Instituto de ciências biomédicas

Bactérias e Interação com Plantas

Welington Luiz de Araújo
wlaraujo@usp.br

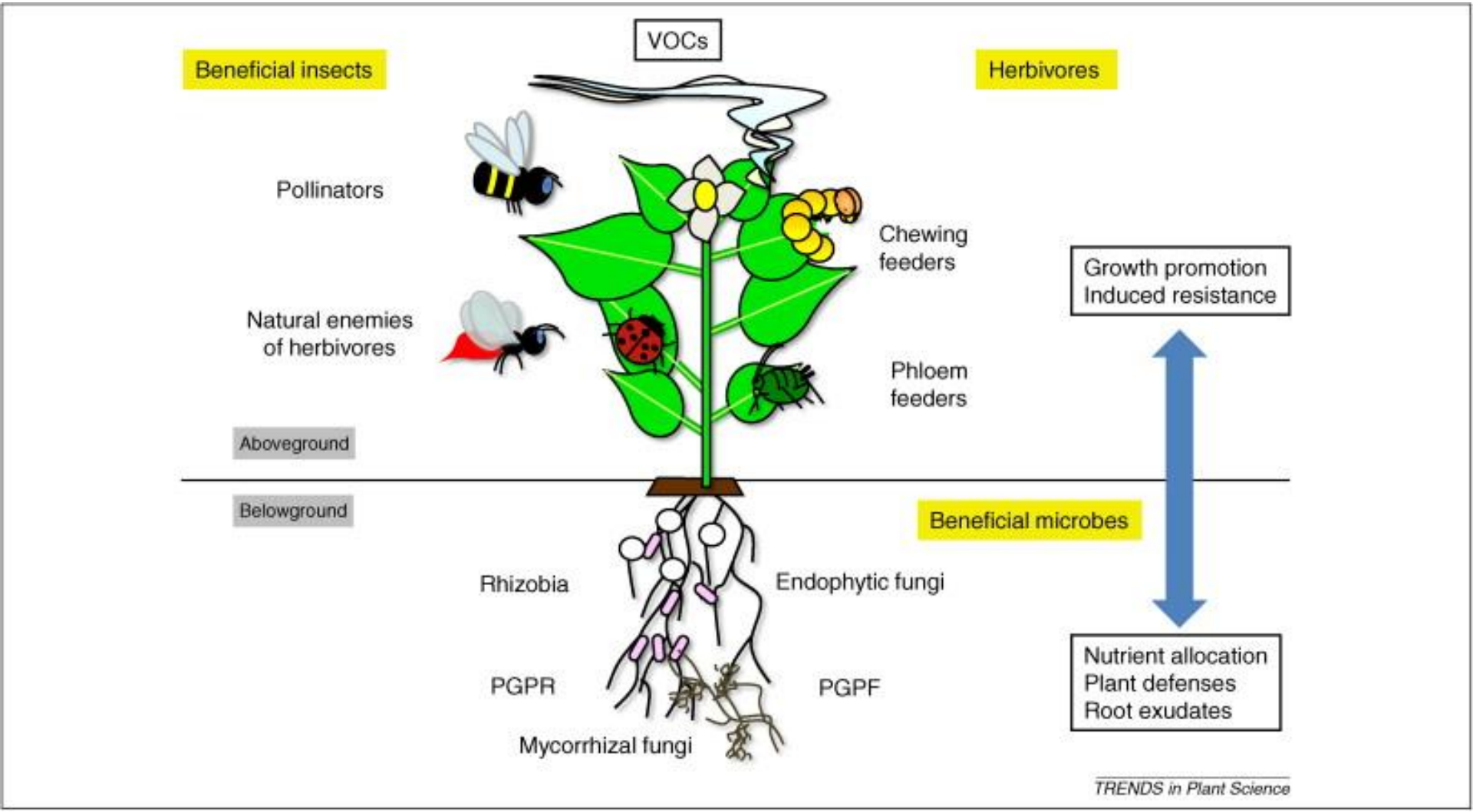
BMM0123- Ecologia de Ecossistemas
2021

Cultivo de plantas

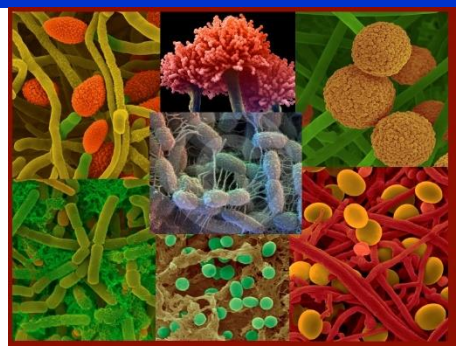
Interações no ambiente

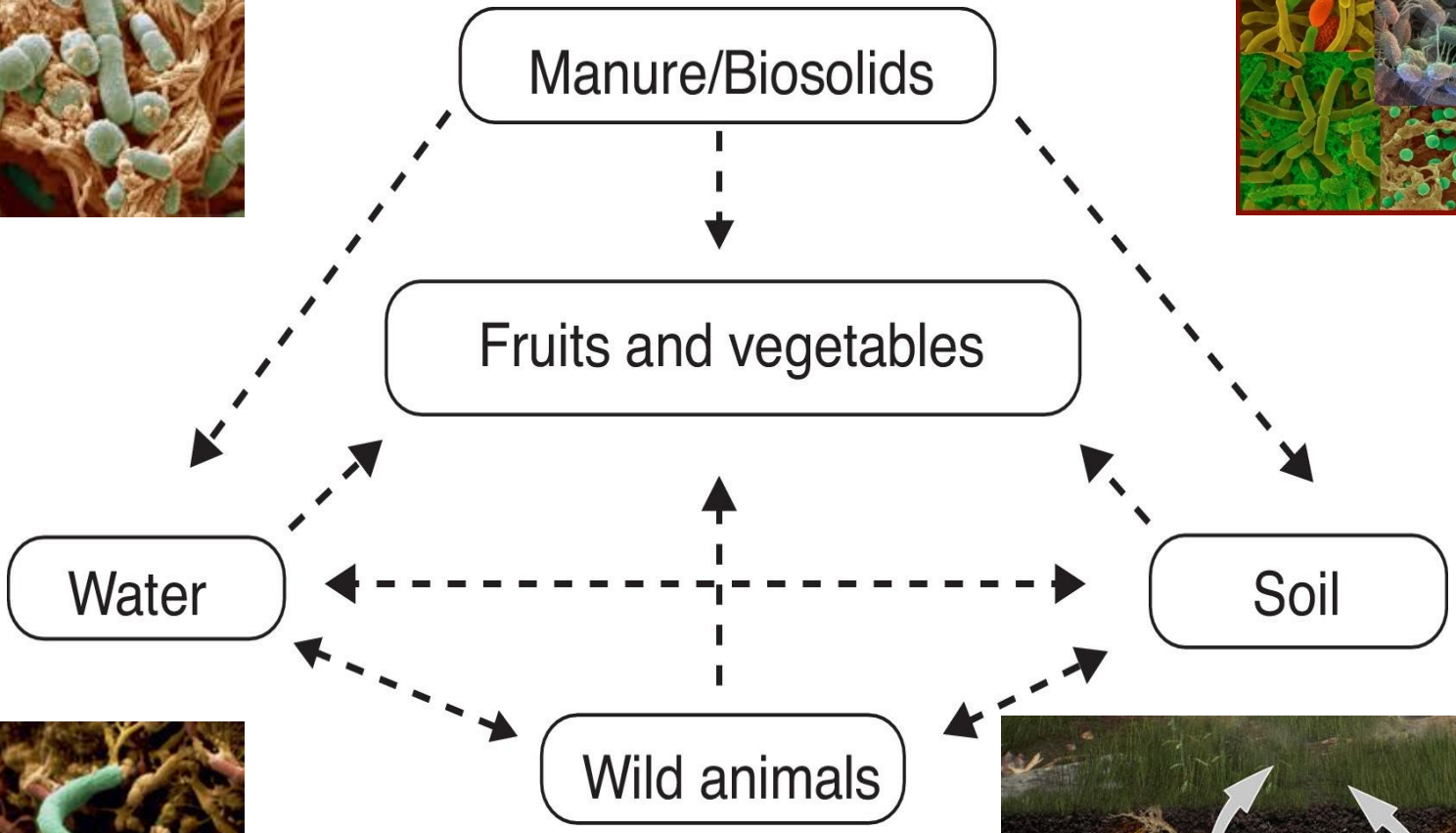
- A planta obtém nutrientes e água do solo
- A planta exsuda uma série de moléculas para o solo
- Interação química com diferentes espécies de seres vivos

