Instituto de ciências biomédicas

Ecologia Microbiana
Interações microbianas no Solo

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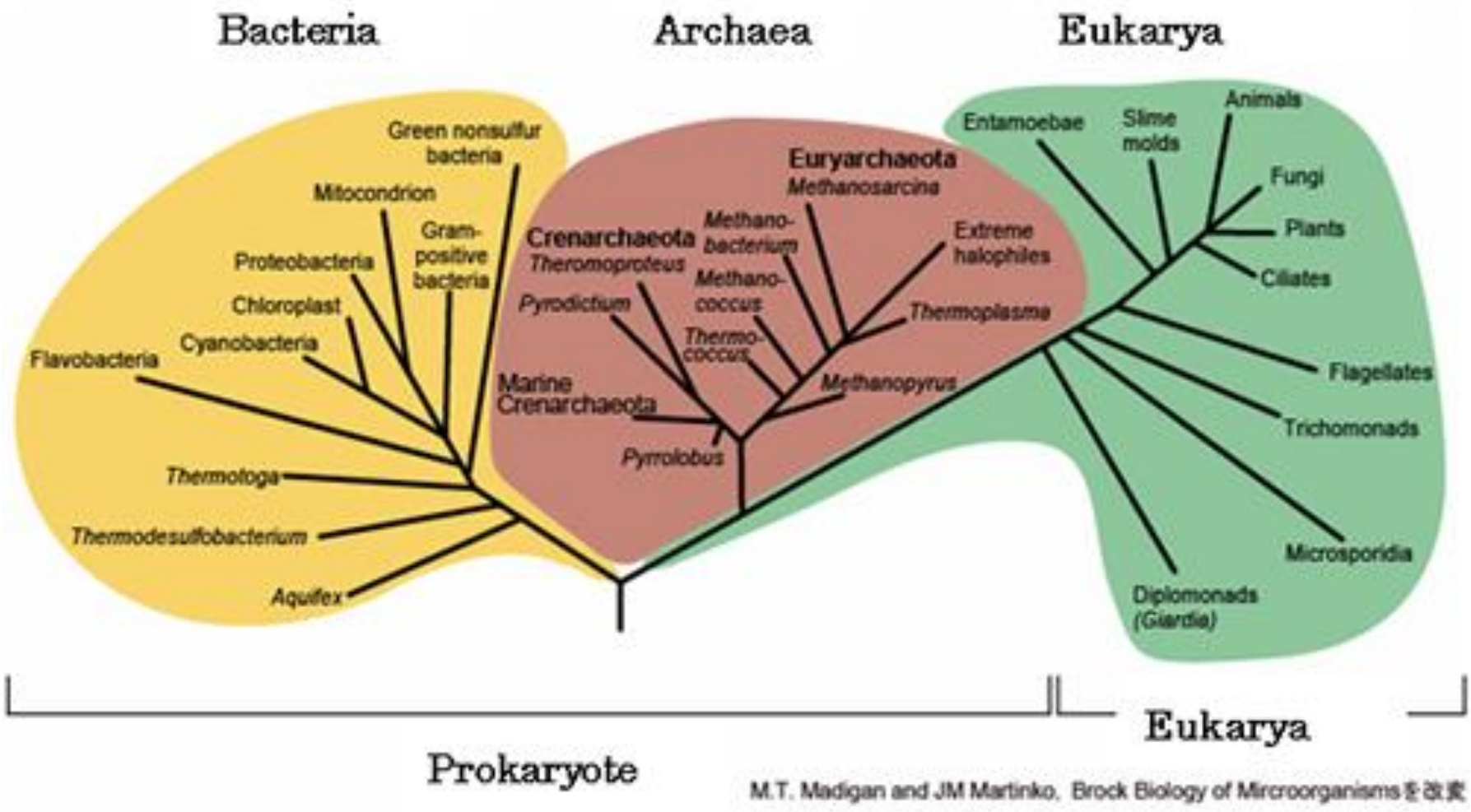
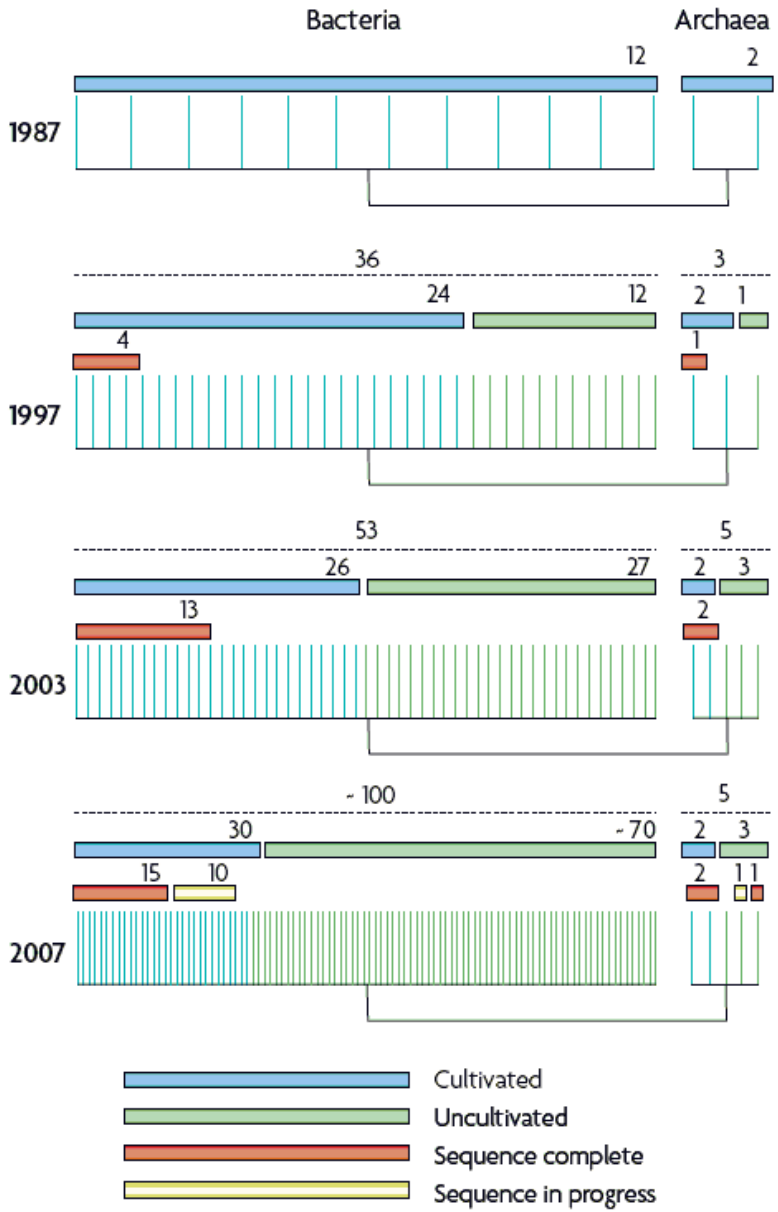
BMM0123 - Ecologia de Ecossistemas - 2021

Quem são os micro-organismos?

