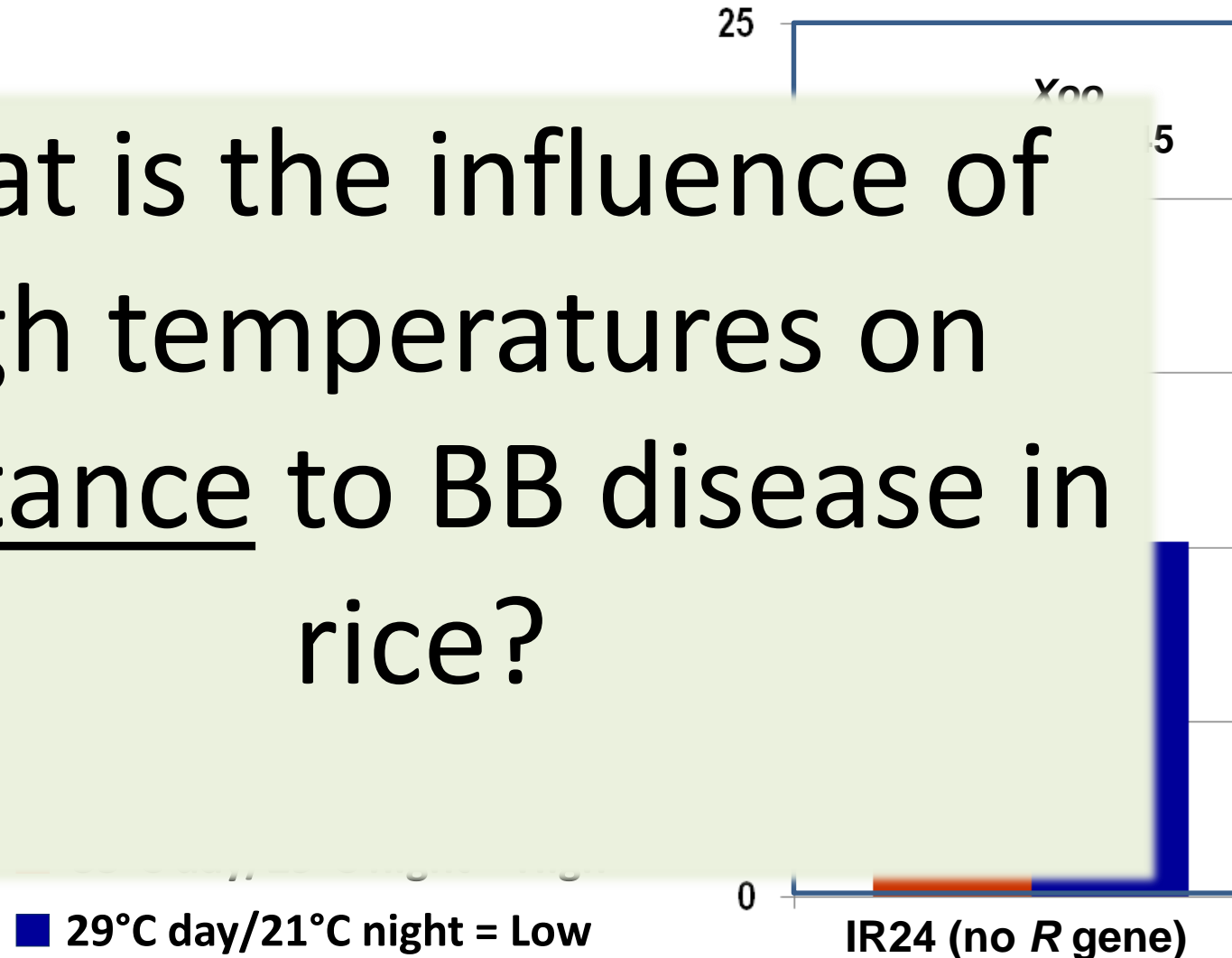




For many plant diseases, disease pressure increases with increasing temperature

- Bacter
- dise
- seas
- muc
- cool

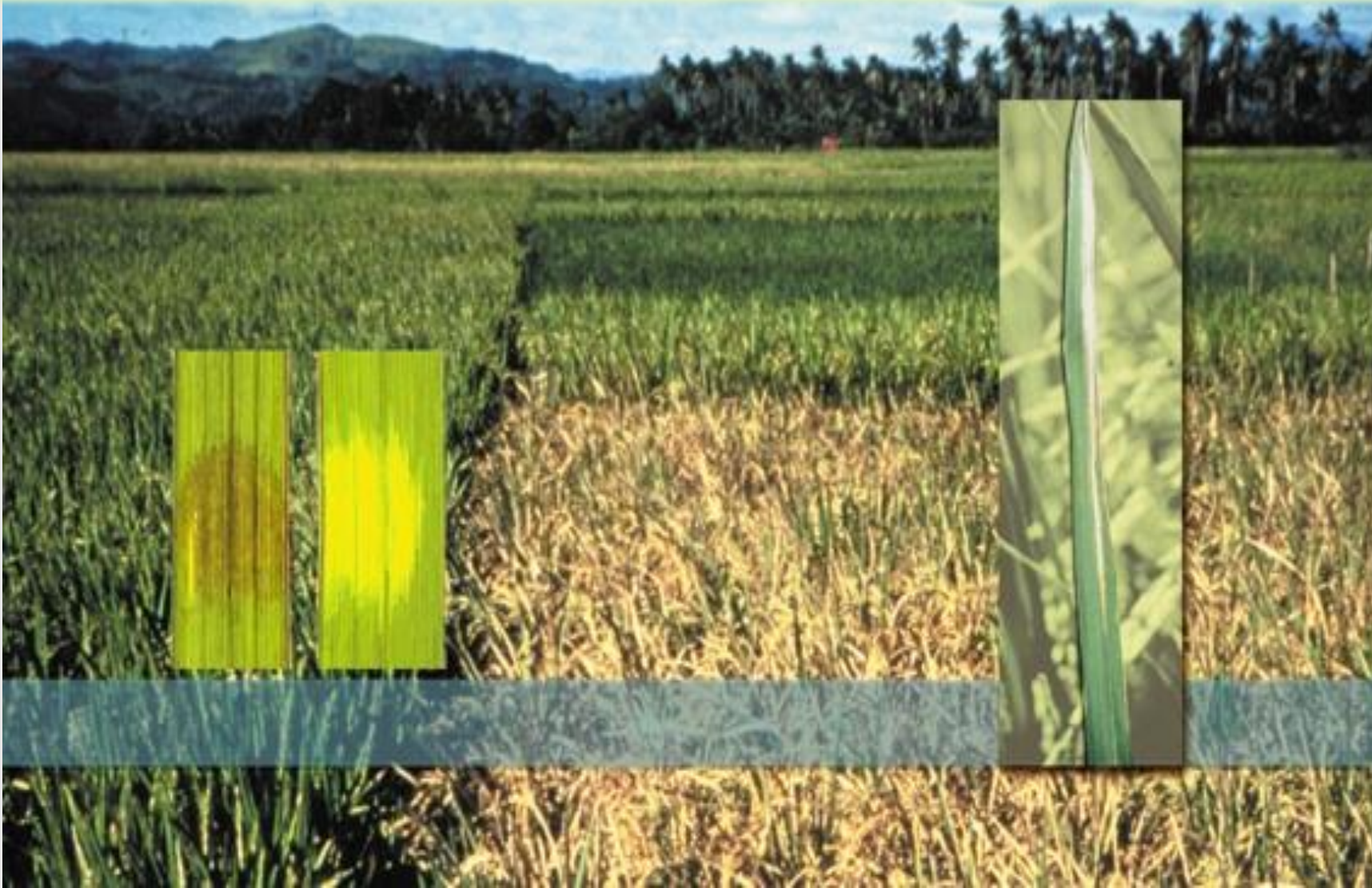
What is the influence of high temperatures on resistance to BB disease in rice?





# Most sources of resistance to bacterial blight disease are single *R* genes

~40 *R* genes identified





Most rice bacterial blight resistance genes  
lose efficacy at high temperatures

**EXCEPT *Xa7***

Why are plants more susceptible to  
disease at high temperatures?

Why are some resistance genes more  
effective at high temperatures?