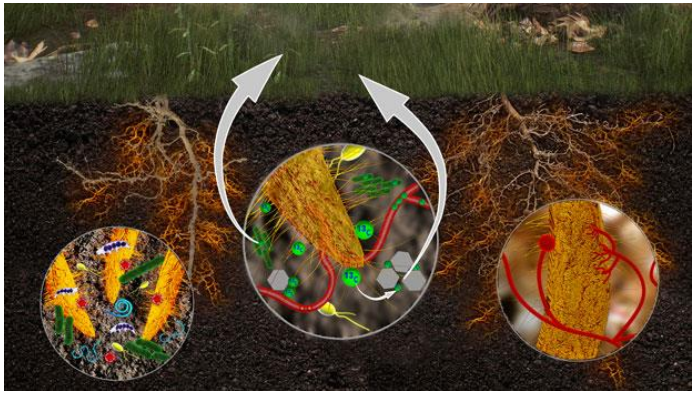
Micro-organismos nas plantas



Origem dos micro-organismos para as plantas

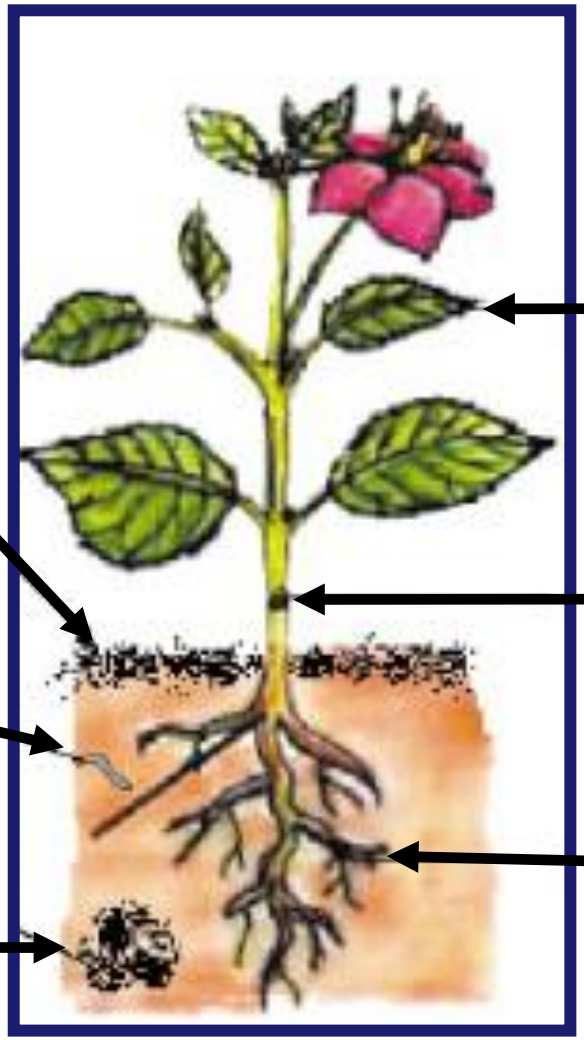






Maffei et al. (2016). Brazilian J. Microbiol. 47(1): 99-105

Micro-organismos nas plantas



Epifíticos

Solo

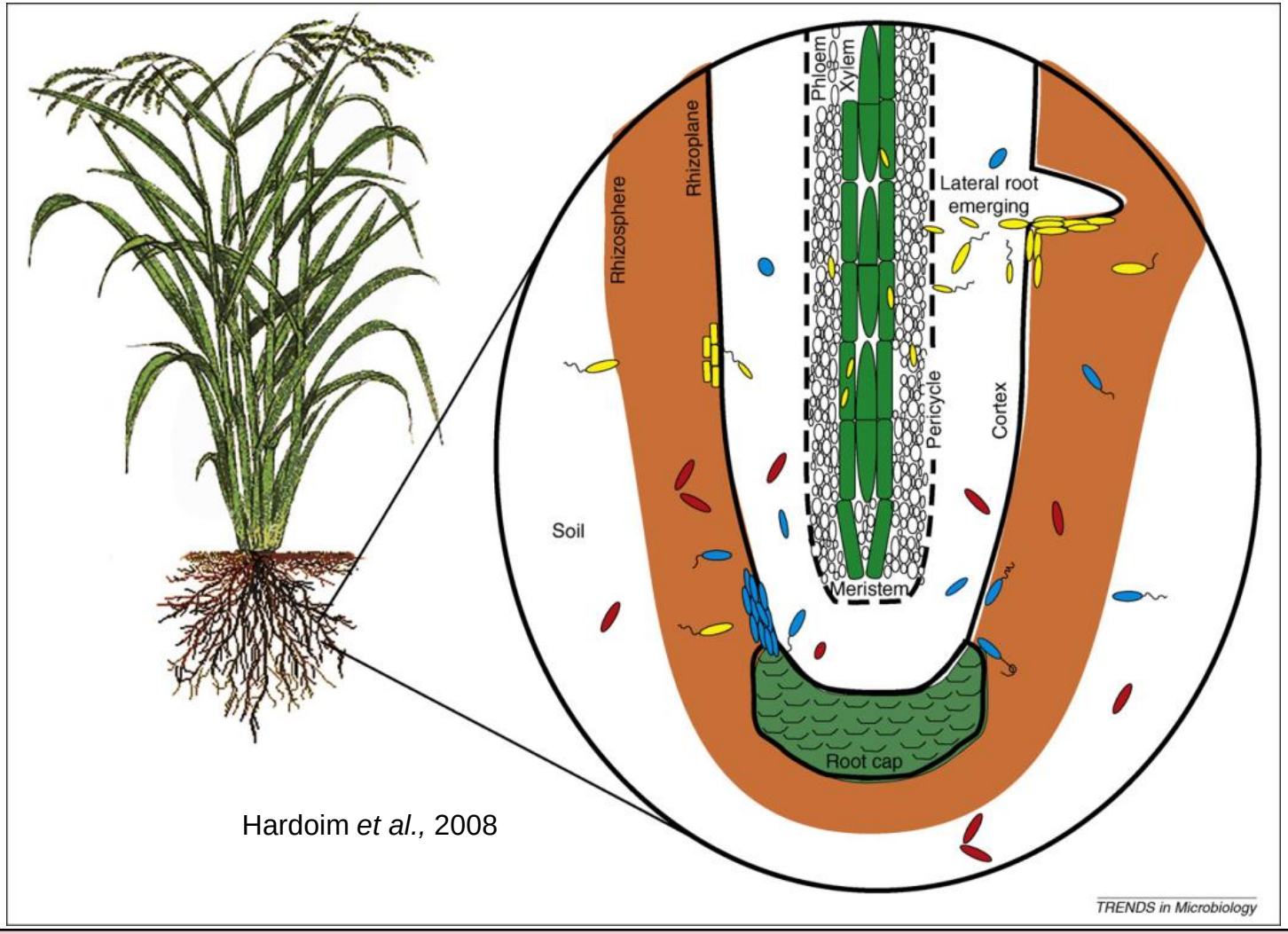
Endofíticos

Animais invertebrados

Rizosfera

Material em decomposição

Interação plantas com micro-organismos

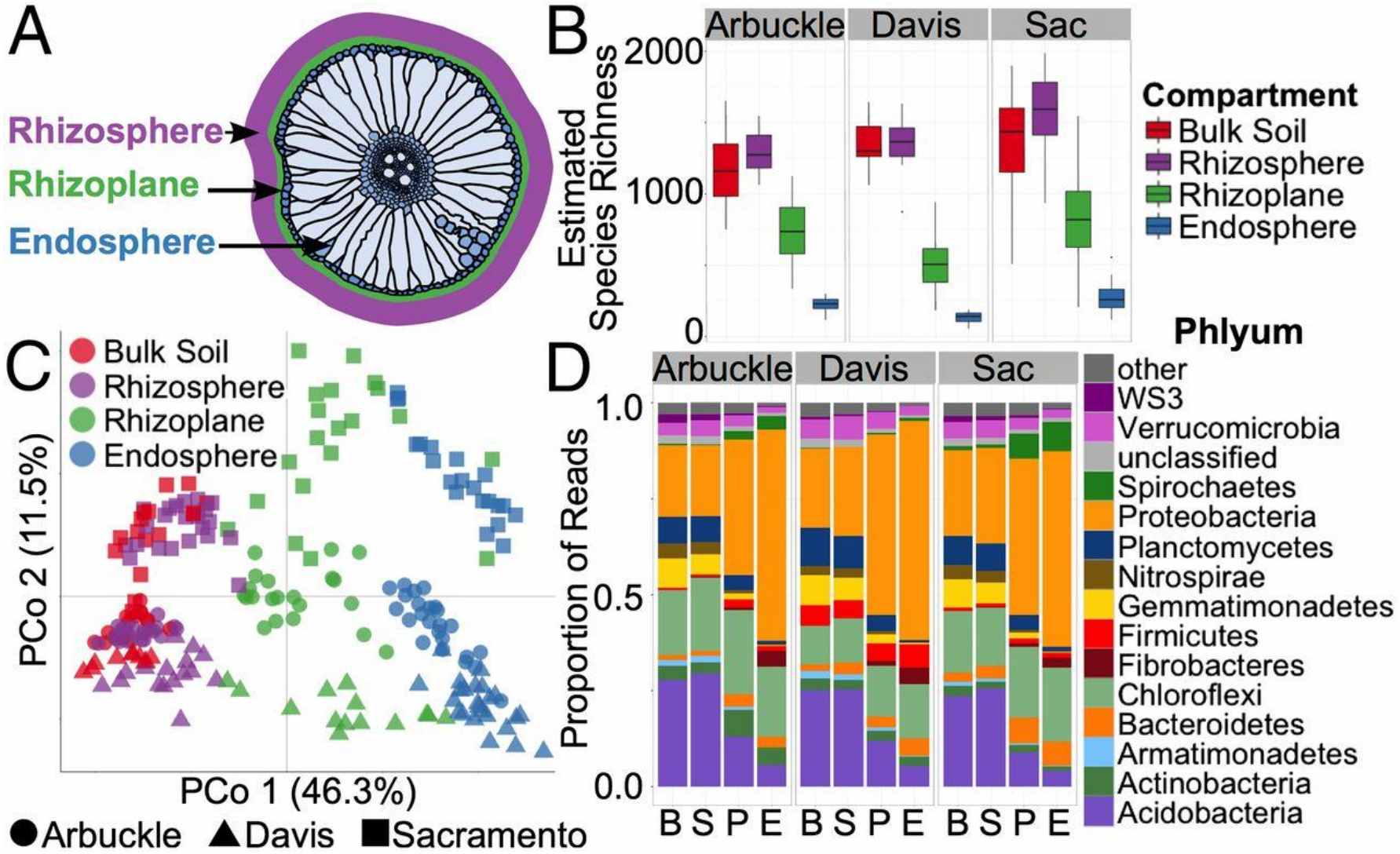


Hardoim *et al.*, 2008

Algumas bactérias podem colonizar a superfície, enquanto outras colonizam os tecidos internos da planta.

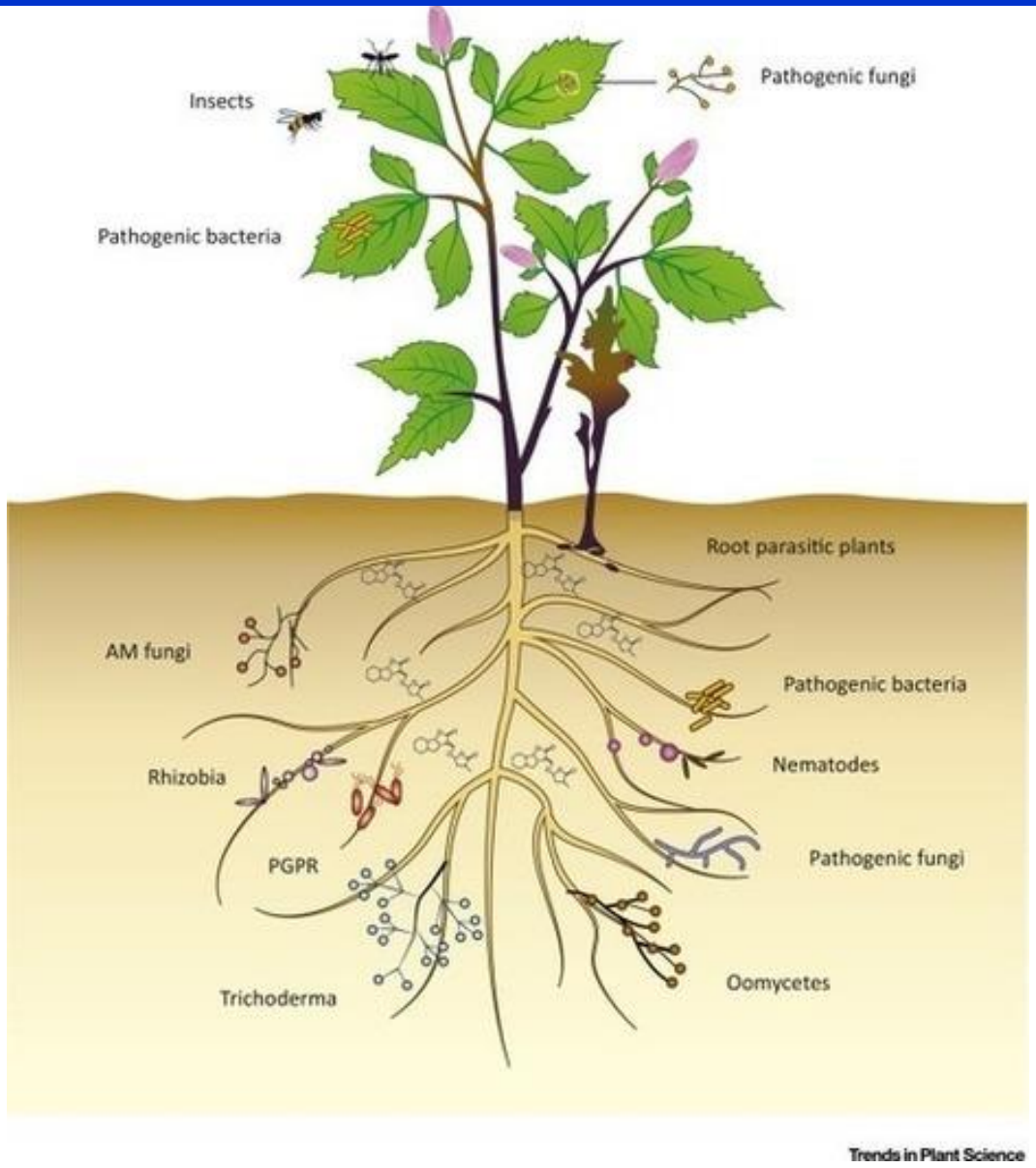
A mesma bactéria pode se estabelecer na superfície e no interior da planta.

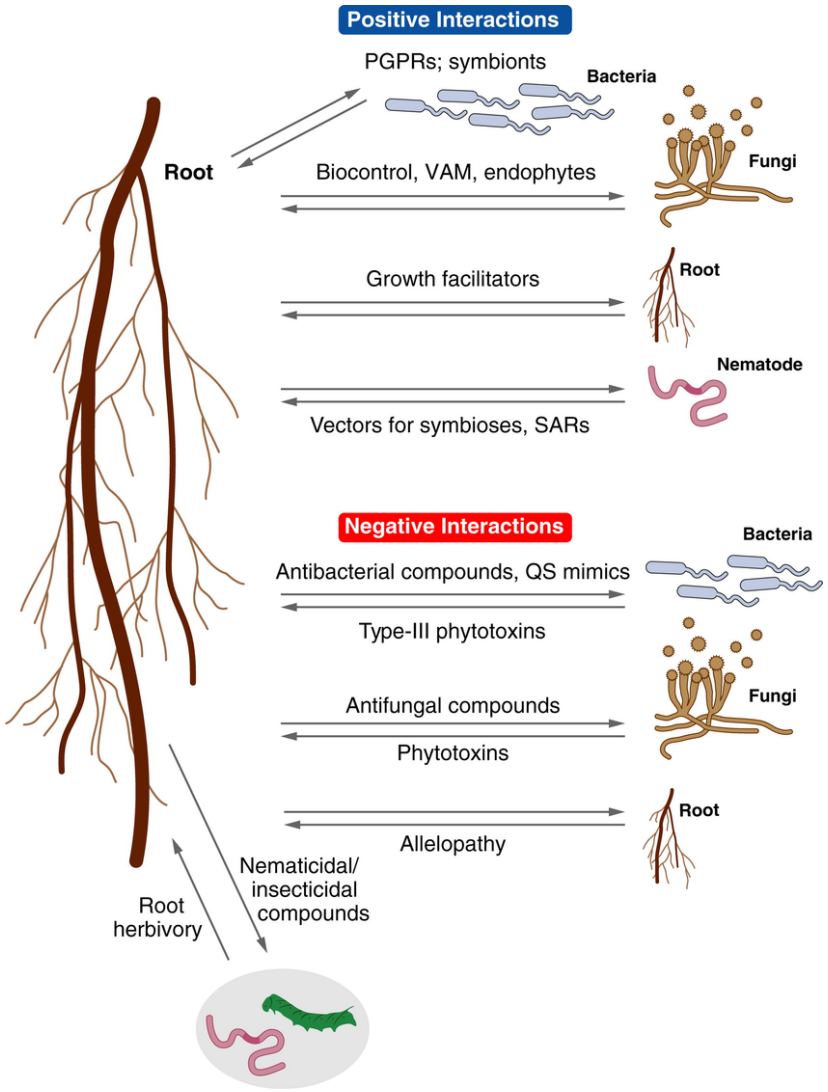
Diversidade de bactérias associadas à planta de arroz