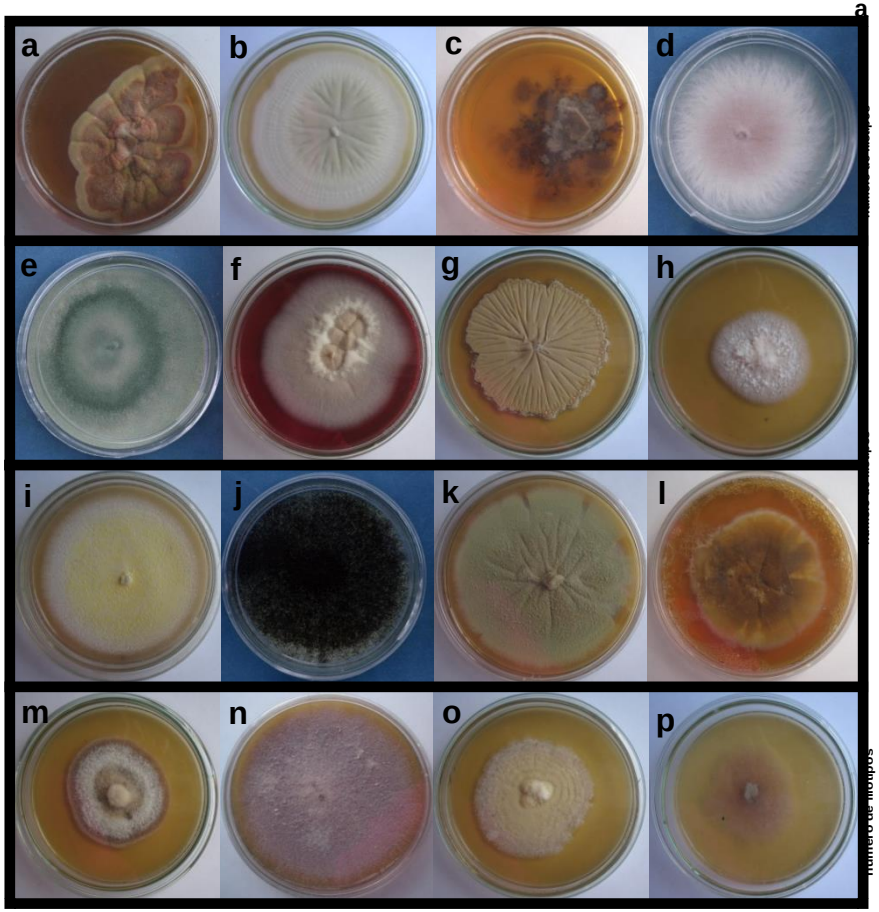


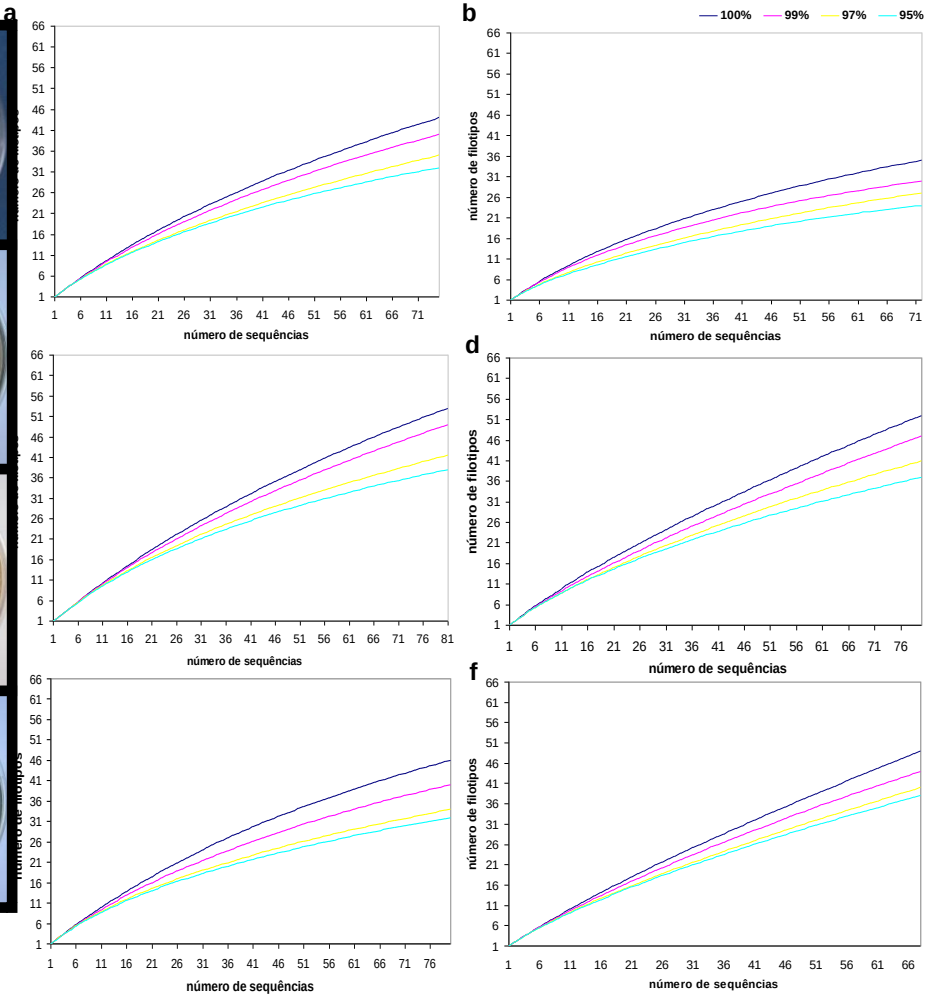
O conhecimento sobre a diversidade microbiana aumenta



- Novos filos
- Novas vias metabólicas
- Novos mecanismos de interação

Diversidade microbiana cultivável





Riqueza de espécies é alta, mas o que observamos está abaixo da realidade

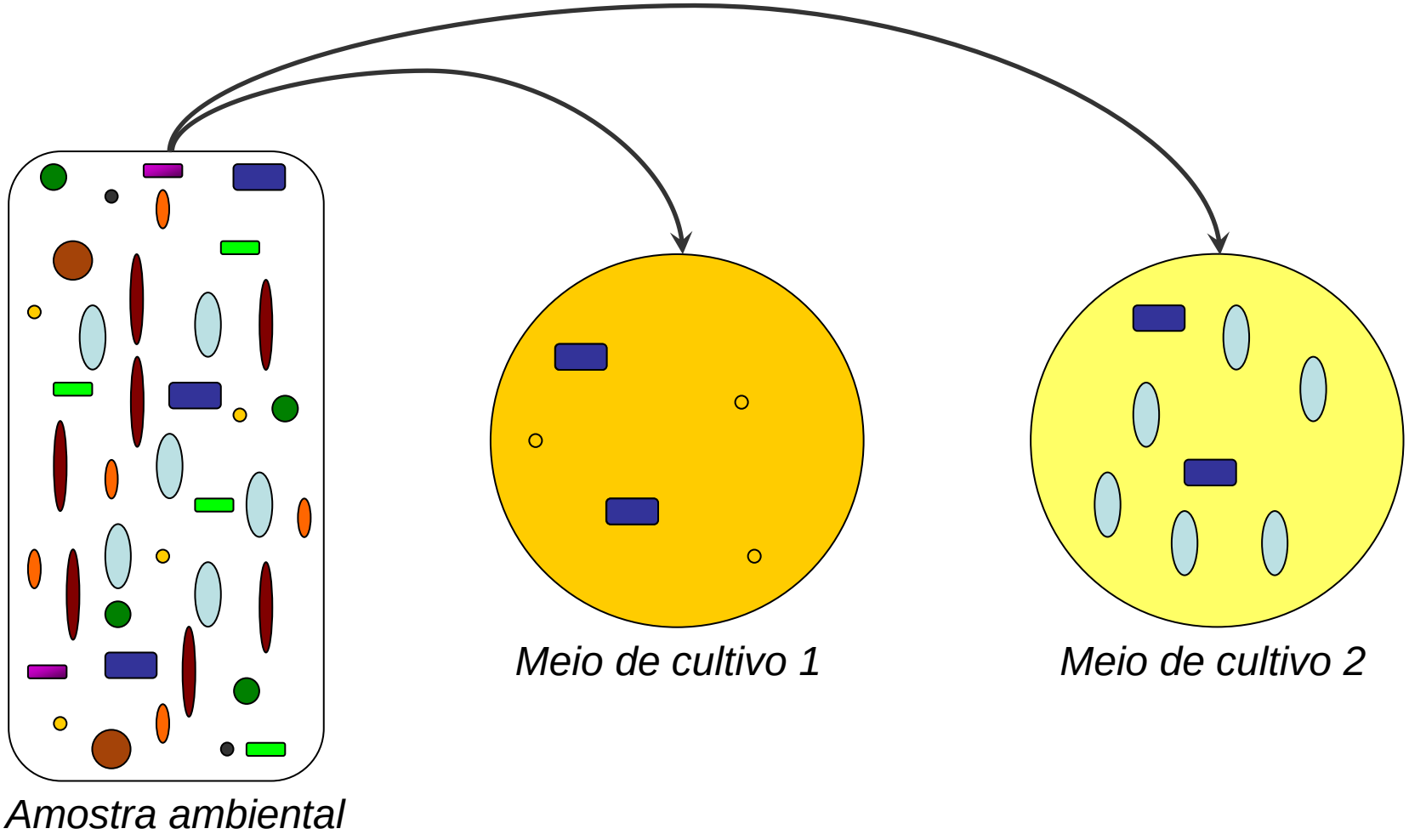
Diversidade microbiana

- **Diversidade ≠ riqueza de espécies**
- **Riqueza de espécies:** o número de espécies em uma área
- **Diversidade:** a variedade e a abundância relativa de espécies

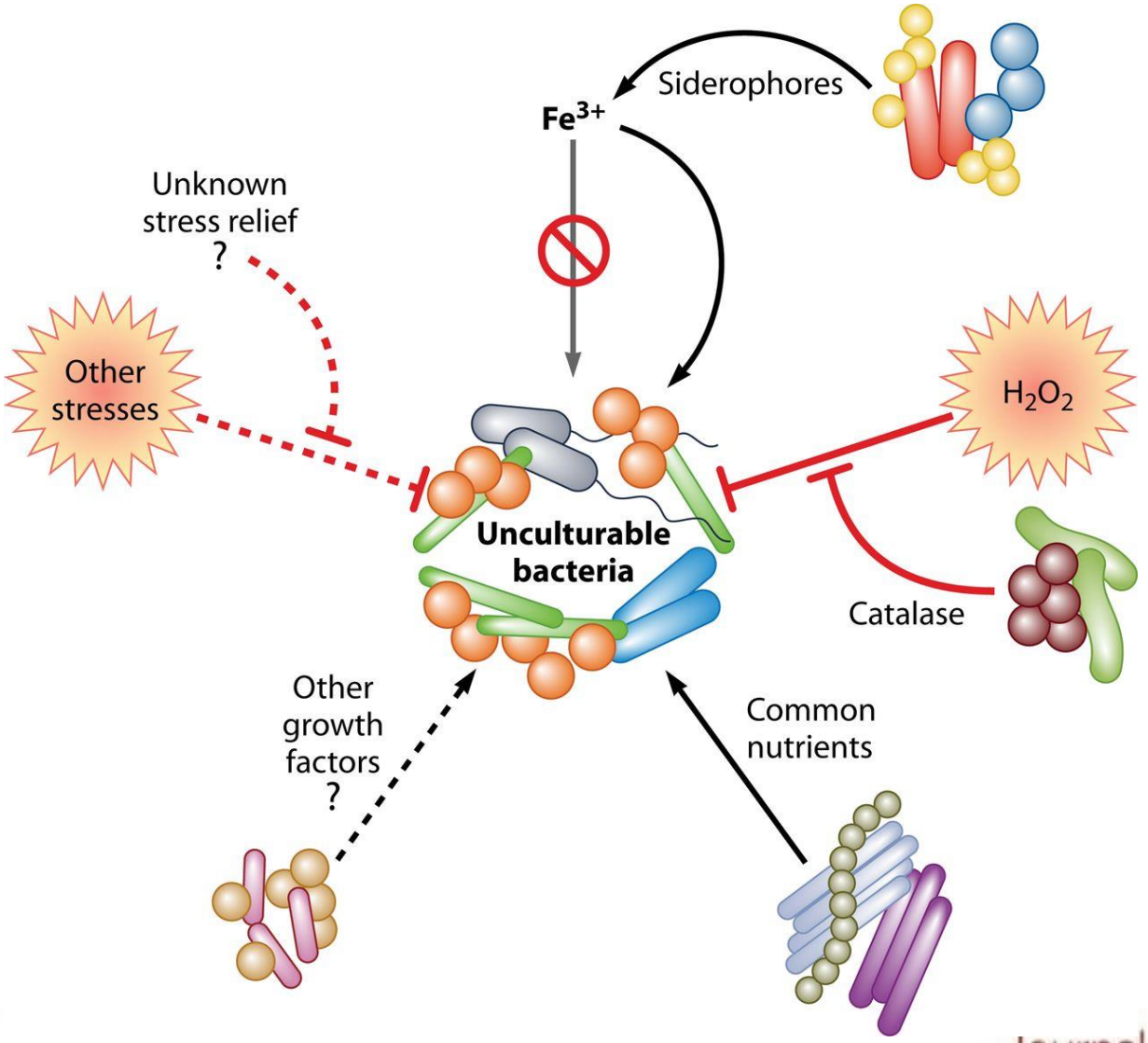
- Diversidade α (alfa) ou local é a diversidade dentro de um habitat ou comunidade (é restrito)
- Diversidade β (beta) é a diversidade entre habitats ou outra variação ambiental qualquer, medindo o quanto a composição de espécies varia de um lugar para outro.