# **ABA responsive genes are downregulated by high temperature during resistant interactions (Transcriptome Analysis)**

## **Why do we care?**

- **Identify/create resistance sources that are effective and durable at high temperatures**
- **Facilitate planning/breeding for sustainable crop production under conditions of increasing global temperatures**



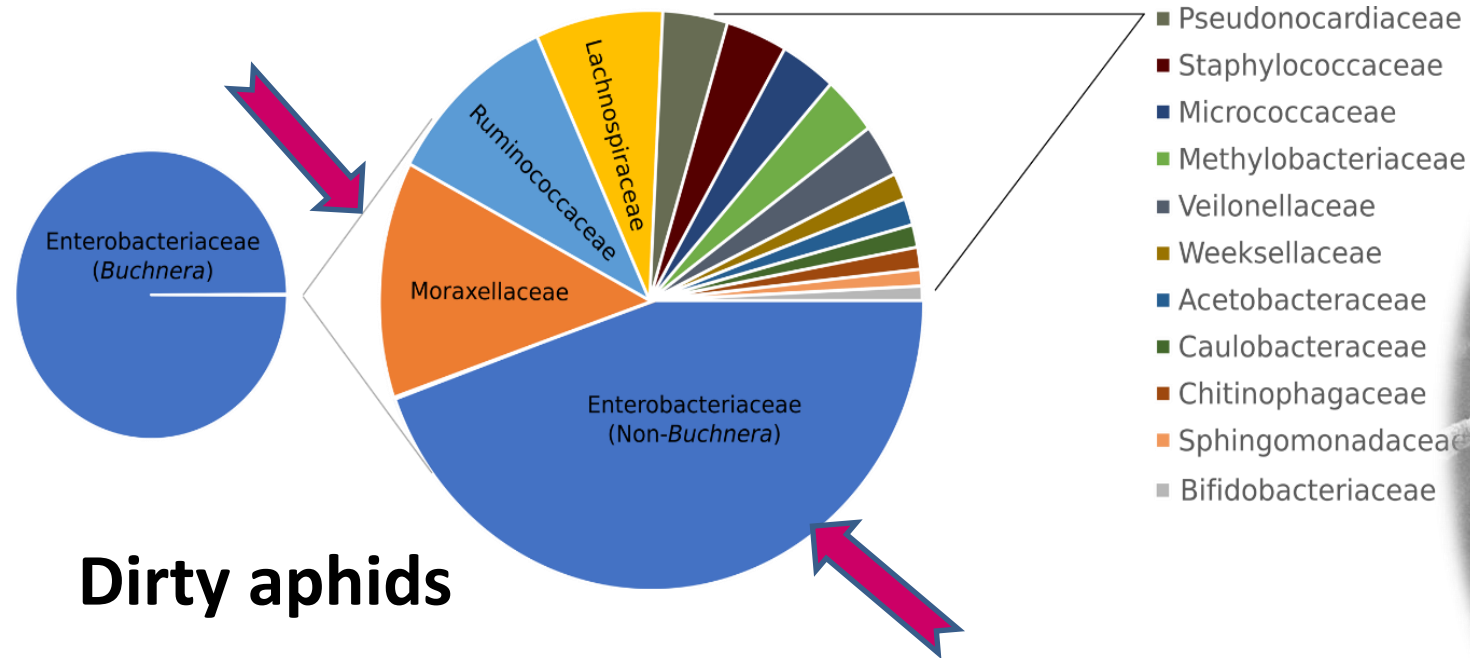
# Can we manage the phytobiome to control plant pests?

- Do **bacteria** associated with Russian wheat **aphids** enhance aphid virulence to **plants**?