Edwards et al. (2015) PNAS. 112(8): E911–E92

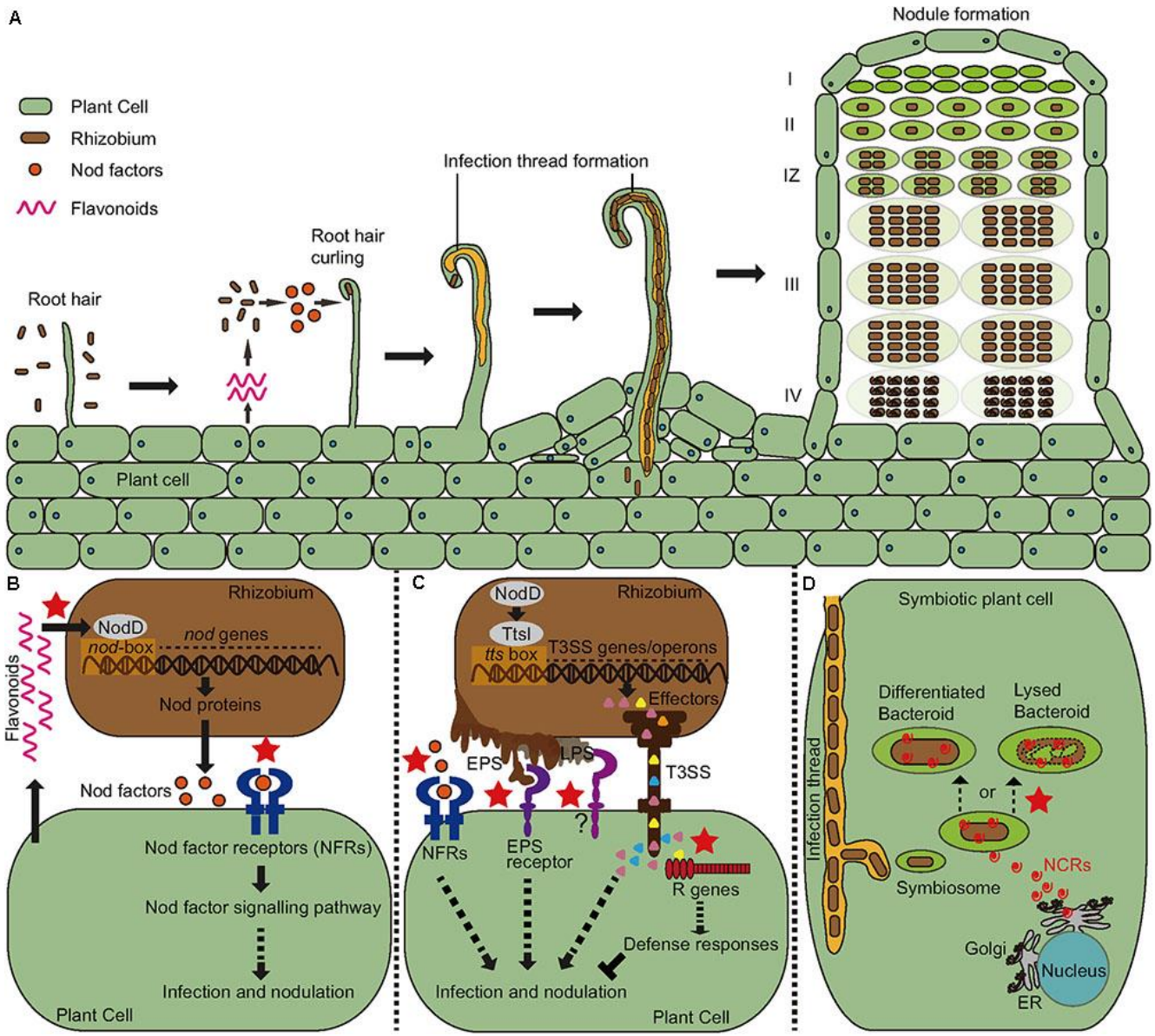
Interações microbianas nas plantas



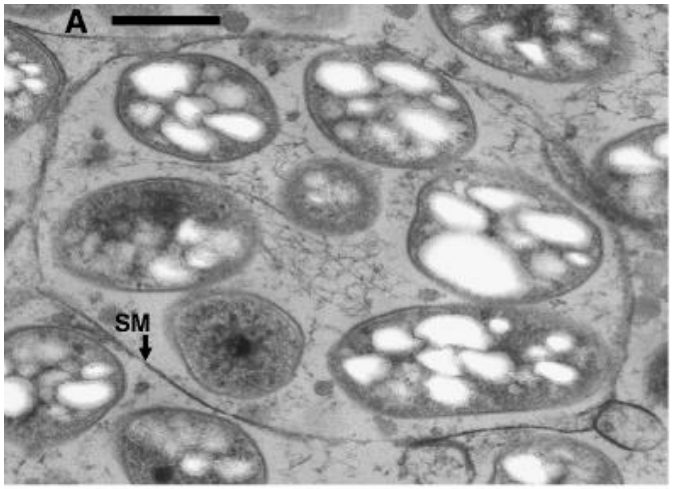


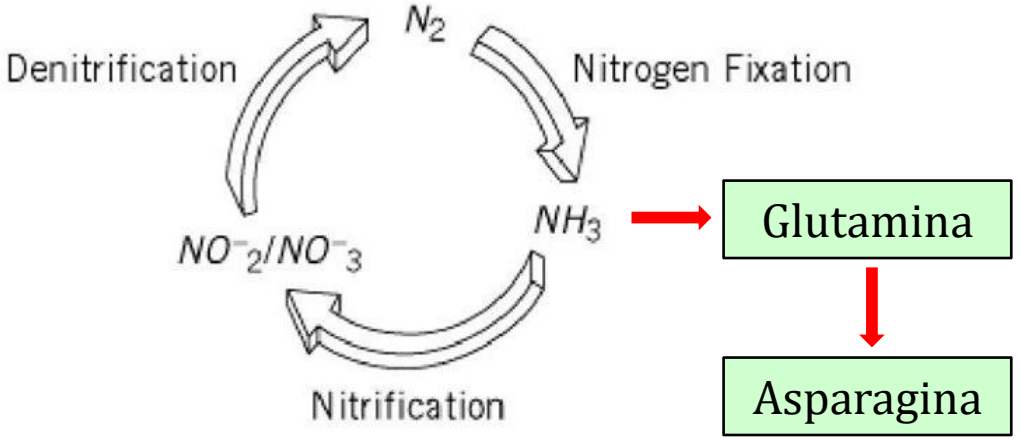
Bais HP, et al. 2006.
Annu. Rev. Plant Biol. 57:233–66