- **Diversidade:** necessário identificar e conhecer os grupos biológicos e o ambiente

Culturabilidade



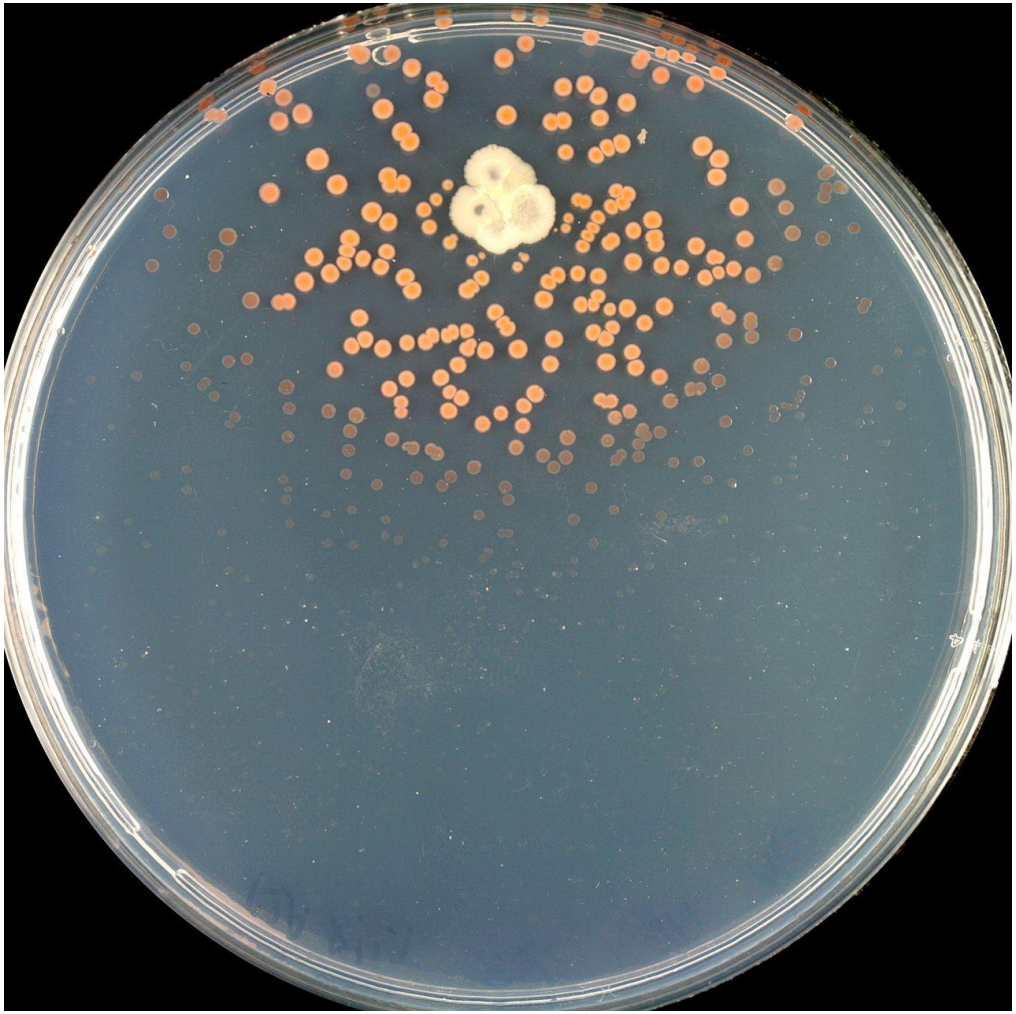
Modelo proposto para mecanismo mutualísticos de cocultivo