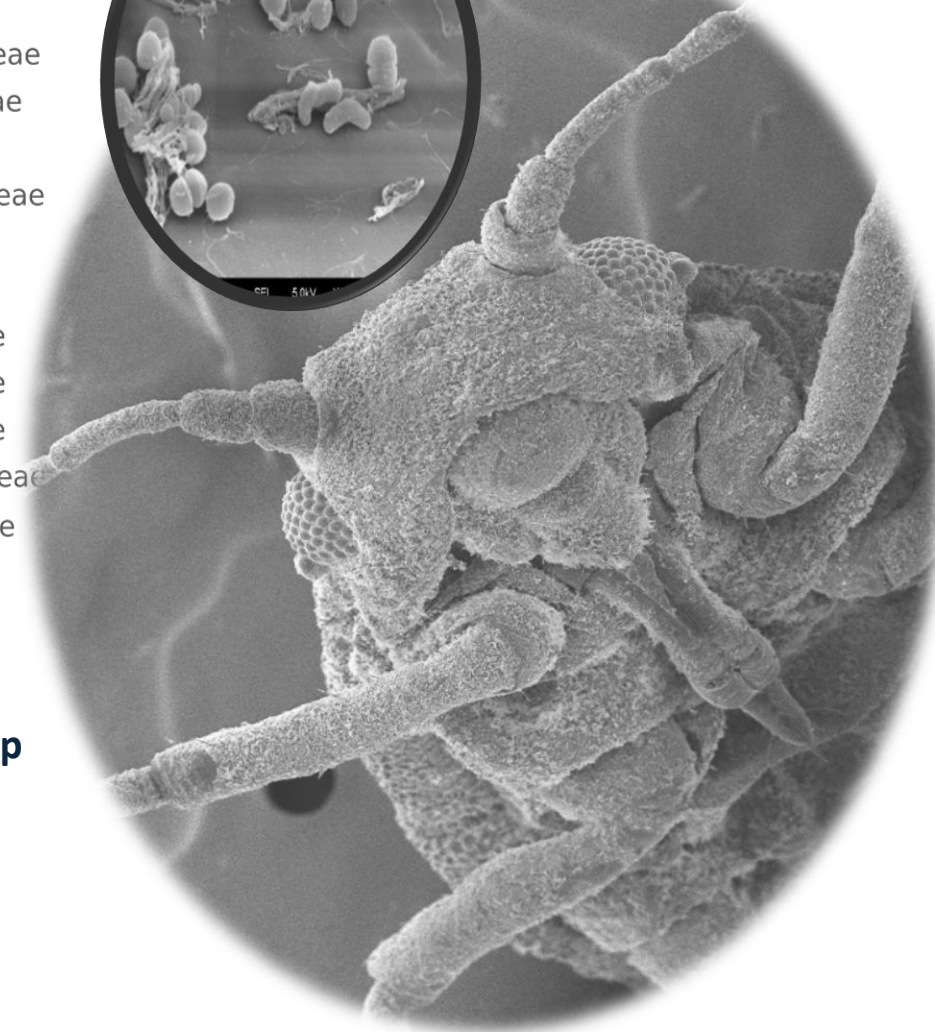
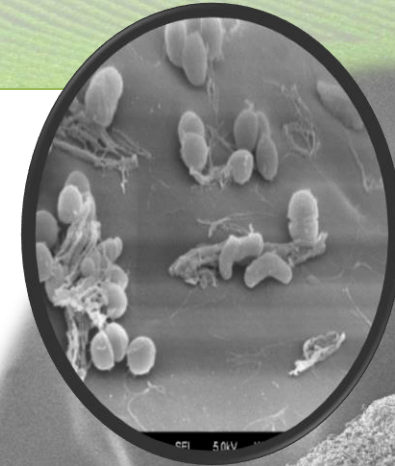