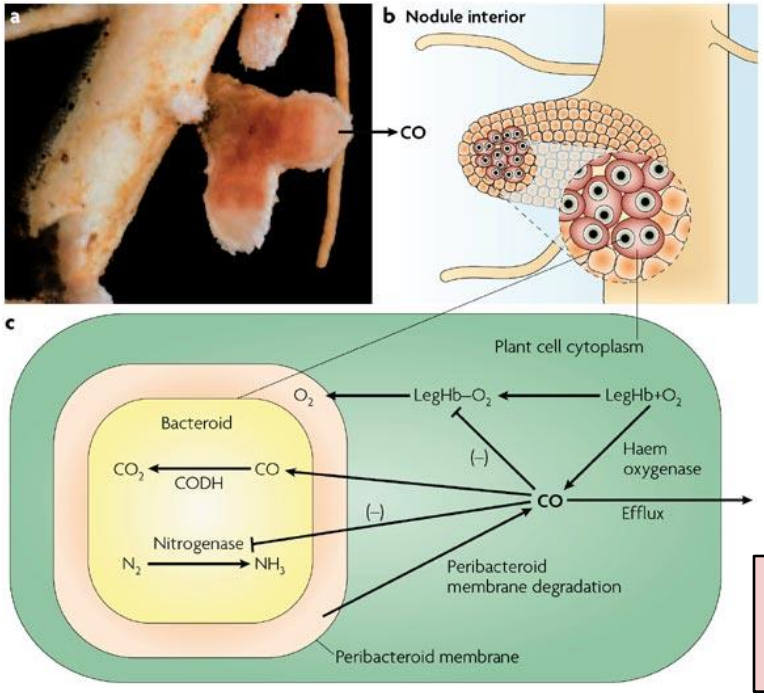
Interação entre *Bradyrhizobium* e Soja

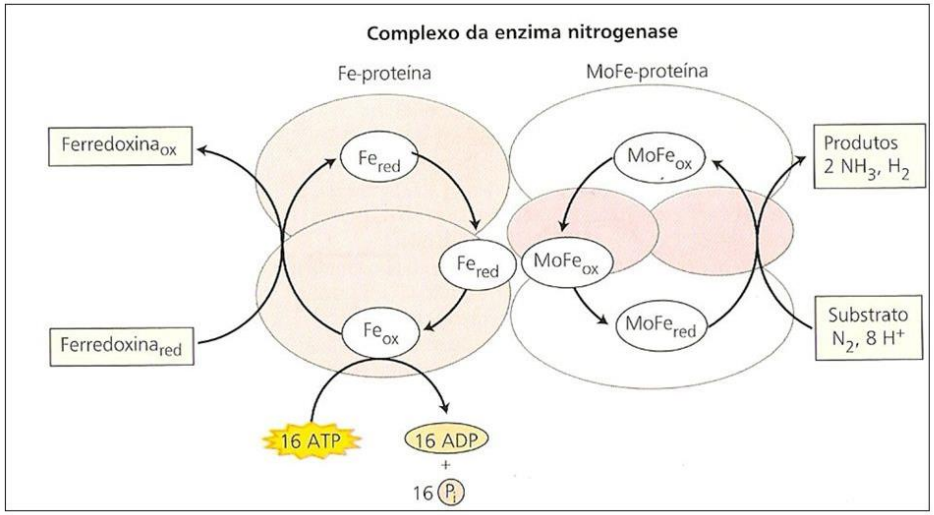


Interação entre *Bradyrhizobium* e Soja



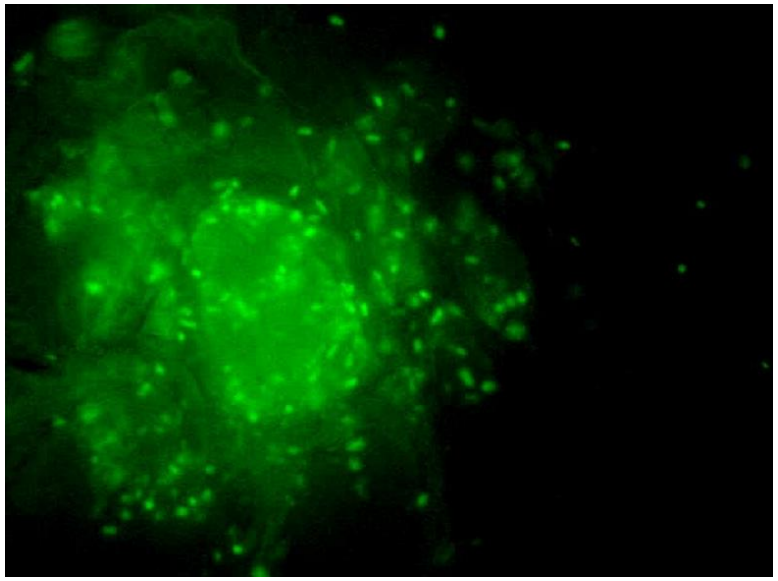


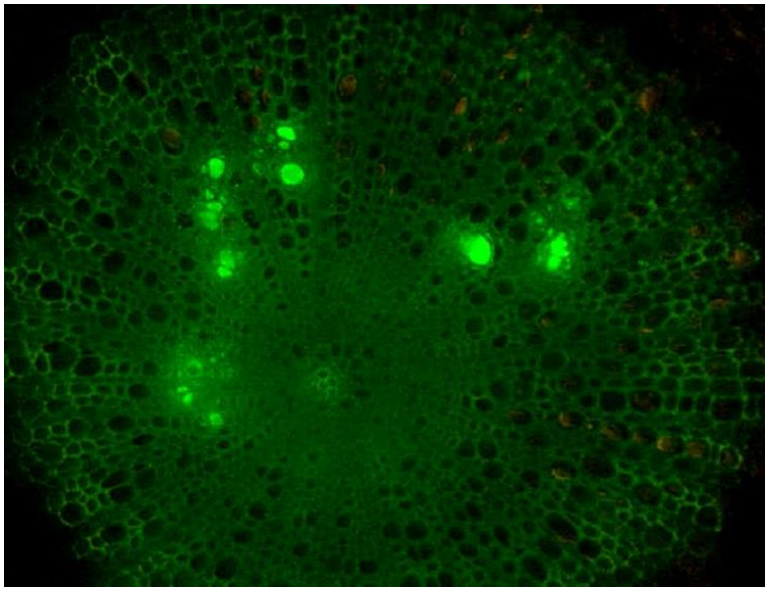


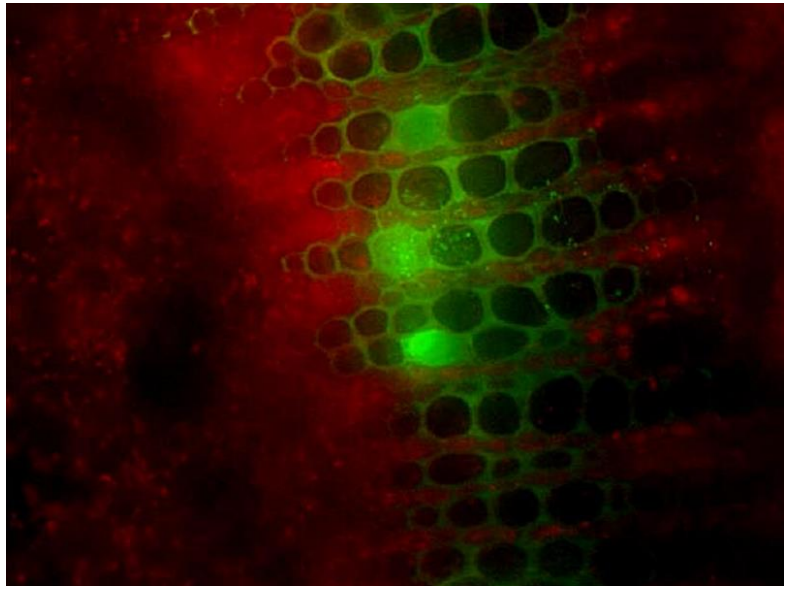


Enzima nitrogenase e Leghemoglobina: são importantes na fixação biológica de N_2

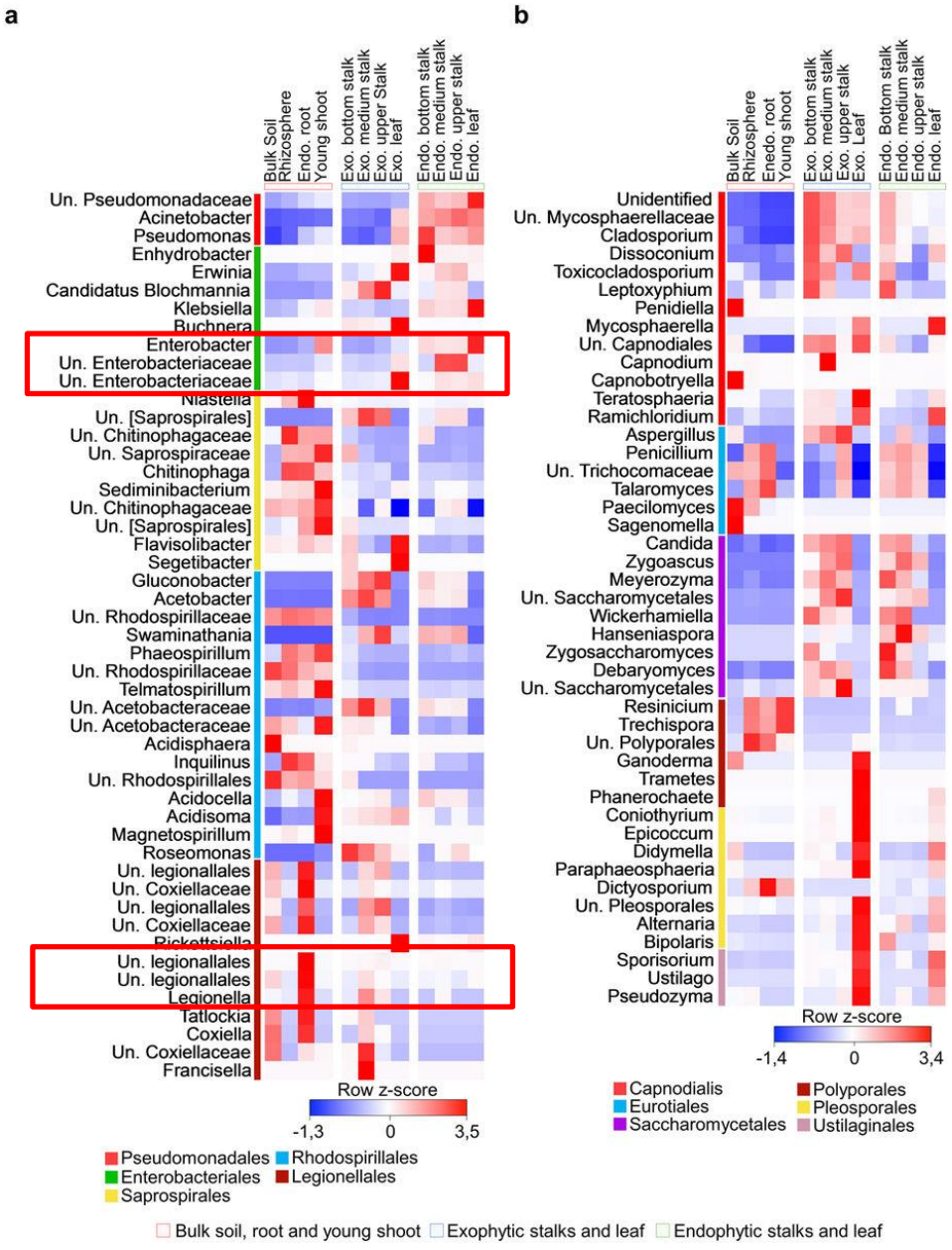
Bactérias no interior de plantas







Diversidade de bactérias associadas à cana-de-açúcar

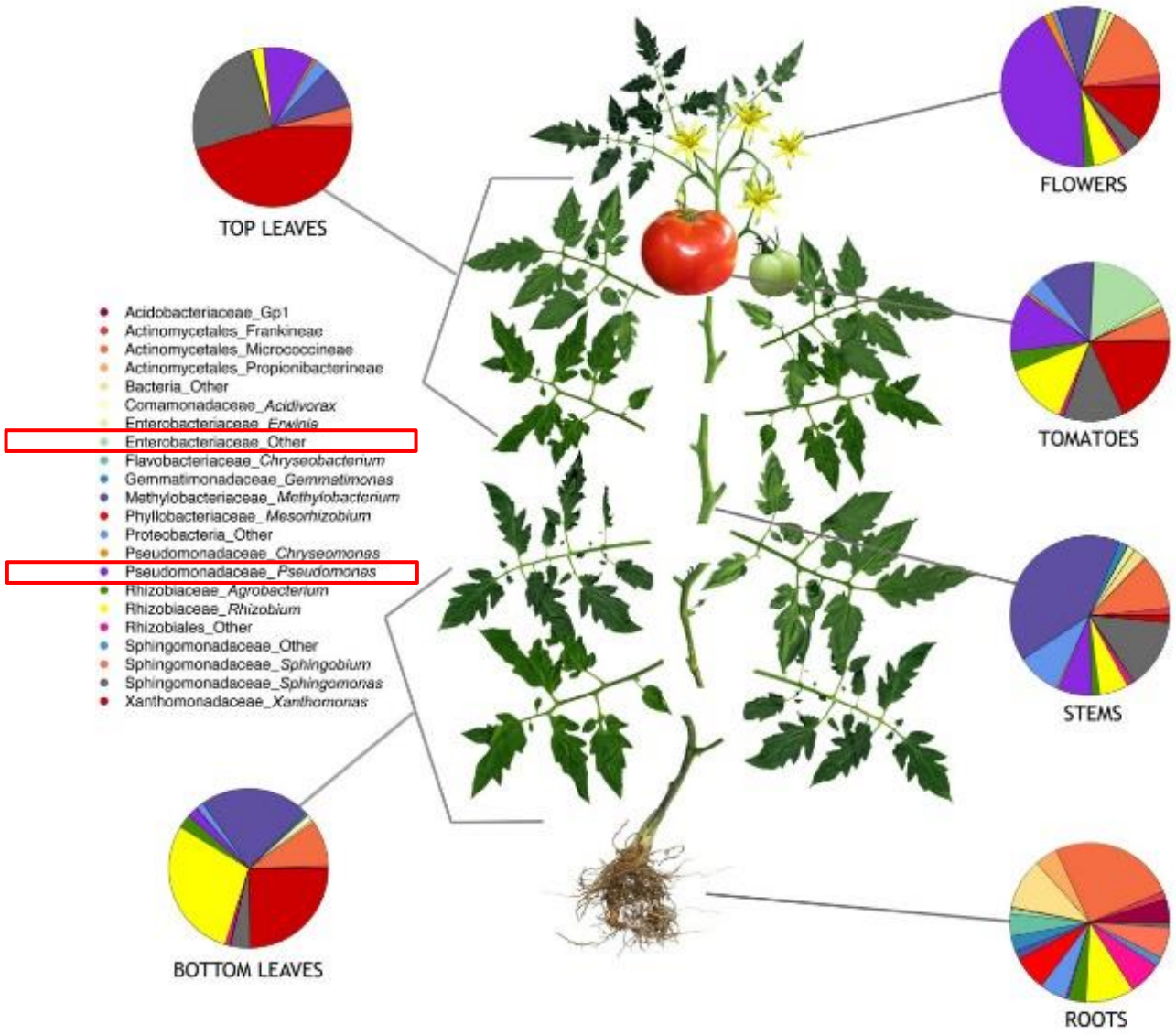


(a) A total of 49 bacterial genera
(b) A total of 45 fungal genera

Exo.: Exophytic; Endo.: Endophytic

De Souza et al. (2016) *Scientific Reports* **6**, Article number: 28774

Interação micro-organismos – plantas: tomateiro



Bacterial diversity in roots, bottom leaves, stems, tomatoes, flowers and top leaves of tomato plants using 16SrRNA. Bacterial diversity associated with diverse tomato organs (16S). Ottesen *et al. BMC Microbiology* 2013 **13**:114 doi:10.1186/1471-2180-13-114

Bactérias patogênicas em vegetais

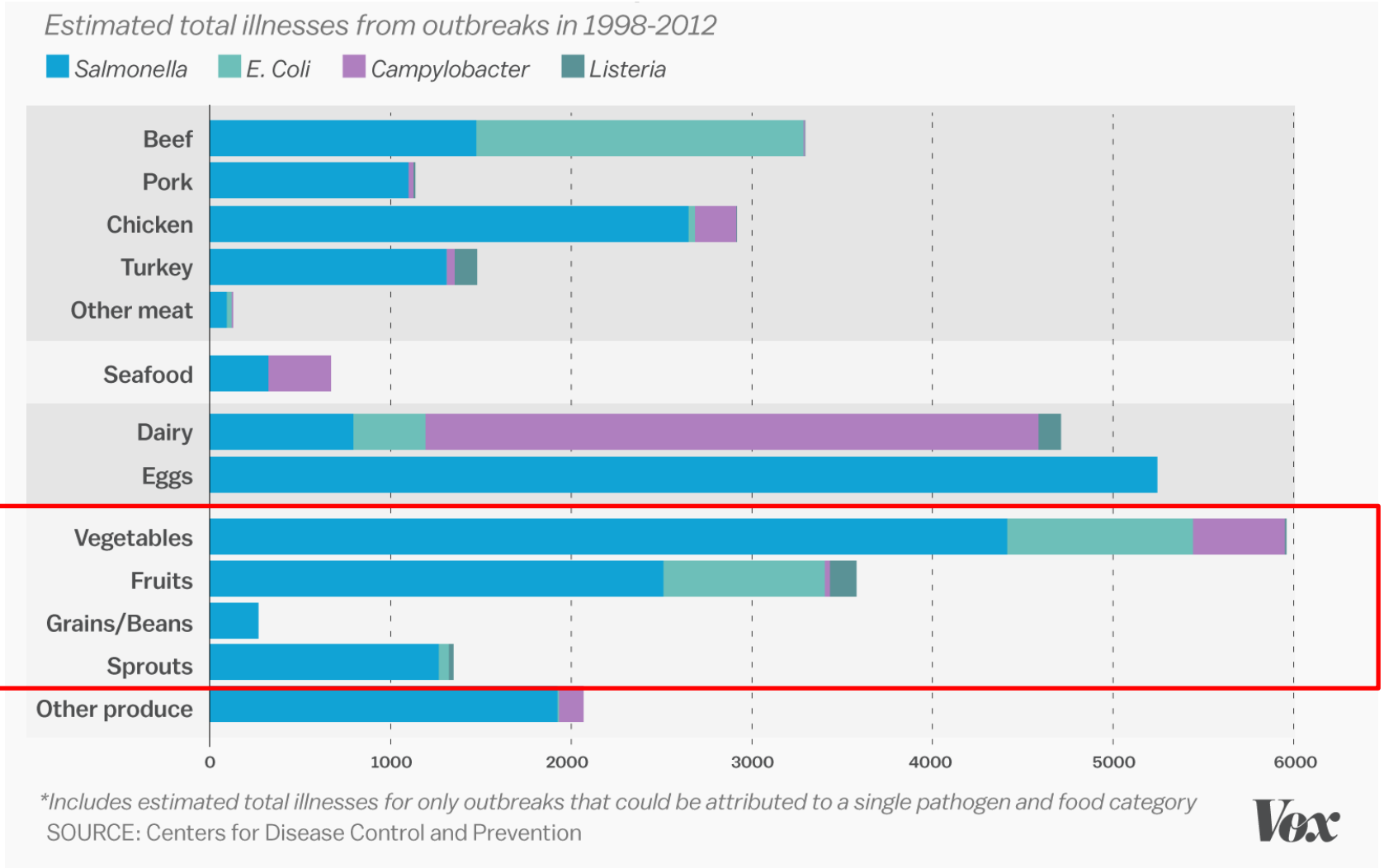
Country	Pathogen	Number of samples		Reference
		Total *n*	Positive *n* (%)	
Brazil	*Salmonella* spp.	75	1 (1.33)	Ceuppens et al.[51]
Brazil	*Salmonella* spp.	36	1 (2.77)	Rodrigues et al.[66]
Korea	*B. cereus*	63	17 (26.9)	Tango et al.[59]
	L. monocytogenes	63	10 (15.8)	
	S. aureus	63	13 (20.6)	
Malaysia	*E. coli* O157:H7	210	4 (1.90)	Chang et al.[61]
Northern Ireland	*Aeromonas* spp.	86	29 (34.0)	McMahon and Wilson[64]
Norway	*L. monocytogenes*	179	2 (1.11)	Loncarevic et al.[62]
USA	*Salmonella* spp.	178	4 (2.24)	Marine et al.[54]
USA	*Salmonella* spp.	476	2 (0.42)	Mukherjee et al.[55]
Zambia	*L. monocytogenes*	80	16 (20.0)	Nguz et al.[65]
	Salmonella spp.	160	37 (23.1)	
	S. aureus	80	54 (80.0)	