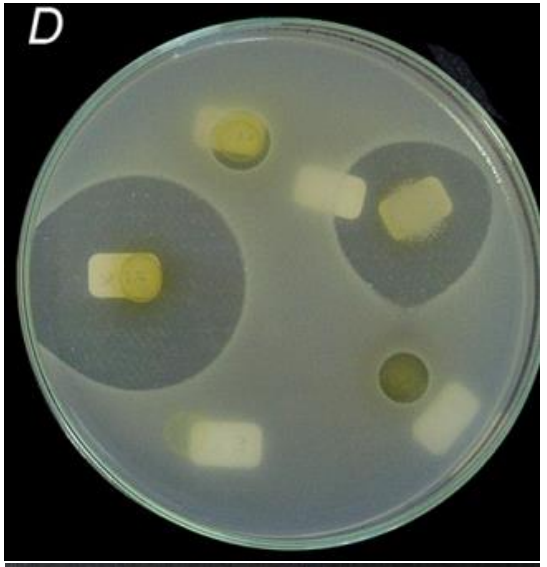


Stewart E J J. Bacteriol. 2012;194:4151-4160

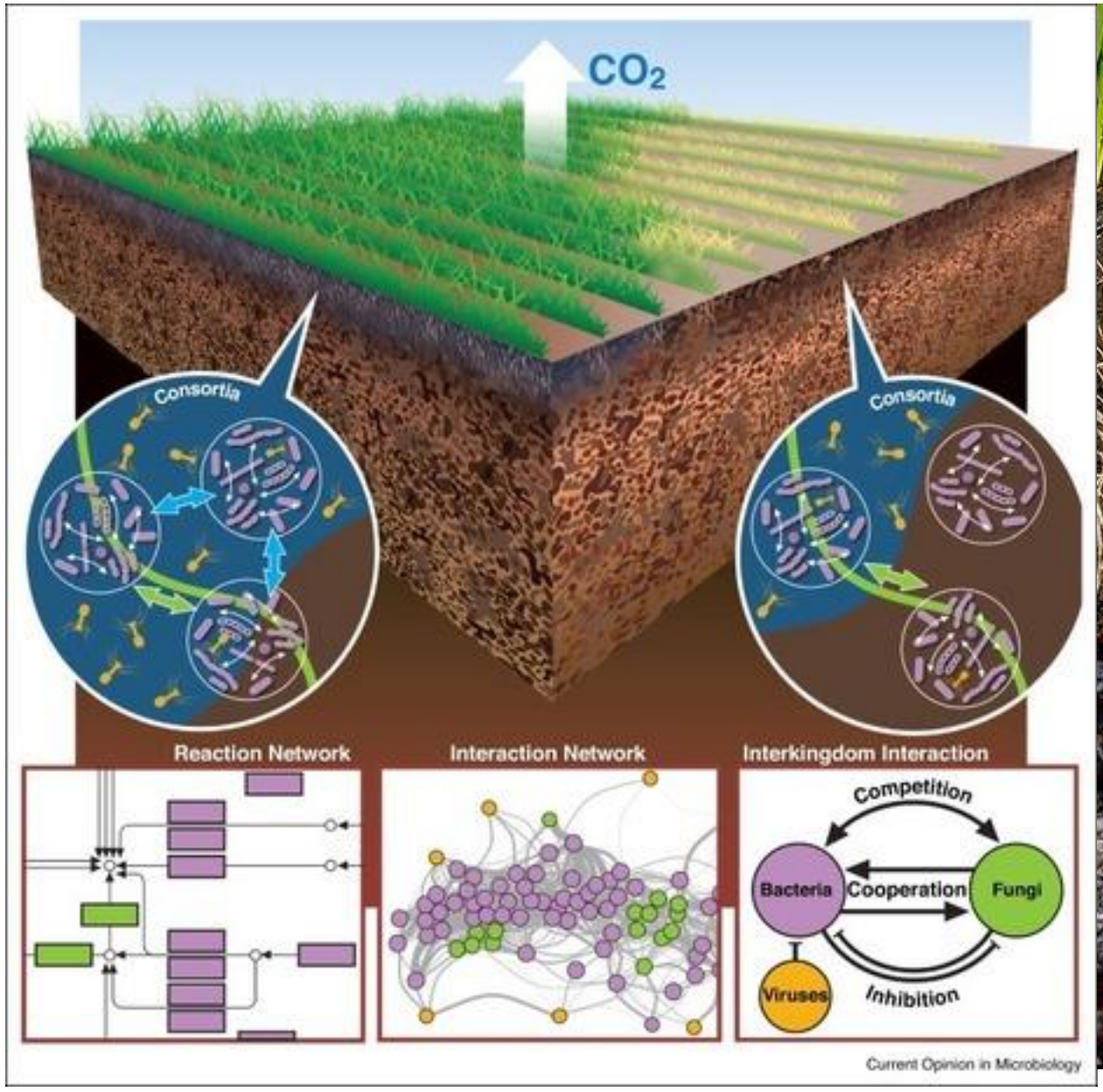
Journal of Bacteriology

Microbial Interactions - Culturabilidade





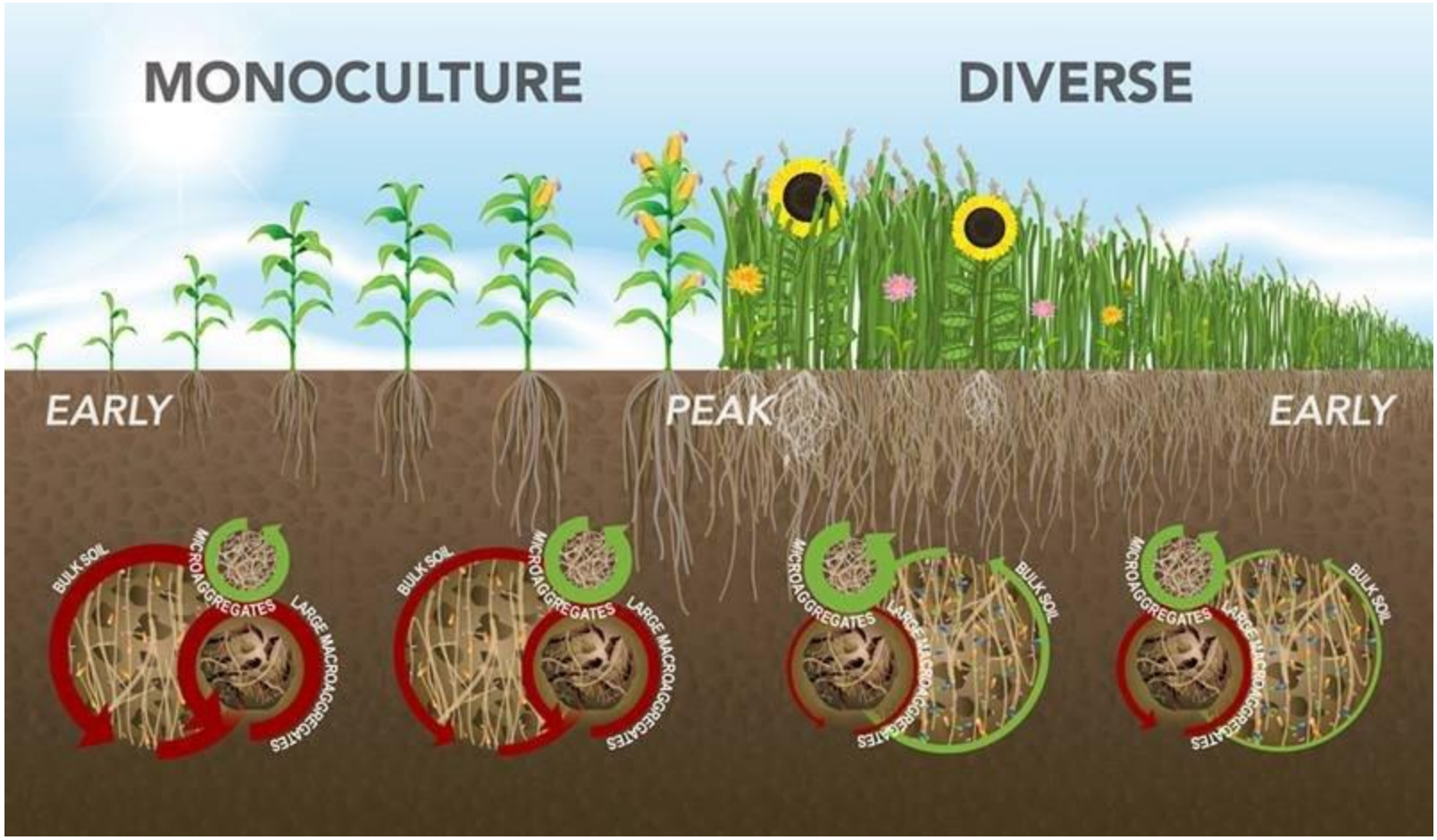
Microbiologia do solo



Importância dos micro-organismos no solo

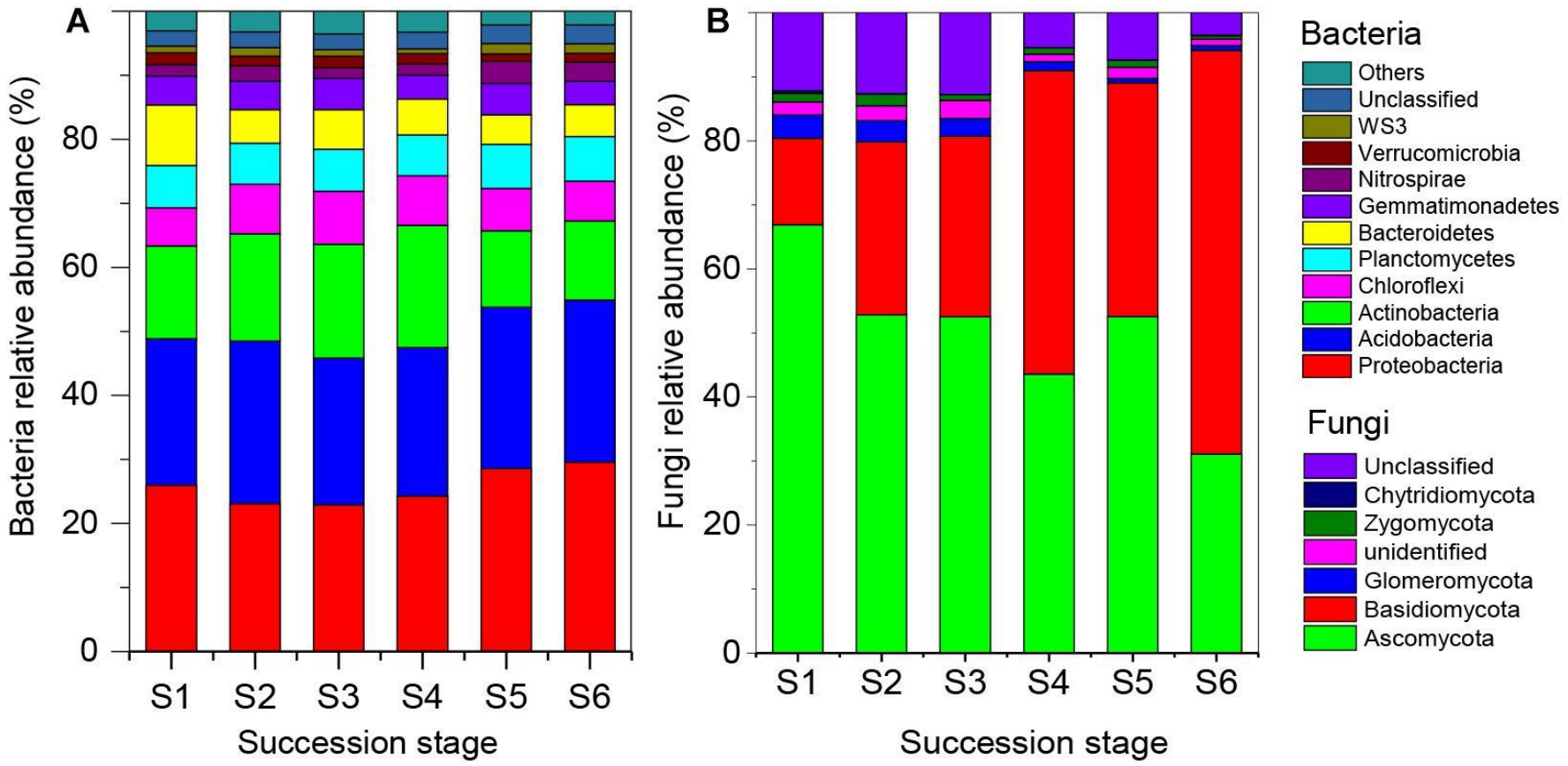
- Os micro-organismos do solo afetam a estrutura (agregação) e fertilidade do solo
- Contribui para a disponibilidade de nutrientes (degradação da matéria orgânica, formação do húmus, fixação de N e germinação de sementes
- Degrada pesticidas e produtos químicos do solo
- Contribui para o crescimento e produtividade das plantas
- Contribui com a estabilidade do solo por meio de diferentes processos bioquímicos
- Reduz a incidência de patógenos no solo (solos supressivos).

Comunidade microbiana do solo



Diversidade de plantas pode disponibilizar novos nichos para os micro-organismos do solo.
Pode aumentar a riqueza de micro-organismos no solo.

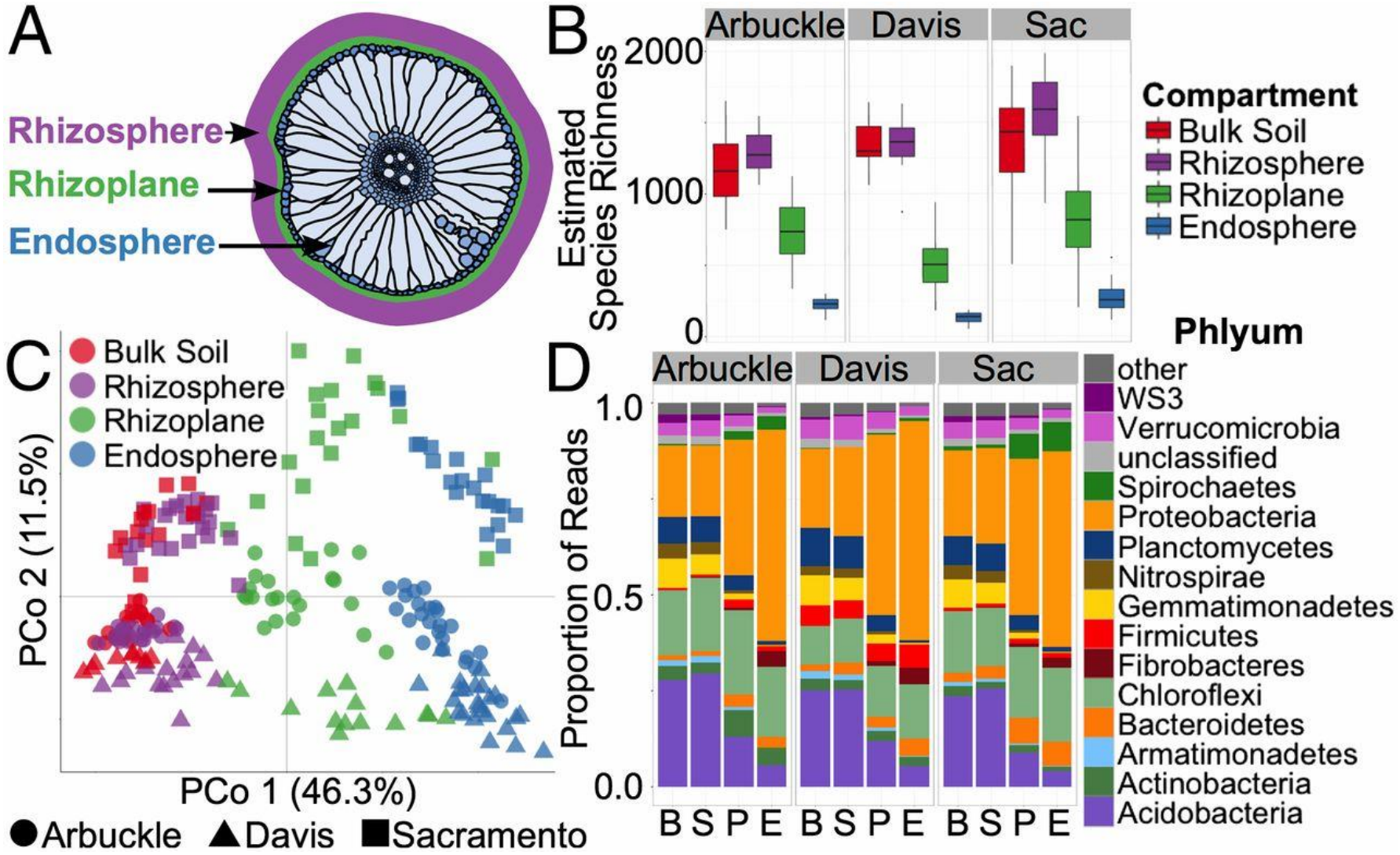
Comunidade microbiana do solo



Efeito dos diferentes estágio de sucessão vegetal sobre a comunidade microbiana do solo.