# The Russian wheat aphid microbiome is diverse



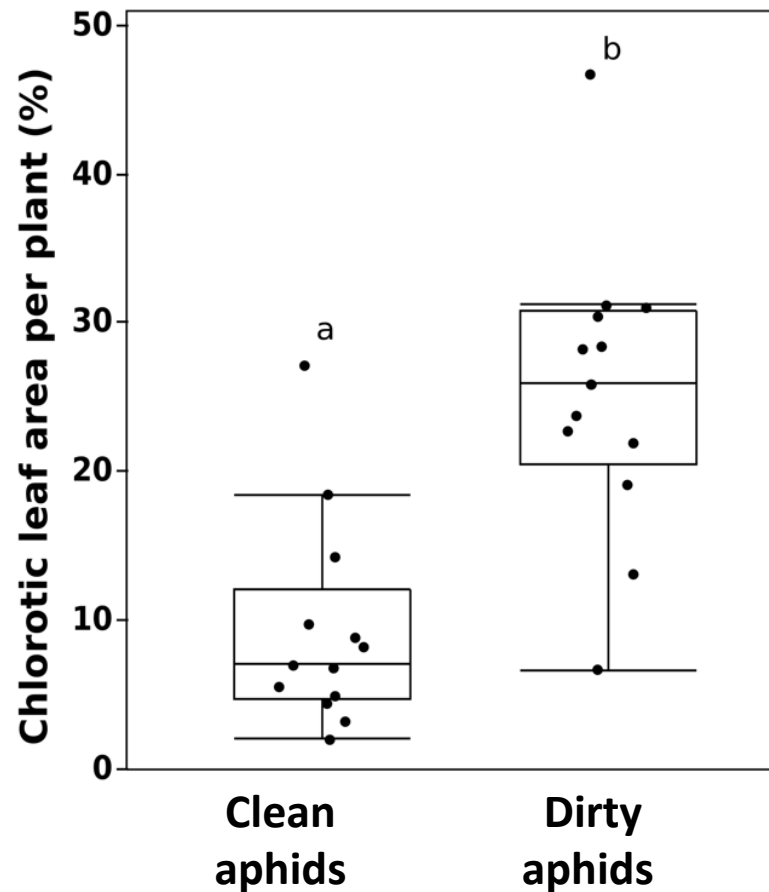
**Dirty aphids**

Luna, Van Eck, Campillo et al., in prep





# Bacteria associated with Russian wheat aphid enhance aphid virulence to wheat



Aphids treated with antibiotics (to kill bacteria) cause less damage to wheat





# Managing the phytobiome to control plant pests

## Phytobiome knowledge can guide management strategies

- $H_0$  : Bacteria manipulate plant defenses to enhance aphid virulence
- *Should breeding programs target the bacteria rather than the insect?*
- *Can the leaf microbiomes be altered to protect plants from aphid feeding?*
- *Have some aphids evolved to rely on bacteria for virulence, and if so, can we identify novel resistances that detect/disrupt that process?*





# *A future of ....Healthy and productive cropping systems*

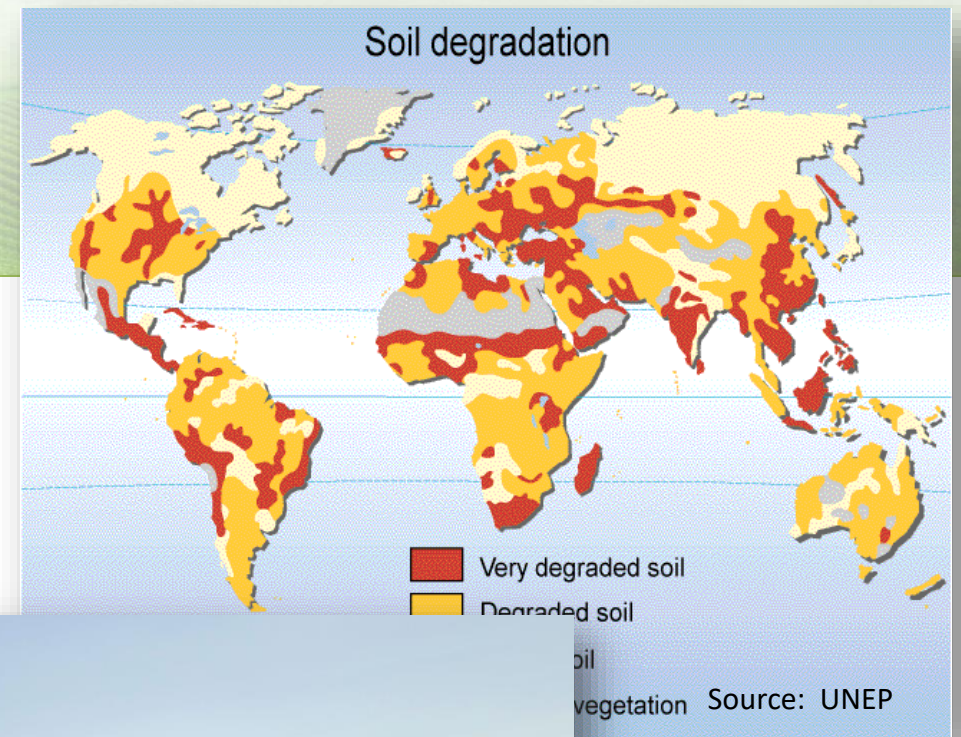
- **Plants that ‘select’ & foster beneficial microbiomes to:**
  - Enhance plant growth/productivity
  - Control diseases and insect pests
  - Increase plant nutritional quality