Maffei et al. (2016). Brazilian Journal of Microbiology. 47(1): 99-105

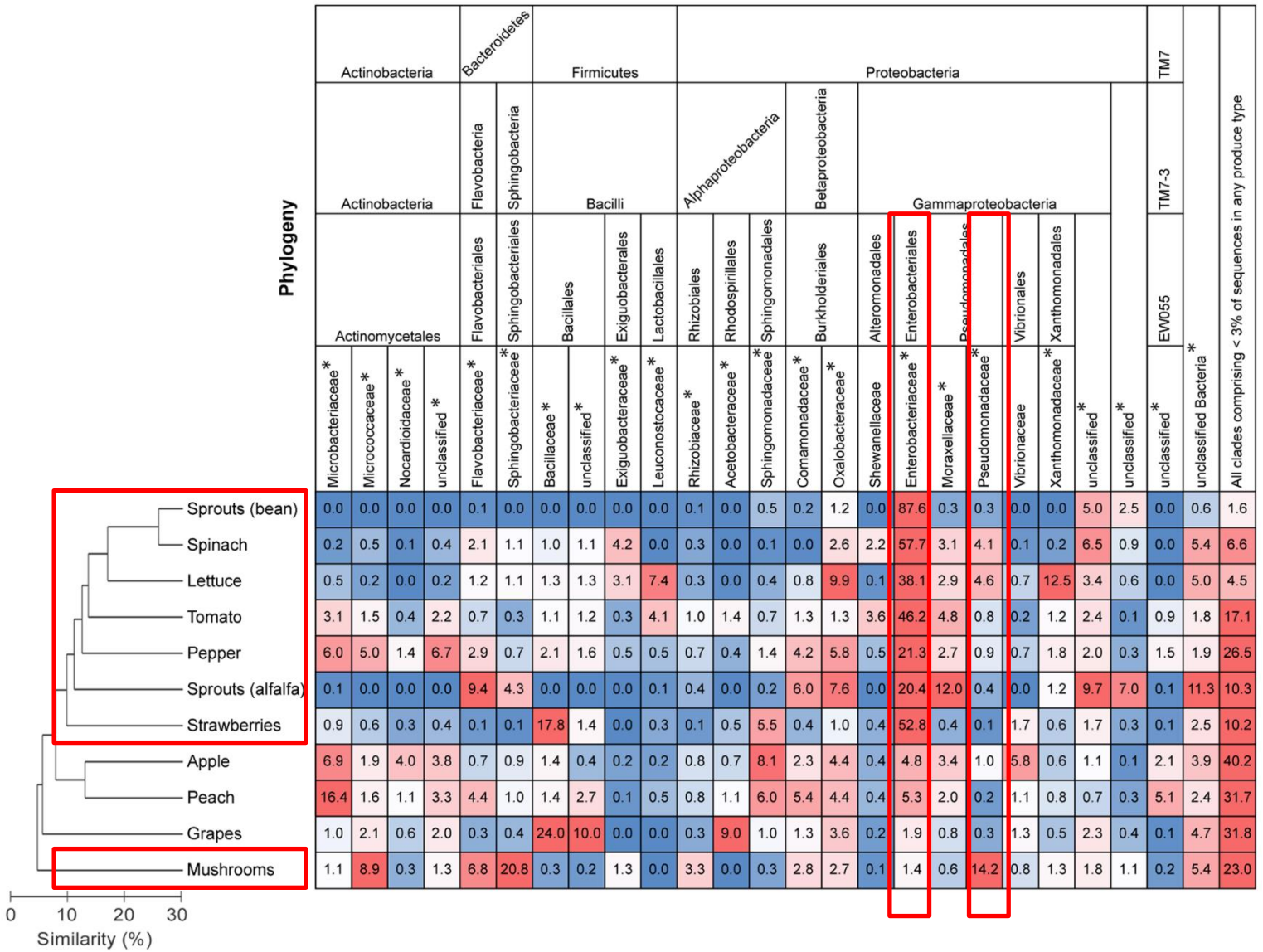
Escherichia coli na superfície de vegetais

Alface romana | Espinafre | Alface lisa

Alimentos como fonte de patógenos

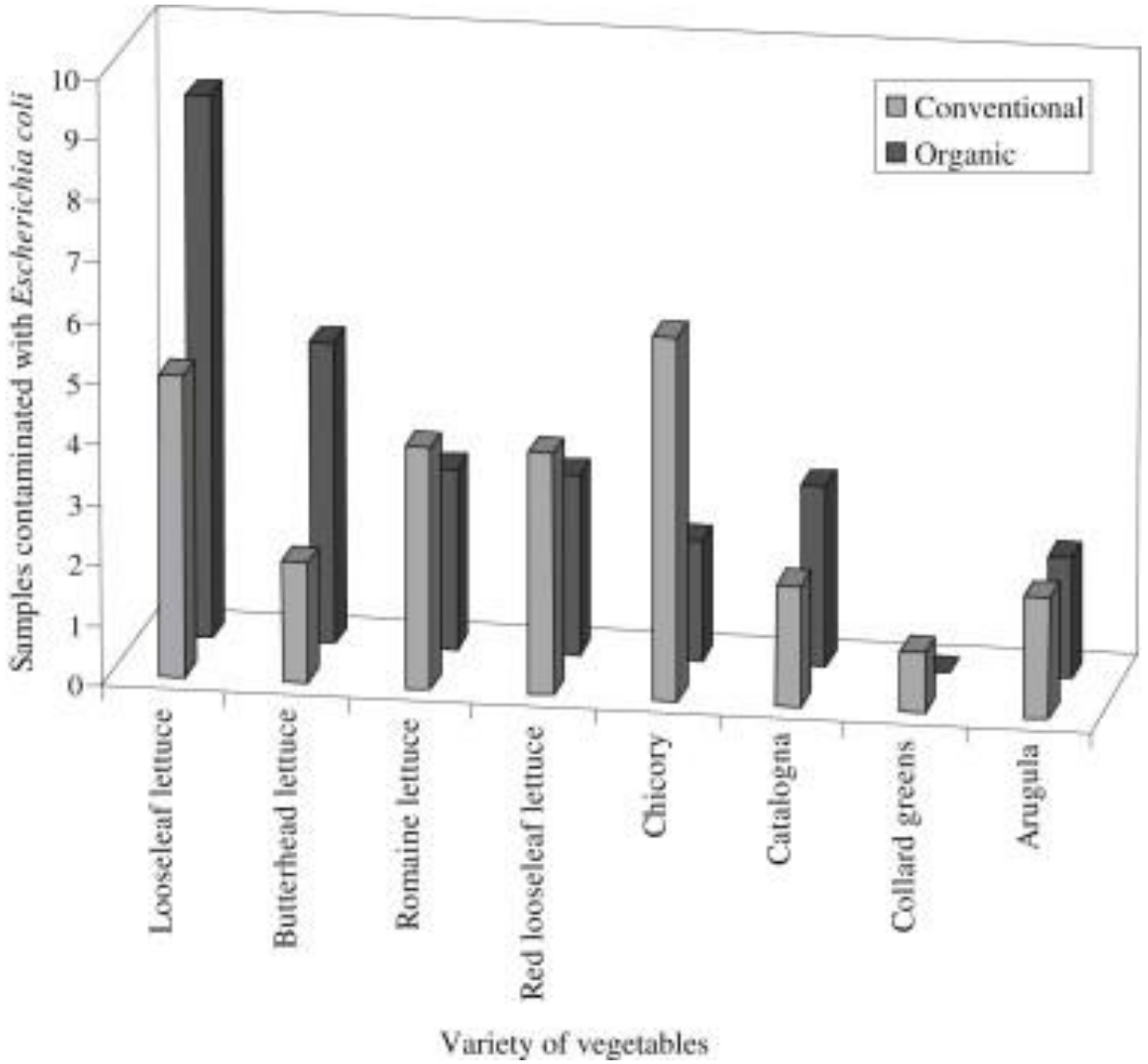


Relação entre a comunidade bacteriana em vegetais e a abundância relativa de cada família



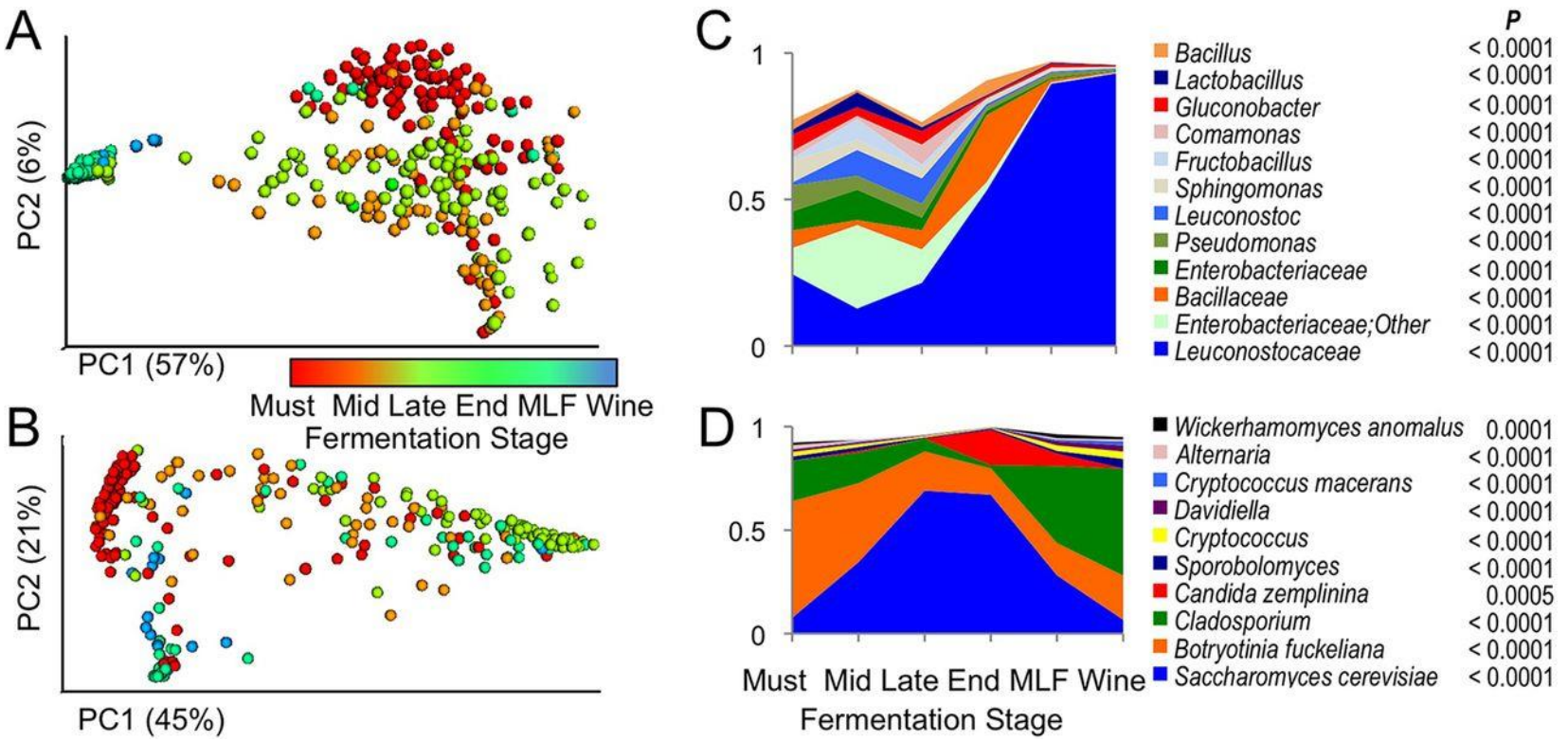
Leff & Fierer (2013). Bacterial Communities Associated with the Surfaces of Fresh Fruits and Vegetables. Plos One. https://doi.org/10.1371/journal.pone.005931

Escherichia coli em vegetais produzidos de forma orgânica ou conventional



Maffei et al. (2013). Microbiological quality of organic and conventional vegetables sold in Brazil. Food Control. 29 (1):226-230

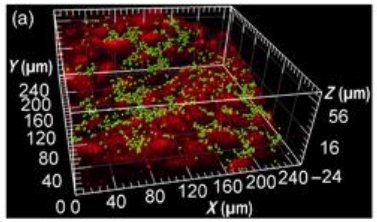
Stage of fermentation influences microbial composition of Cabernet Sauvignon.

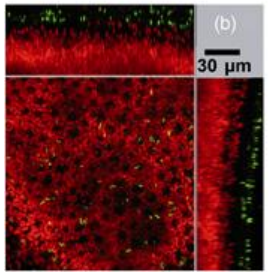


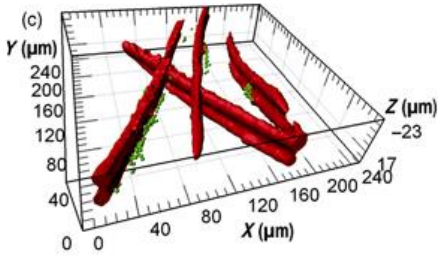
Nicholas A. Bokulich et al. mBio 2016;
doi:10.1128/mBio.00631-16

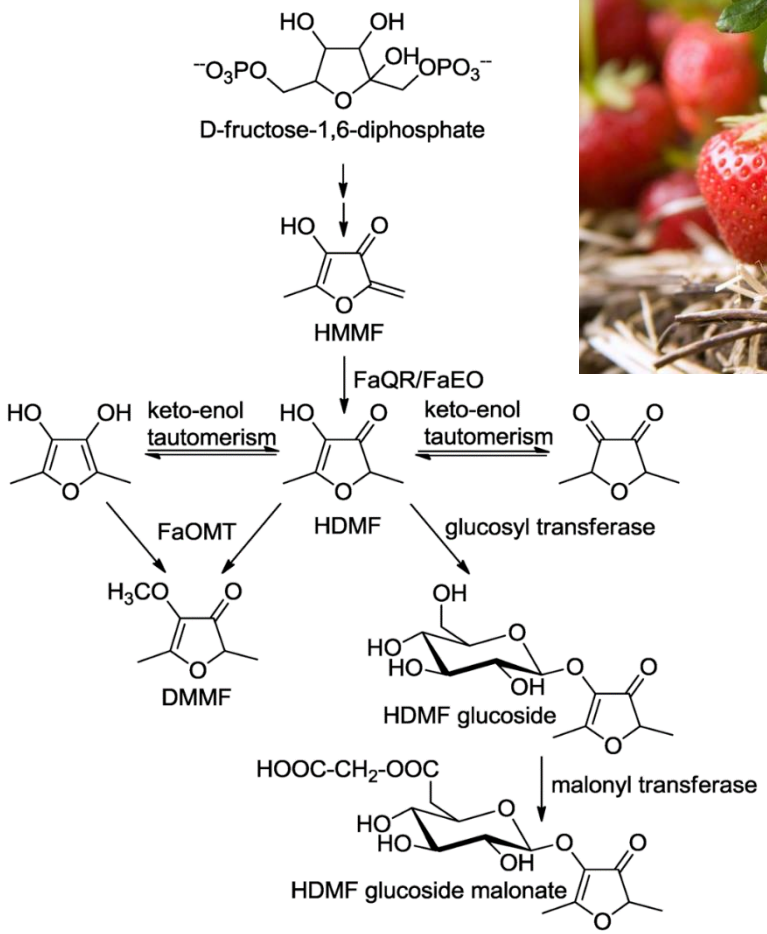
Micro-organismos indutores de flavours

A bacteria *Methylobacterium* induz o fruto de morango a produzir uma maior quantidade de flavour









Furanonas em morangos:

- 4-Hydroxy-5-methyl-2-methylene-3(2*H*)-furanone, HMMF;
- 4-hydroxy-2,5-dimethyl-3(2*H*)-furanone, HDMF;
- *Fragaria x ananassa* quinone oxidoreductase, FaQR;
- *F. x ananassa* enone oxidoreductase FaEO
- *F. x ananassa O*-methyltransferase FaOMT

Micro-organismos fitopatogênicos

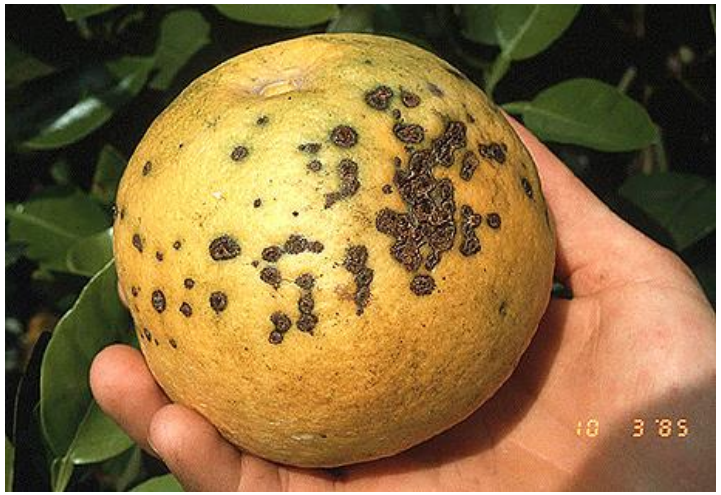
- Micro-organismos fitopatogênicos causam perda de qualidade dos vegetais
- Produção de toxinas
- Doença de pós-colheita – perda do produto
- Deterioração durante armazenamento
- Utilização de produtos químicos para controle
- Contaminação cruzada

Micro-organismos fitopatogênicos

Pectobacterium carotovorum

Pectobacterium carotovorum

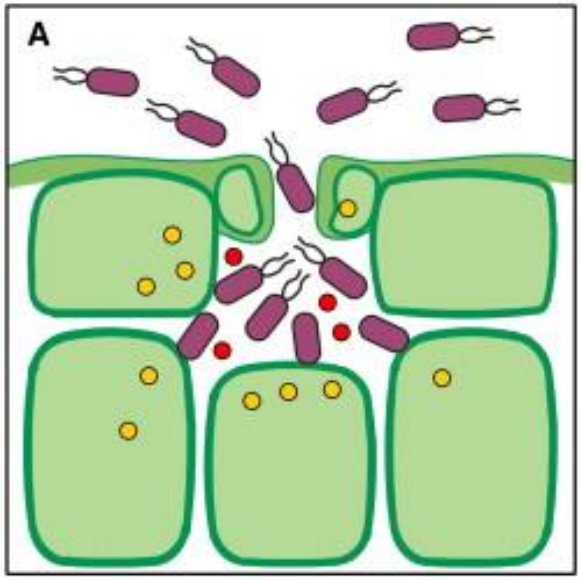
Xanthomonas campestris

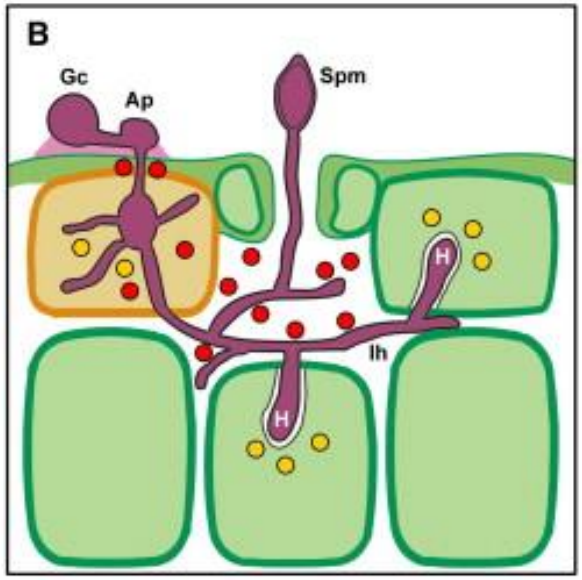


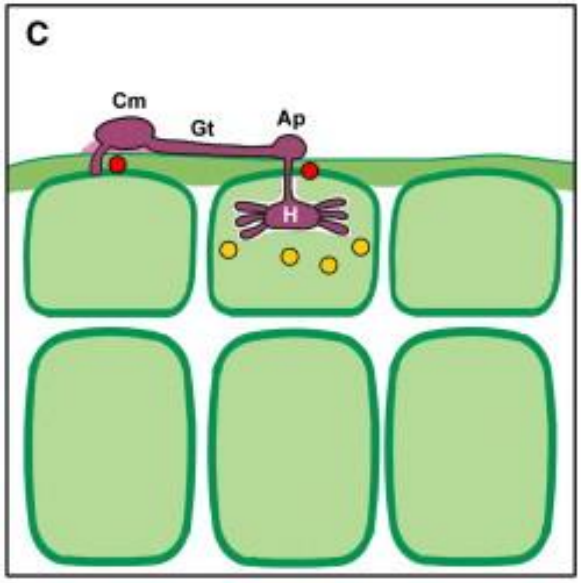
Xanthomonas citri

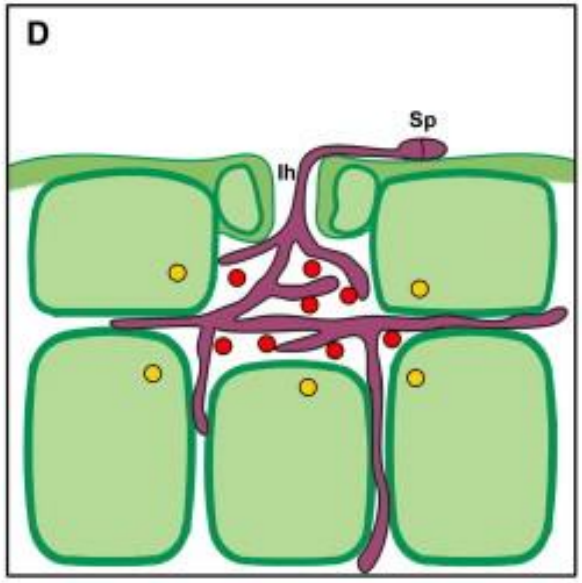
Ralstonia solanacearum

Interações patogênicas nas plantas





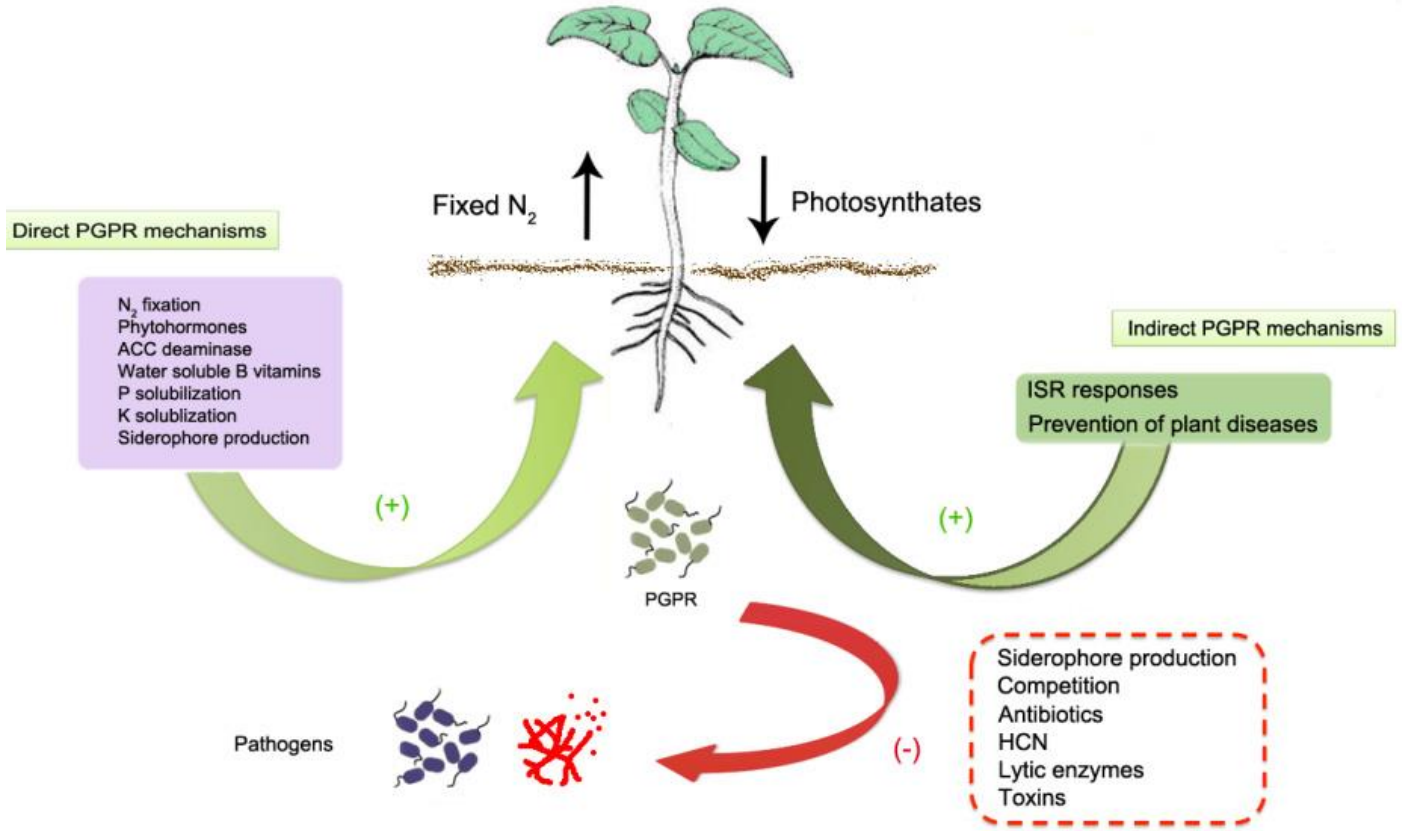




Bactérias benéficas

- **Promoção de crescimento vegetal**
  - Fixação de nitrogênio (nutriente)
  - Solubilizadores de fosfato (nutriente)
  - Disponibilização de nutrientes (K, Mg, Ca e etc)
  - Reguladores vegetais (aumento de Sistema radicular)
  - Redução do estresse biótico (inibe bactérias deletérias)
  - Redução de estresse abiótico (resistência a seca, metais tóxicos e etc)

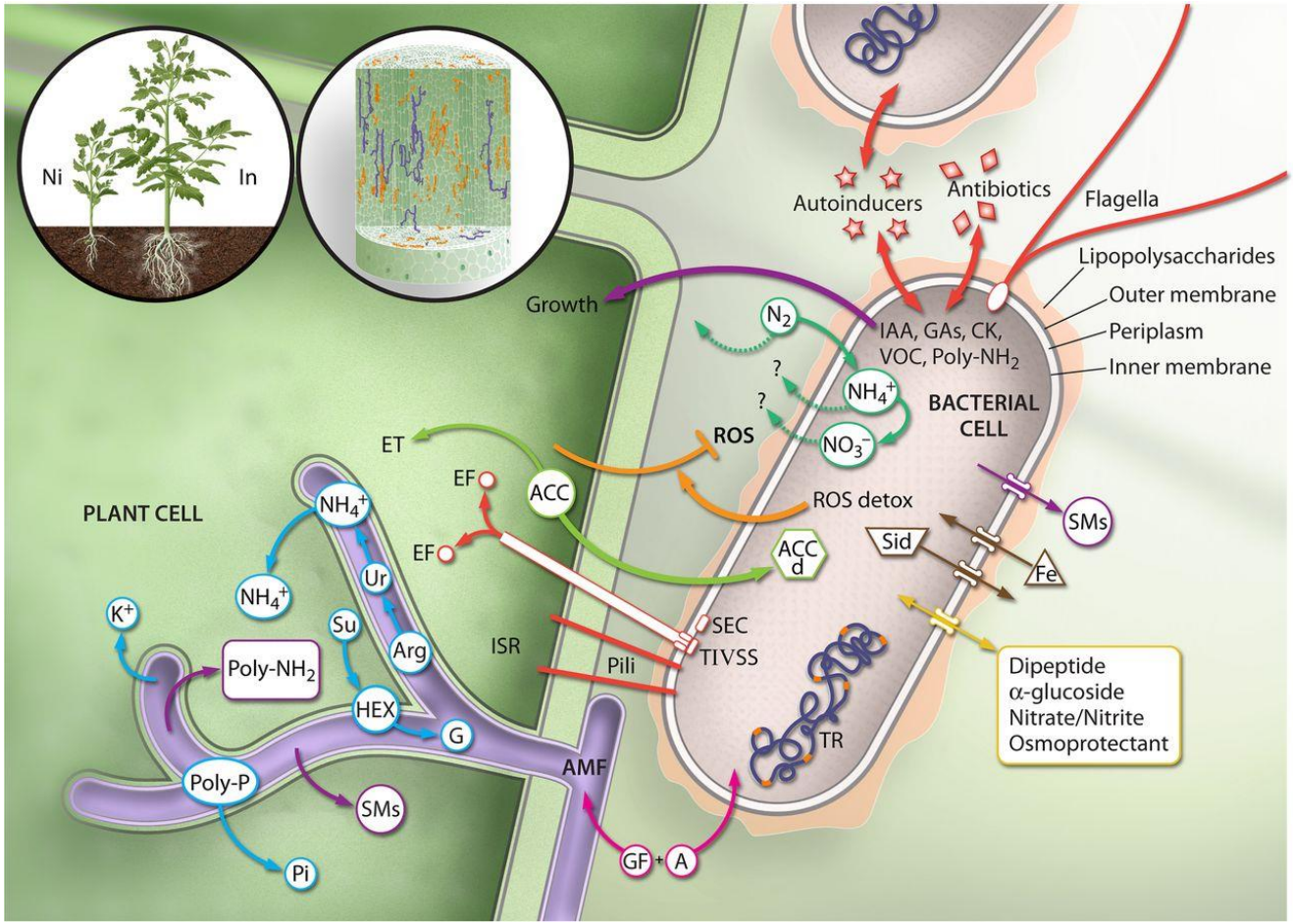
Interações microbianas para promoção de crescimento vegetal