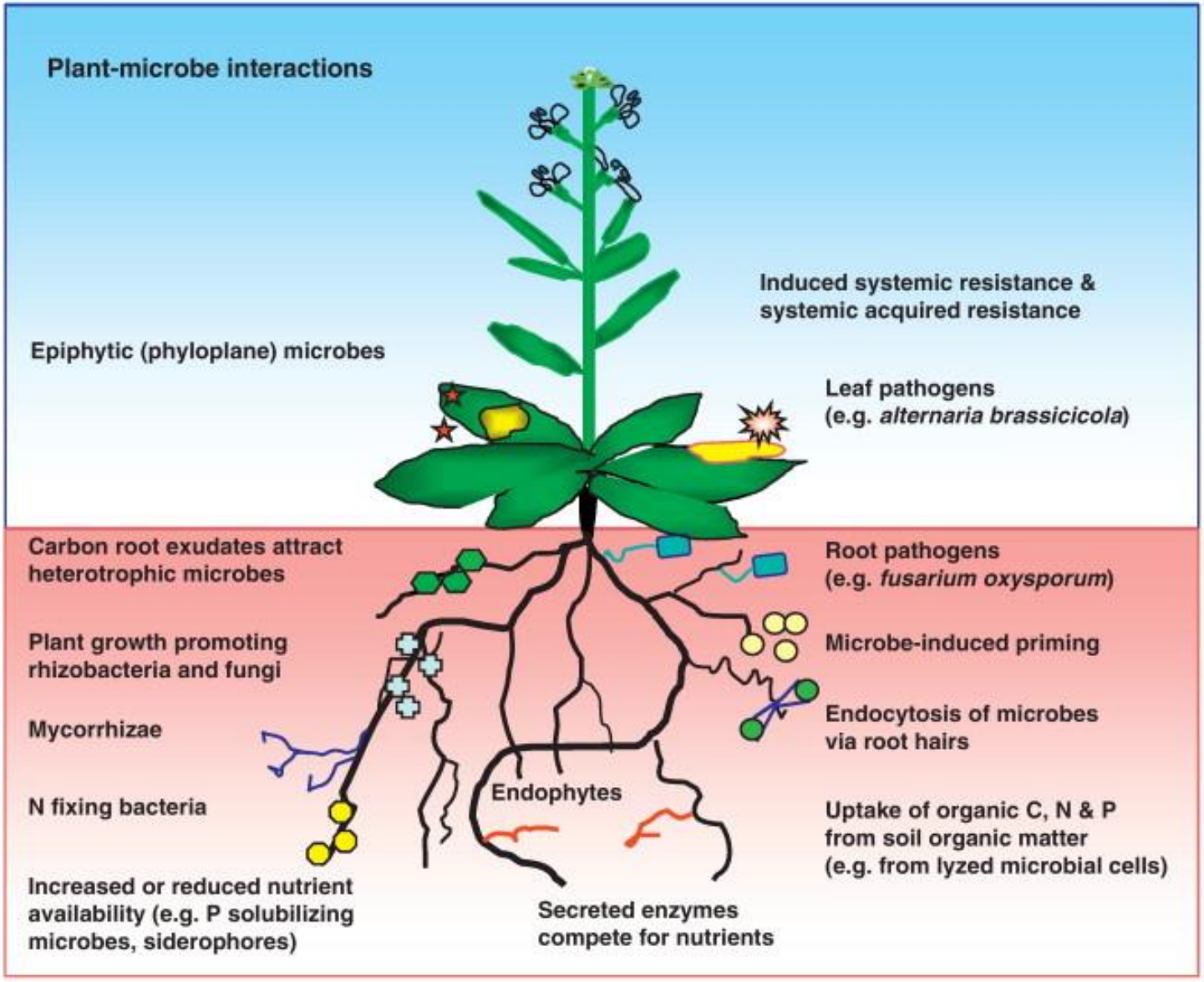
Front. Microbiol., 26 April 2019 | https://doi.org/10.3389/fmicb.2019.00895

Diversidade de bactérias associadas à planta de arroz

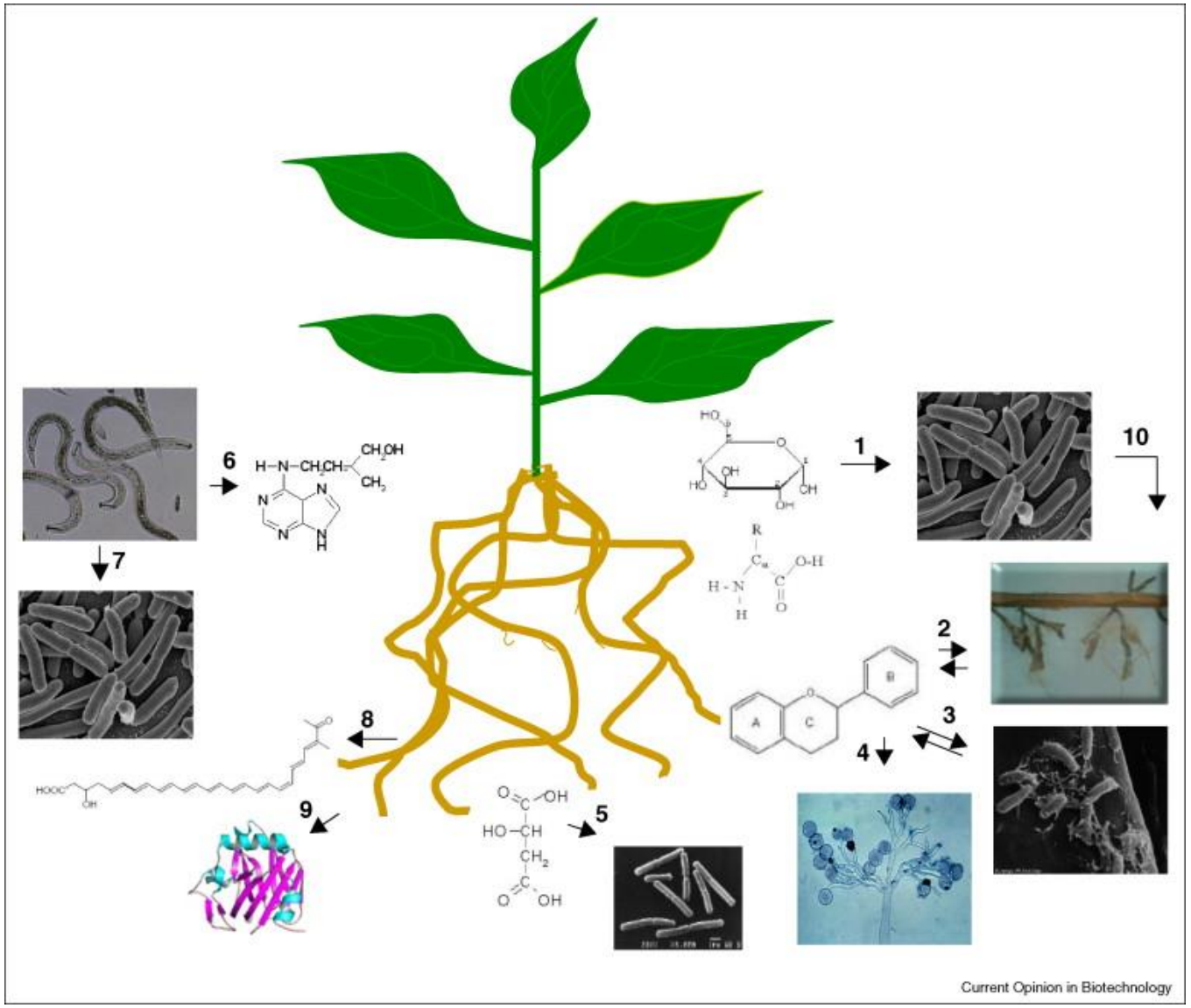


Edwards et al. (2015) PNAS. 112(8): E911–E92

Interações Microbianas no solo



Interações Microbianas efeito da planta



Comunicação química entre a planta e os micro-organismos da rizosfera/solo

Fatores que afetam a interação microbiana

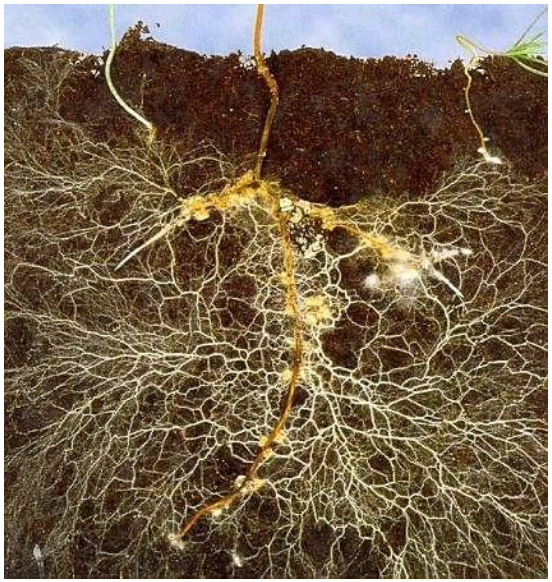
Aspectos Abióticos

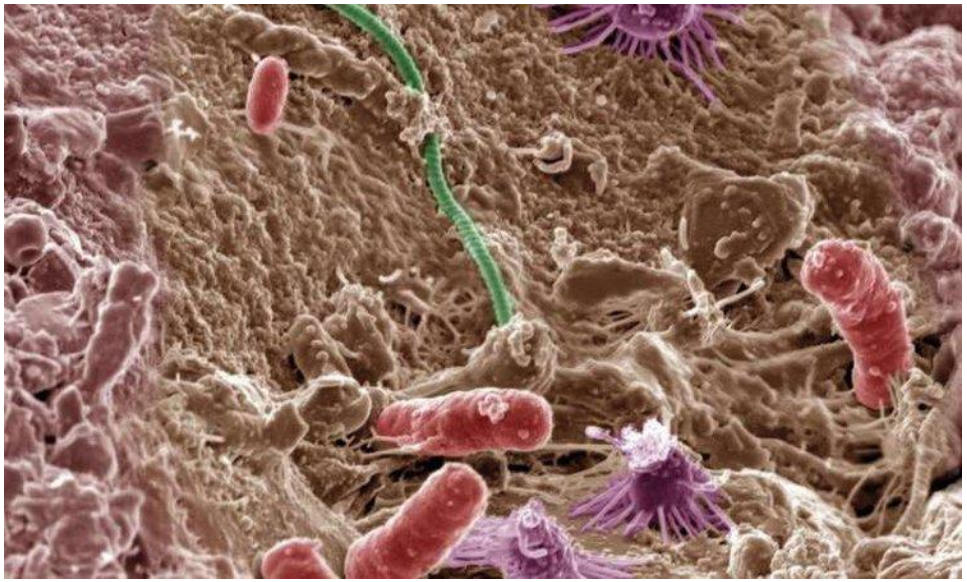
- pH do ambiente;
- Disponibilidade de nutrientes;
- Temperatura e umidade;
- Pressão de CO_2 e/ou O_2