## *A future of:*

- **Managed/engineered phytobiomes that:**
  - rebuild depleted/degraded soils
  - produce with less water, or in unfavorable environments



**and lands for survival!**





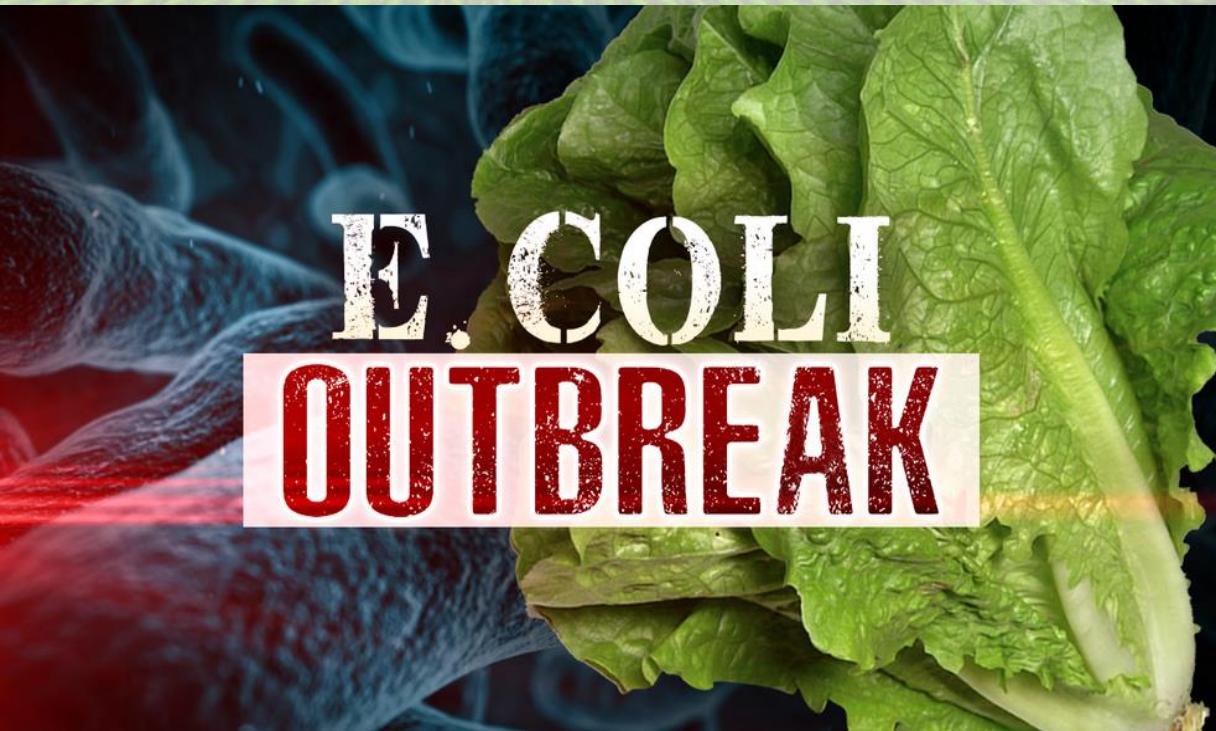
*A future of.....*

*Practices that promote healthy, productive soils*





*A future of safer, healthier foods.....*





# *Phytobiome....*

- Achieve sustainable agricultural productivity through a systems-level understanding of the diverse interacting components







# INTERNATIONAL ALLIANCE FOR PHYTOBIOMES RESEARCH

*A nonprofit consortium of industry,  
academic, and governmental  
scientists*



A close-up, low-angle shot of a dense field of tall, vibrant green grass. The blades are long and slender, reaching upwards towards the sky. The background shows a clear blue sky with scattered white clouds. In the distance, a dark, silhouetted hill or mountain range is visible under the bright sky.

**¡Gracias!  
Thank you!**