- Mechanisms of plant growth promoting bacteria
- The beneficial bacteria may spread in/on the plant inducing directly or indirectly physiological changes

García-Fraile et al. 2015. AIMS Bioengineering, 2(3): 183-205

Interações microbianas para promoção de crescimento vegetal



α-ketobutyrate +NH_3

Plant growth promotion

ACC Deaminase

acdS

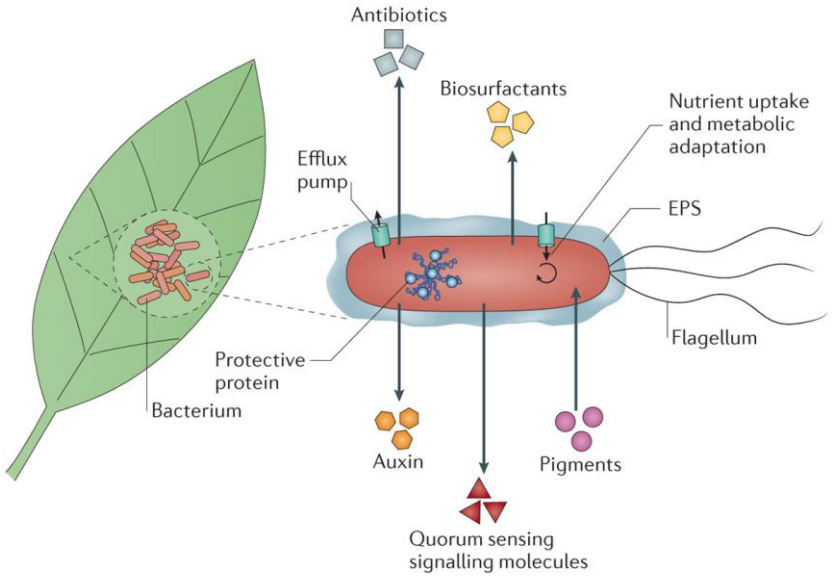
Aminocyclopropane-1-carboxylic (ACC)

ACC oxidase

ethylene

Stress response

Características de micro-organismos para colonizar a planta hospedeira



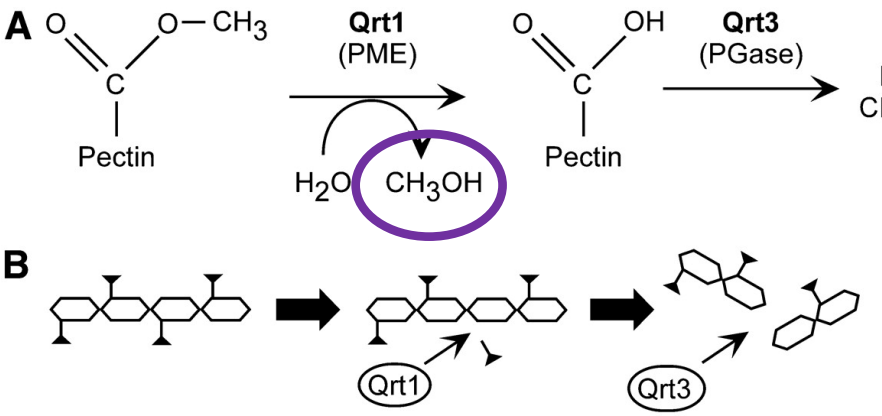
- Complex interaction occur among the microbial communities associated to the host plant.
- Capability to utilize various carbon source (sugars, polymers, amino acids and methanol).
- Biofilm formation, biosurfactants, EPS production and UV and oxidative stress resistance
- Production of antibiotics and signaling molecules (e.g. quorum sensing), secretion systems.
- Production of plant hormones, including indole-2-acetic acid (IAA).
- Microorganisms might produce some molecules that affect the plants fitness.

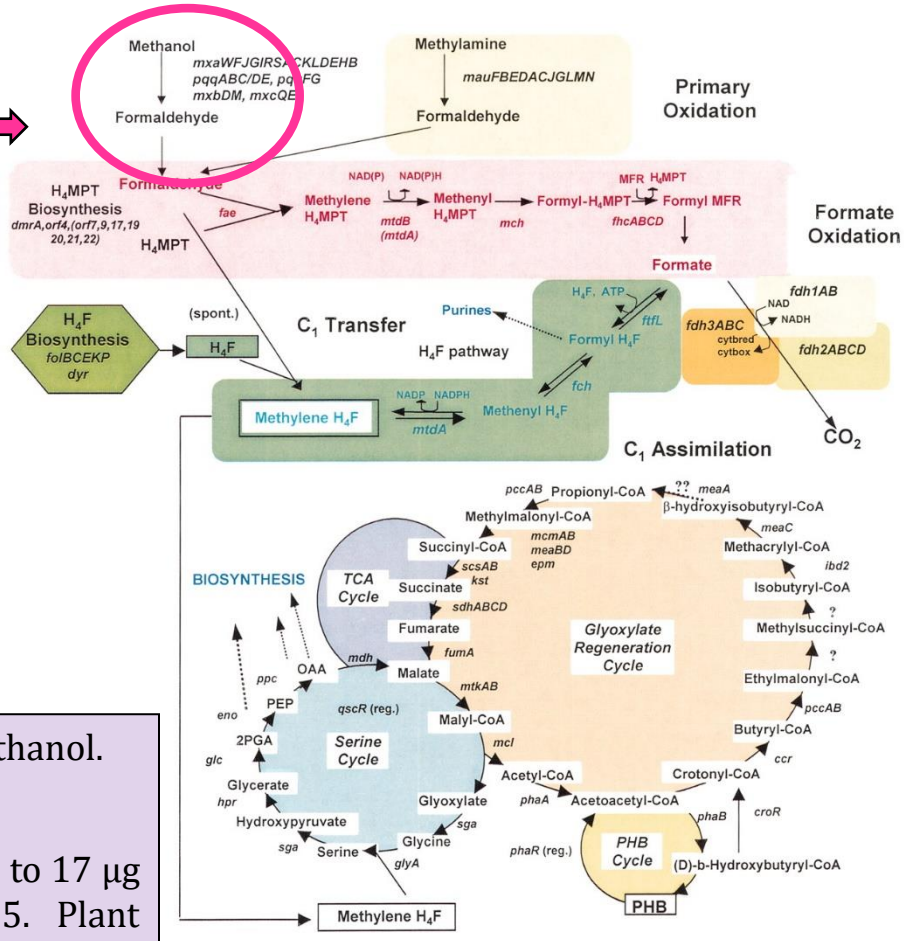
Vorholt 2012. Nature Reviews Microbiology **10**, 828-840

Methylotrophic bacteria associated to plants

Methylobacterium are pink pigmented facultative methylotrophs (PPFM) bacteria capable to growth on one-carbon compounds

*mxa*F gene encode a major subunit of alcohol dehydrogenase – first step for primary methanol oxidation



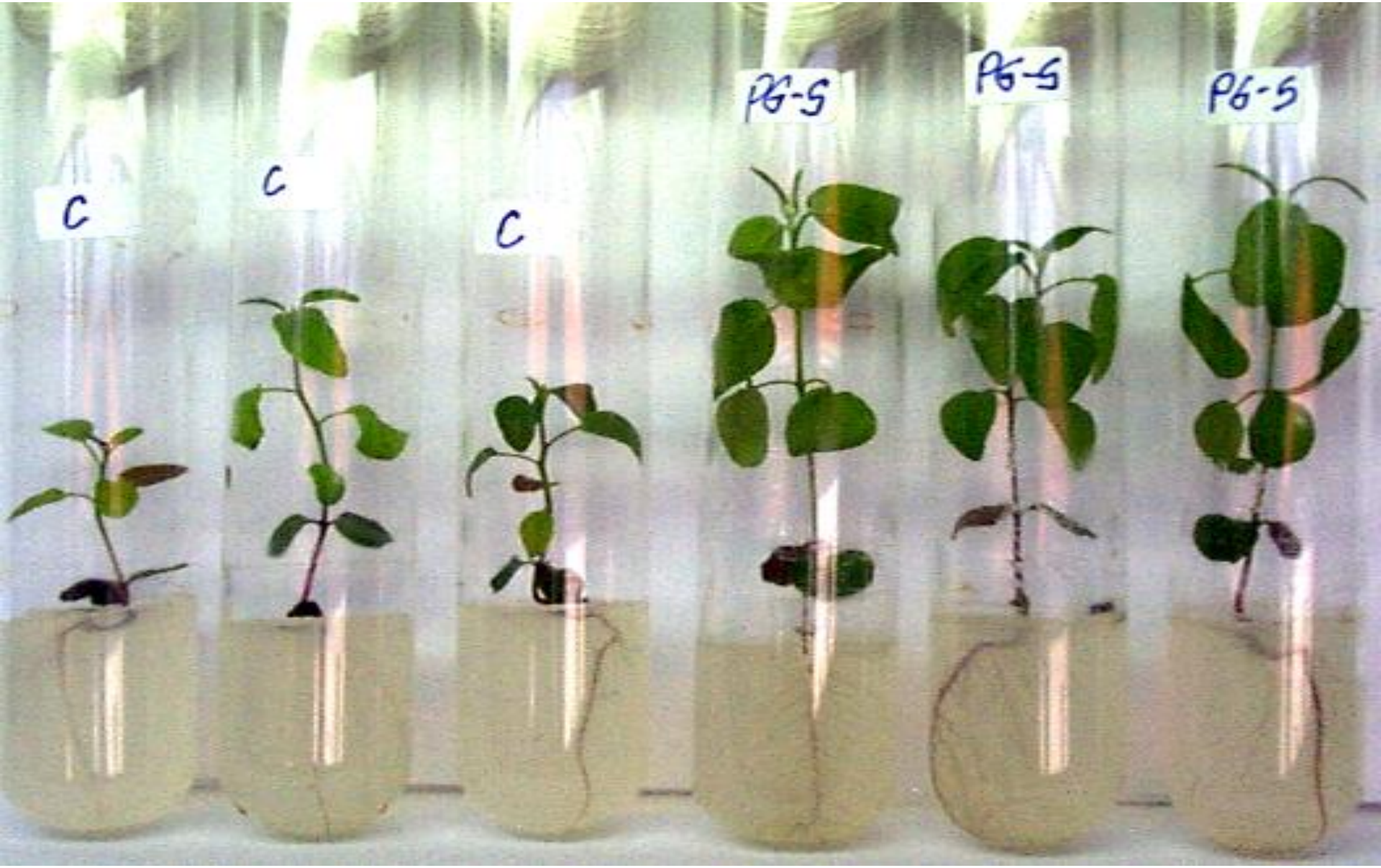


Methylotrophy metabolic modules in *M. extorquens* AM1

- Pectin breakdown by Pectin-methylesterase produce methanol.
- Methanol is released by leaves (stomatal chamber)
- The rates of methanol emission by plants range from 0.6 to 17 µg C $h^{-1}.g^{-1}$ dry weight (Nemecek-Marshall et al. 1995. Plant Physiology)
- Methylotrophic metabolism is advantageous for *Methylobacterium* during plant colonization under competitive conditions

Chistoserdova et al. 2003. J. Bacteriol. 185:2980-2987

Promoção de crescimento vegetal



Promoção de crescimento vegetal

Citrus limonia inoculado com *Methylobacterium* spp. (4 meses)

A promoção de crescimento vegetal é espécie específica

Bogas (2010)

Controle Microbiano de Pragas e doenças

Utilização de Micro-organismos no Controle Biológico de Pragas e doenças de Interesse Agrícola

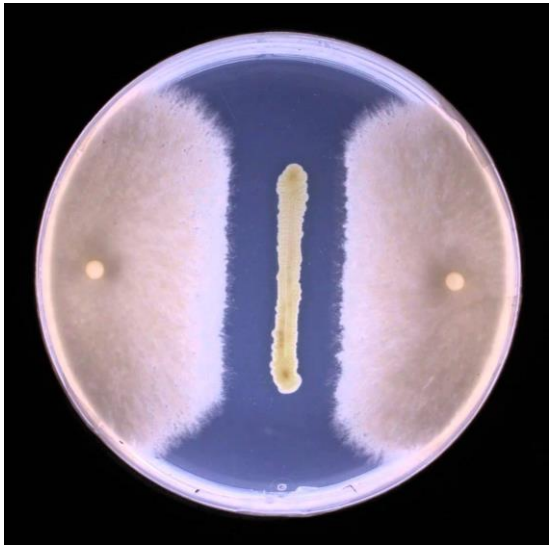
O Controle Biológico:

O controle biológico consiste no emprego de um organismo (predador, parasita ou patógeno) que ataca outro que esteja causando danos econômicos às lavouras. Trata-se de uma estratégia muito utilizada em sistemas agroecológicos, assim como na agricultura convencional que se vale do Manejo Integrado de Pragas (MIP) ou de doenças.