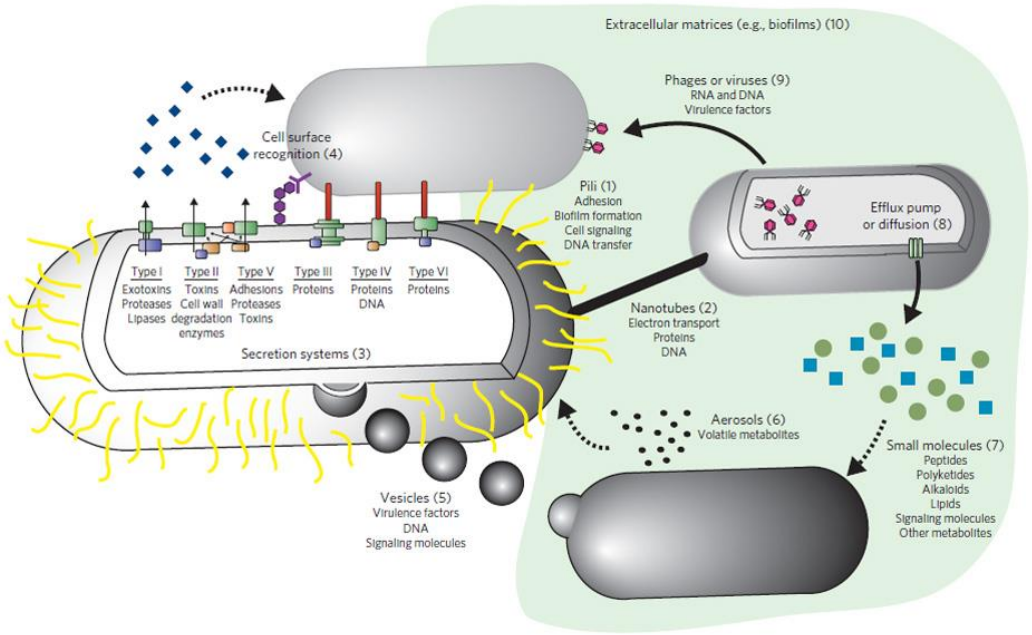
Aspectos Bióticos

- Capacidade de utilizar os nutrientes;
- Competição;
- Predação;
- Interação com organismos hospedeiros;
- Genótipo dos envolvidos.

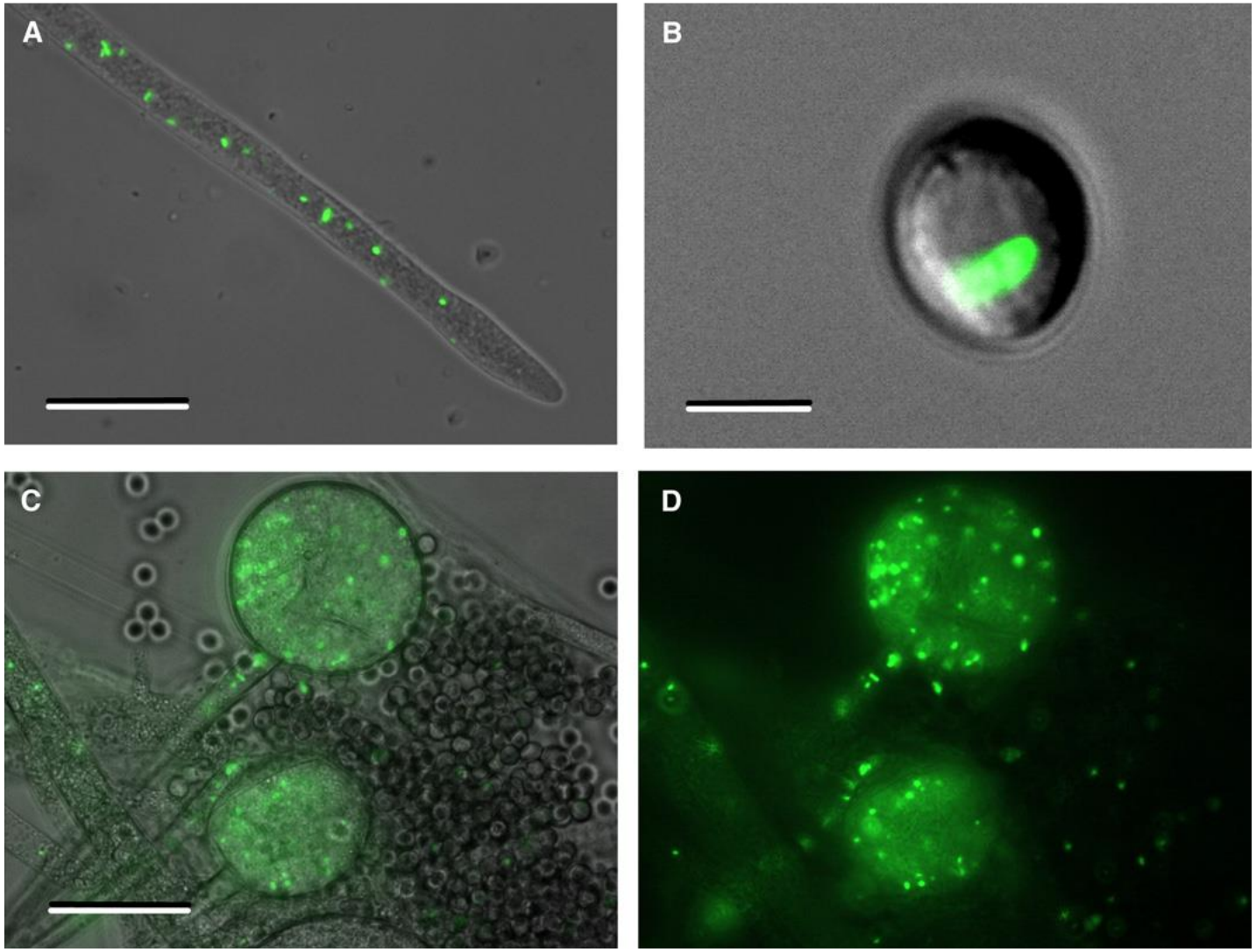
Interações Microbianas







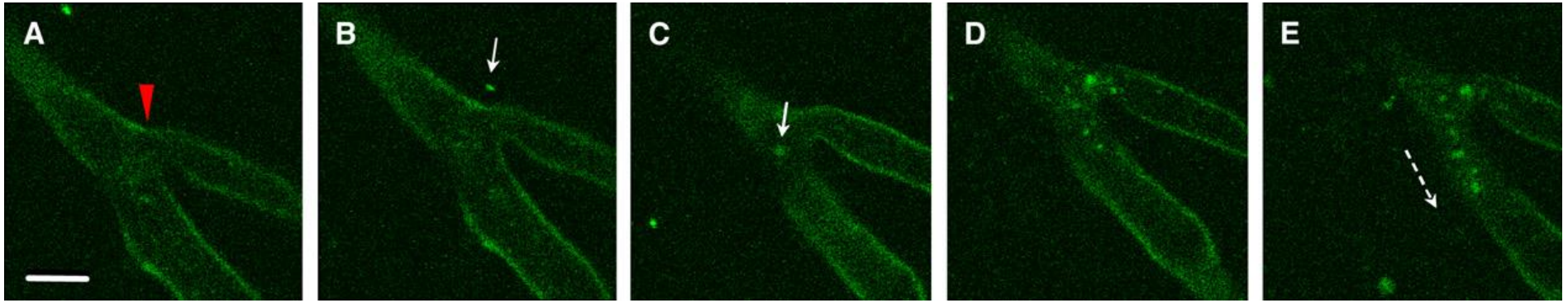
Interação entre *Rhyzopus microporus* e *Burkholderia* sp.



(A) Hypha showing bacteria migrating to the tip (scale bar represents 25 mm). (B) A single vegetative spore containing a rod-shaped GFP-labeled endobacterium (scale bar represents 2 mm). (C and D) Sporangiophores, sporangia, and spores formed after restitution of the symbiosis (white light and fluorescence mode, scale bar represents 30 mm).

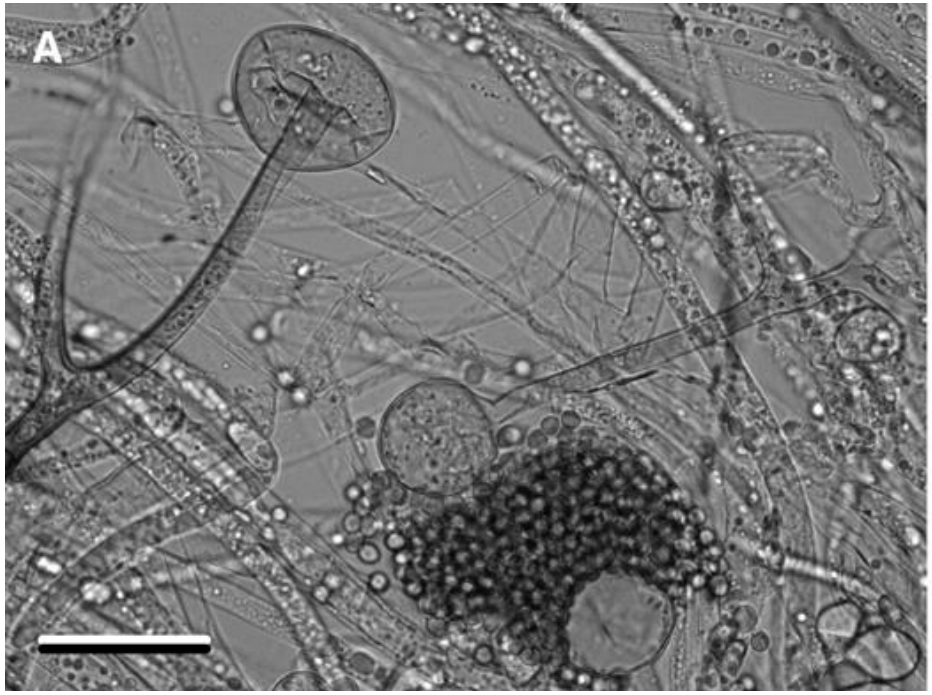
Current Biology 17, 773–777, May 1, 2007 ª2007 Elsevier Ltd All rights reserved DOI 10.1016/j.cub.2007.03.039

Interação entre *Rhyzopus microporus* e *Burkholderia* sp.

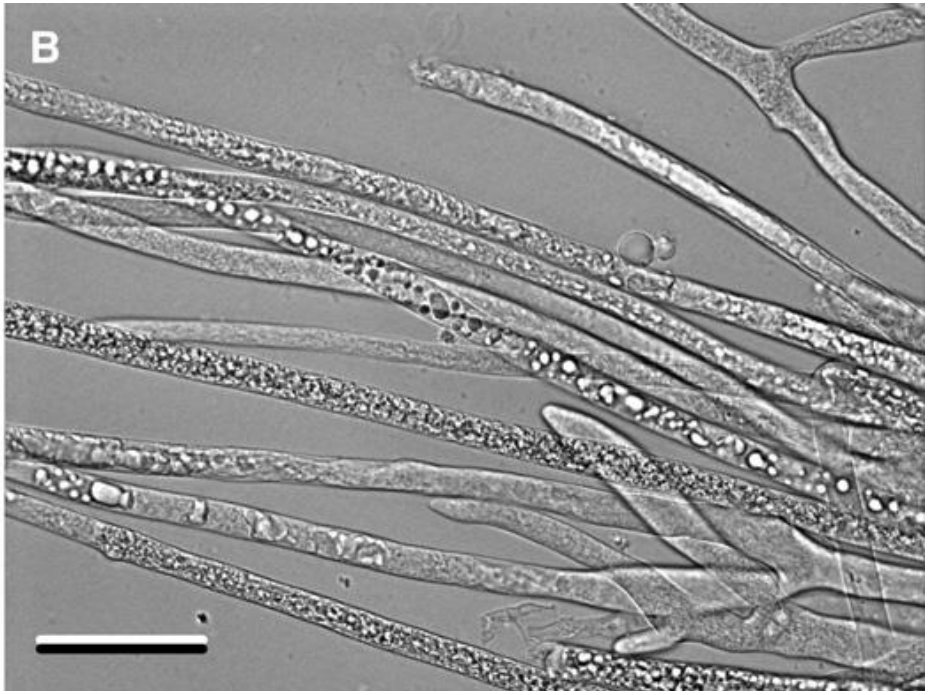


Monitoring Microinjection of GFP-Labeled Endosymbionts into the Fungus and Migration within the Hyphae
Micrographs (A)–(E) are screen captures taken at 0.5 min intervals. Scale bar represents 10 mm. Red arrow indicates site of laser injection; white arrows highlight GFP-labeled bacteria and direction of their migration.

Interação entre *Rhyzopus microporus* e *Burkholderia* sp.

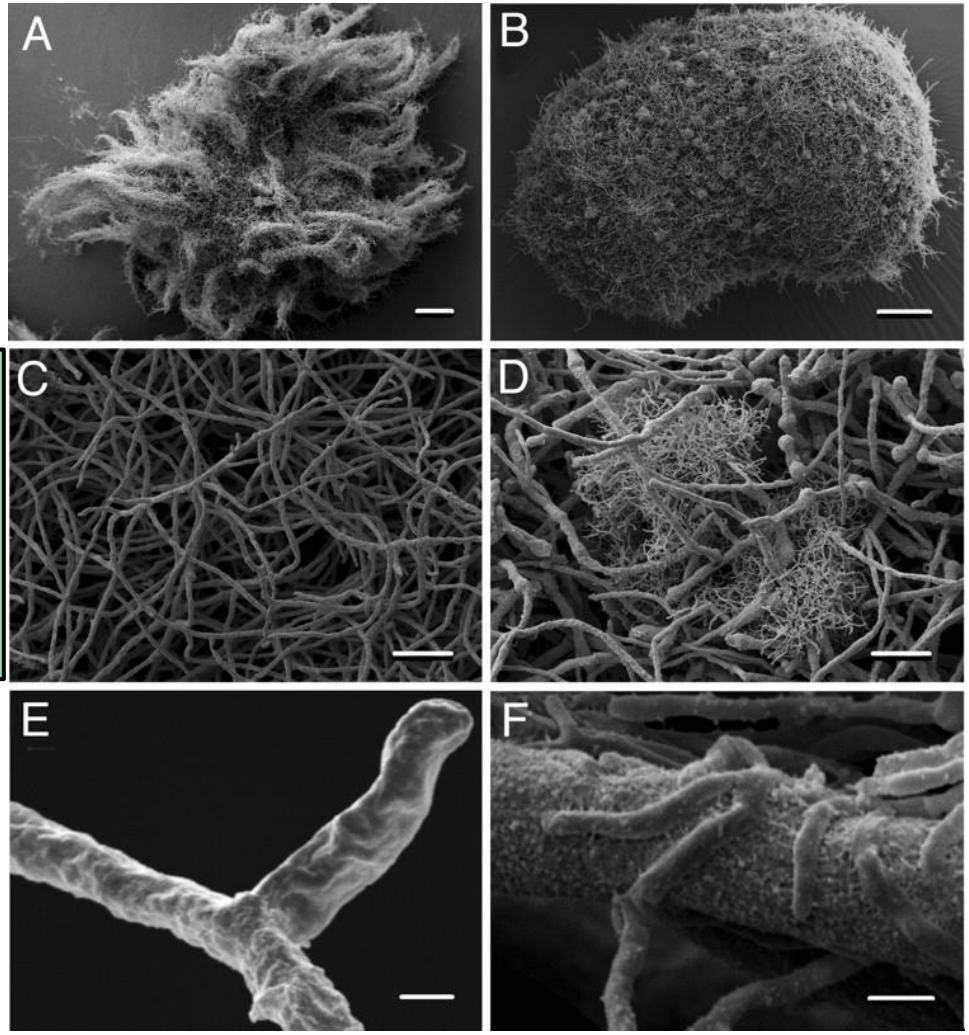


Aparência típica da linhagem selvagem, contenda *Burkholderia* sp.



A linhagem curada não forma esporângio. Scale bars represent 30 mm.

Interação entre *Aspergillus nidulans* e *Streptomyces hygroscopicus*



(*A*) Scanning electron micrograph of *A. nidulans*.

(*C*) Magnification of *A. nidulans* (Scale bar: 20 μm.)

(*E*) Further magnification of *A. nidulans*

(*B*) Scanning electron micrograph of *A. nidulans* coincubated with *S. hygroscopicus*. (Scale bar: 200 μm.)

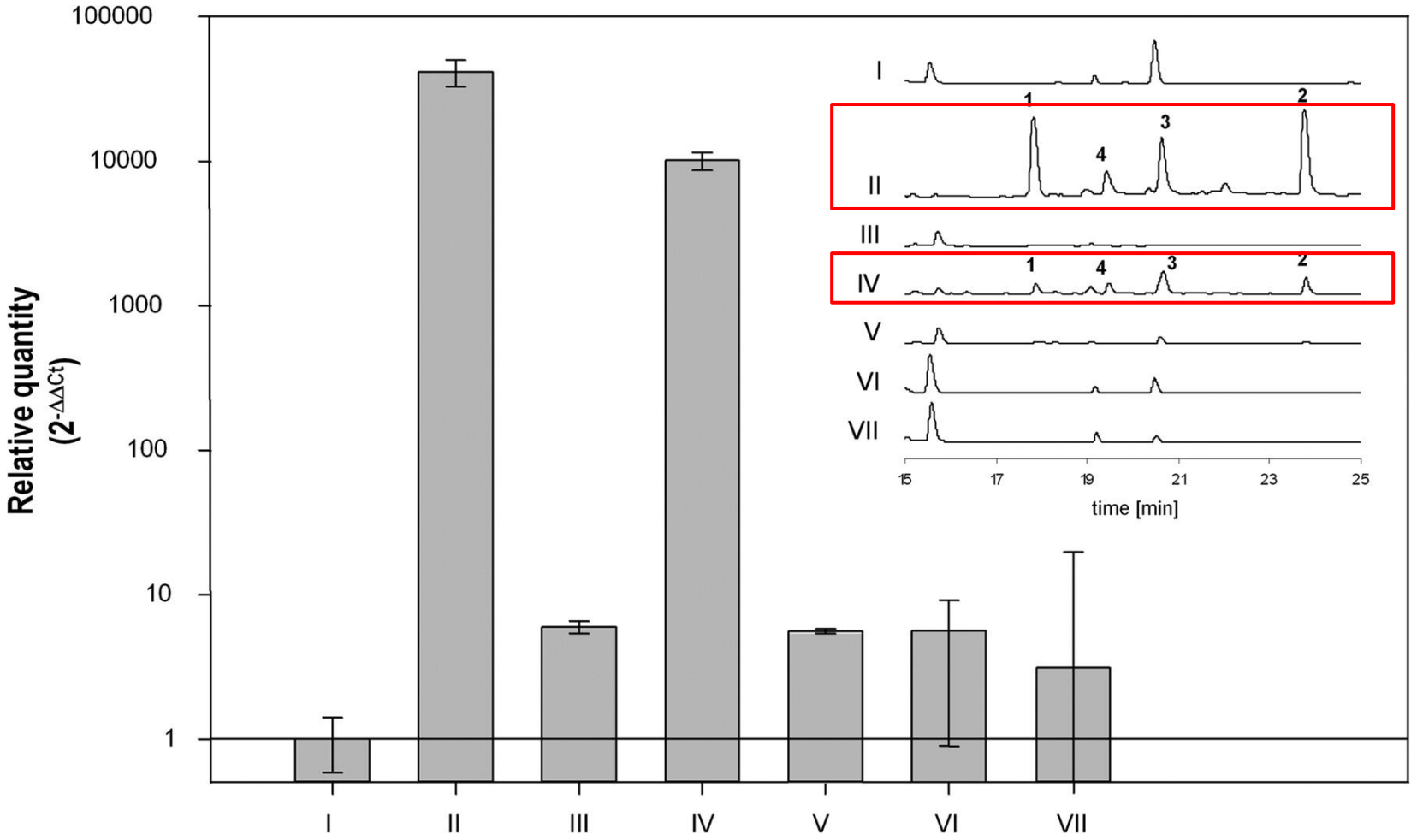
(*D*) Magnification of *B*. (Scale bar: 20 μm.)