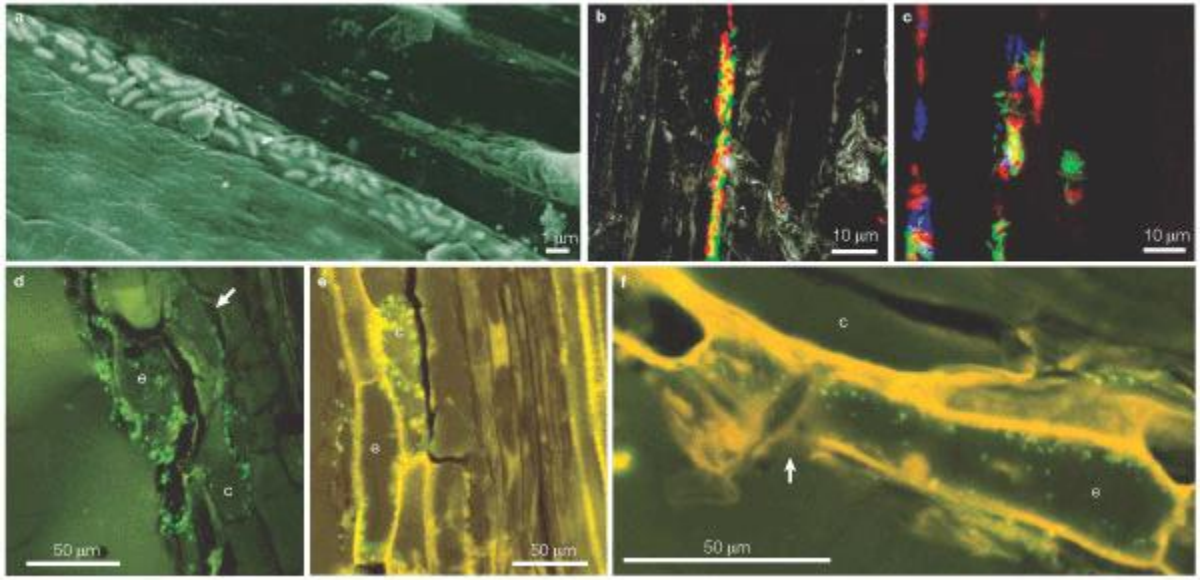
Controle Microbiano de Pragas e doenças

- Na agricultura, as práticas de campo se direcionam para o efeito do desequilíbrio ecológico existente. Este desequilíbrio gera a reprodução exagerada de insetos, fungos, ácaros e bactérias, que acabam se tornando "pragas e doenças" das lavouras e das criações de animais.
- Para o seu controle são utilizados inúmeros agroquímicos, gerando um desequilíbrio no metabolismo de plantas e animais, bem como na constituição físico-química e biológica do solo.

Controle Biológico

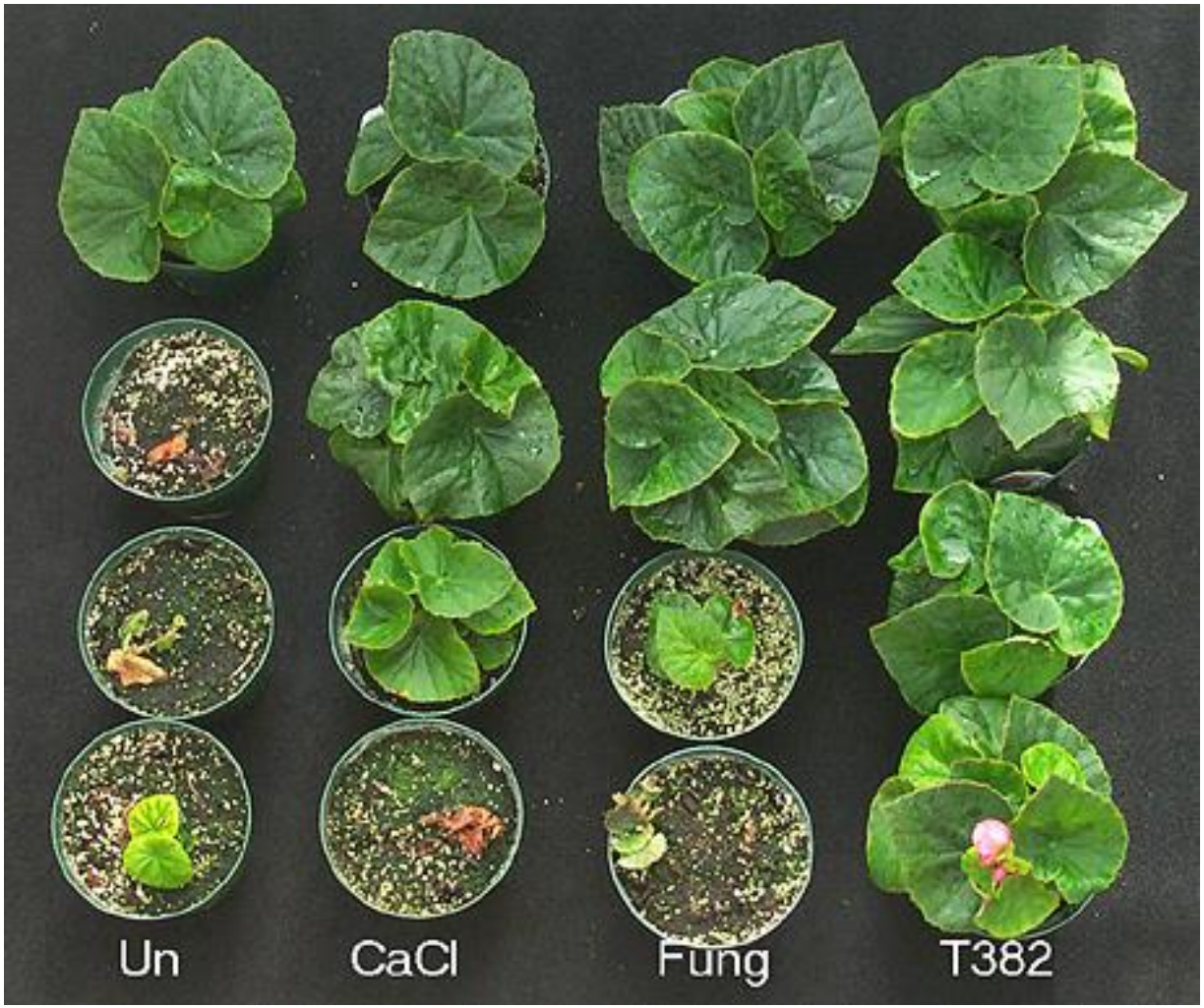


A bactéria pode produzir antibiótico contra o patógeno



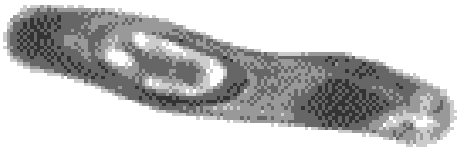
A bactéria ocupa o mesmo nicho ou local da planta (competição)

Controle Biológico



Un: não tratado (controle)	**CaCl:** Cloreto de cálcio
Fung: fungicida	**T382:** agente de controle biológico

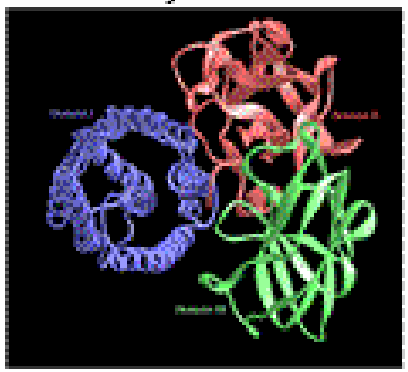
Controle biológico por *Bacillus thuringiensis*



Gram-positive, spore-forming soil bacterium

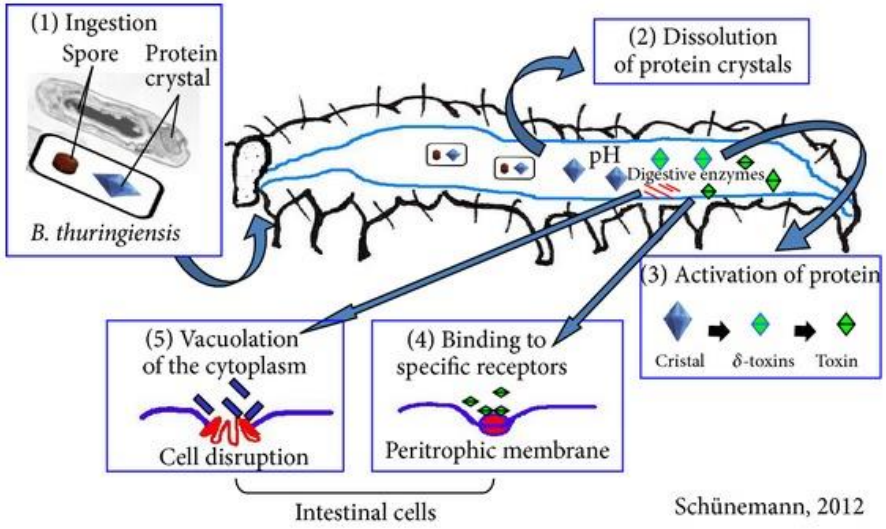
Produce insecticidal crystal proteins (δ-endotoxins) during sporulation

Cry toxin



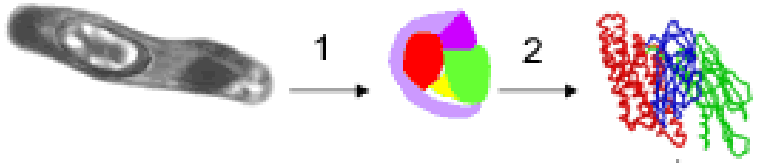
Most *Bt* strains can synthesise more than one crystal, which may be formed by different Cry toxins

Bacillus thuringiensis

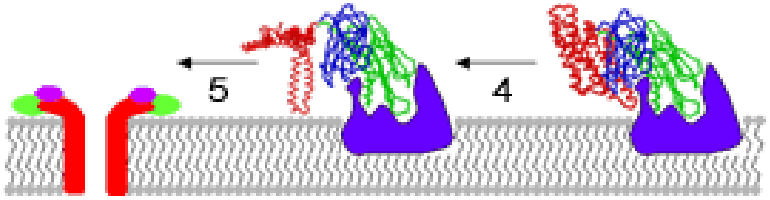


Schünemann, 2012

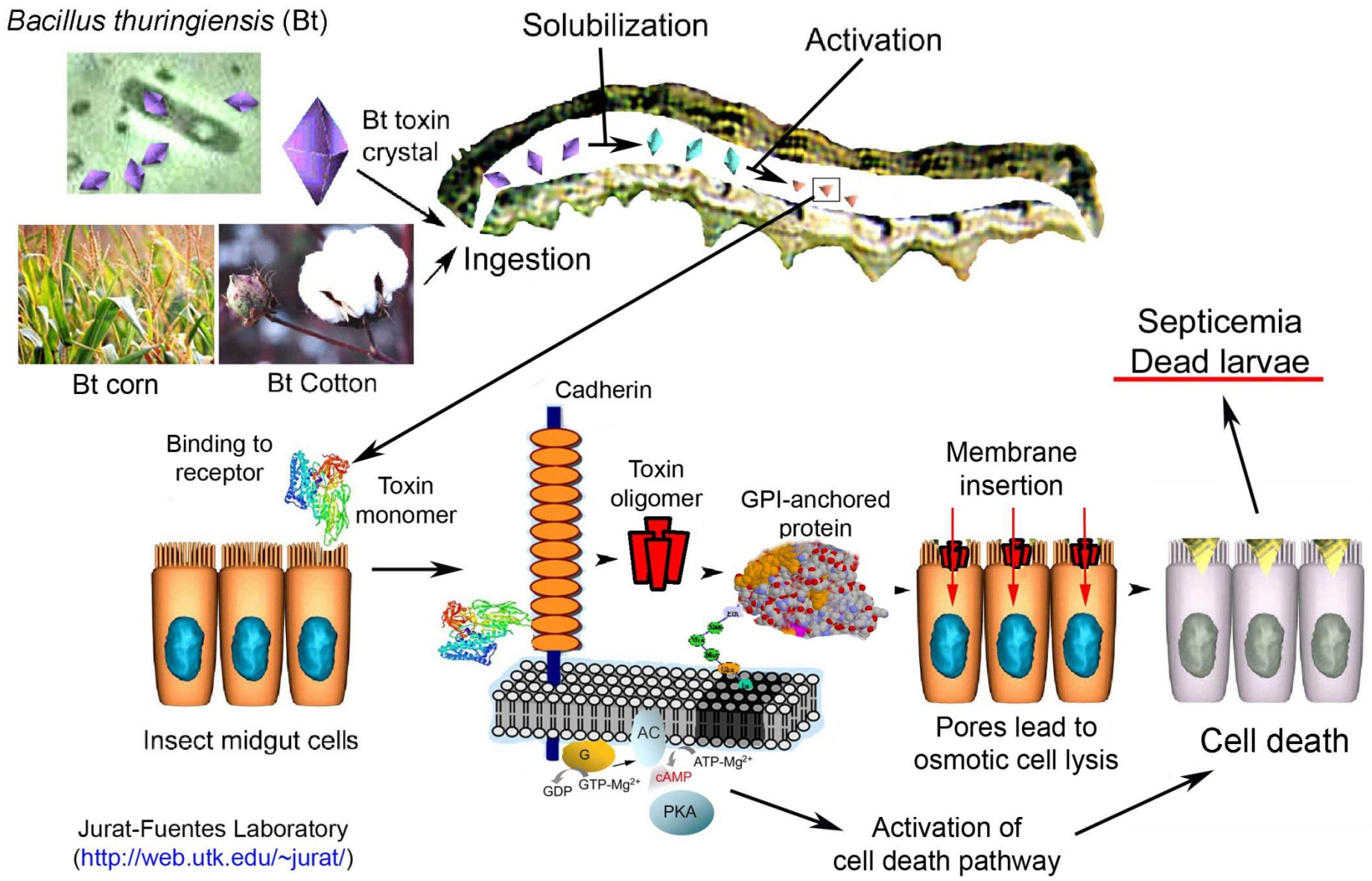
Proposed mode of action of Cry toxins



1) Ingestion & solubilisation of protoxin
2) Proteolytic activation at N- and Ca- termini
3) Interaction with cell surface binding protein
4) Conformational change exposing α4-5 helical hairpin
5) Oligermisation & insertion in membrane to form pore



Bacillus thuringiensis e plantas transgênicas



Hora de descansar……. Boa tarde