(*F*) Further magnification of *D* showing the close contact between the filamentous bacteria and fungal mycelia.

Schroeckh V et al. PNAS 2009;106:14558-14563

PNAS

Quantidade relative de mRNA do gene orsA (AN7909) da policetídeo e análise de HPLC do sobenadante da cultura.

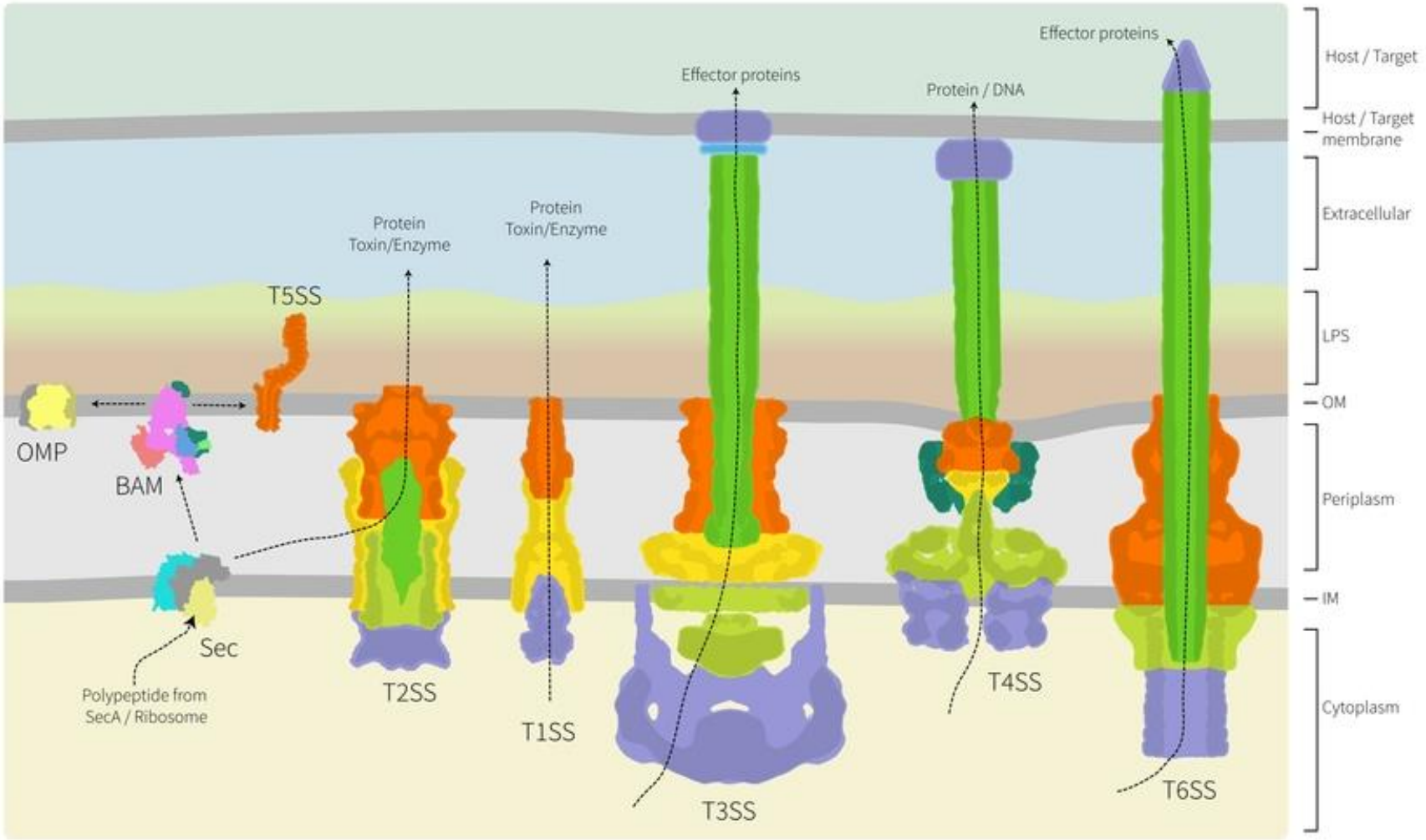


PKS *orsA* (AN7909) gene expression and HPLC profiles of supernatants. I: Control, *A. nidulans.* **II: Cocultivation of *A. nidulans* and *S. hygroscopicus* (1/20)**. III: *A. nidulans* culture, inoculation with filtered *S. hygroscopicus* culture supernatant. **IV: Cocultivation of *A. nidulans* and *S. hygroscopicus*, inoculation with 1/100 volume of *S. hygroscopicus* culture**. V: Cocultivation of *A. nidulans* and *S. hygroscopicus* (1/100) separated by a dialysis bag. VI: Cultivation of *A. nidulans*, inoculation with 1/20 volume culture supernatant of a coculture of *A. nidulans* WT and *S. hygroscopicus*. VII: Cultivation of *A. nidulans* with 1/20 volume culture supernatant of a coculture of *A. nidulans* Δ*orsA* (ΔAN7909) strain and *S. hygroscopicus*.

Schroeckh V et al. PNAS 2009;106:14558-14563

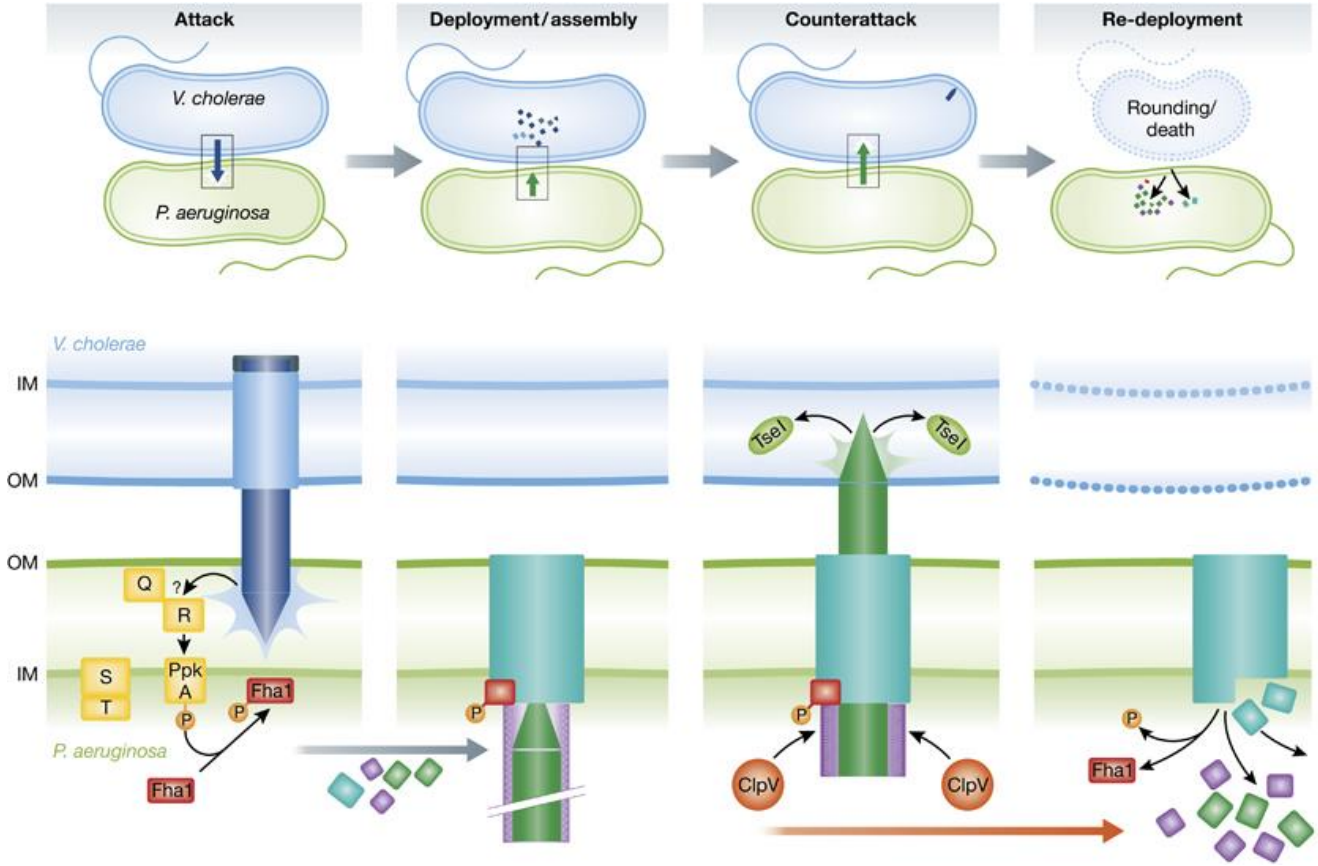
PNAS

Mecanismos de interação: sistemas de secreção



São mecanismos de transferência de moléculas (proteinas, toxinas ou DNA) do interior da célula produtora para o meio externo ou interior de outra célula.
Estes sistemas de secreção podem regular a interação da bacteria com outros organismos do ambiente.

Sistema de Secreção do tipo 6 (T6SS).

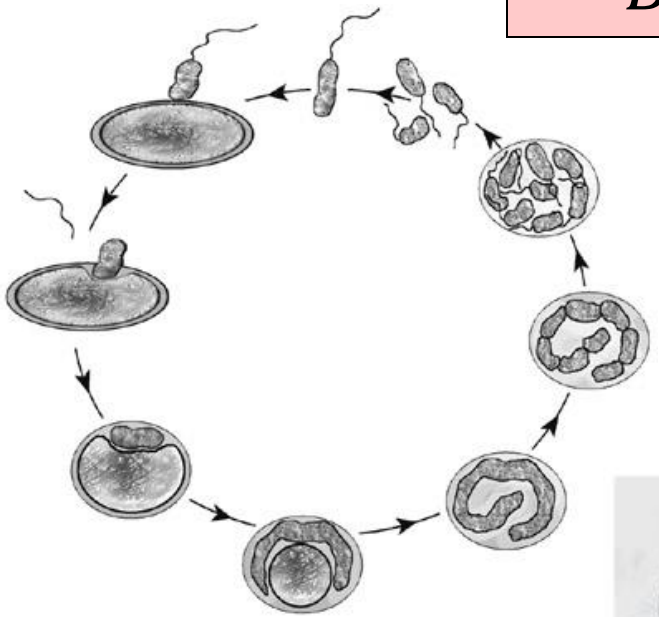


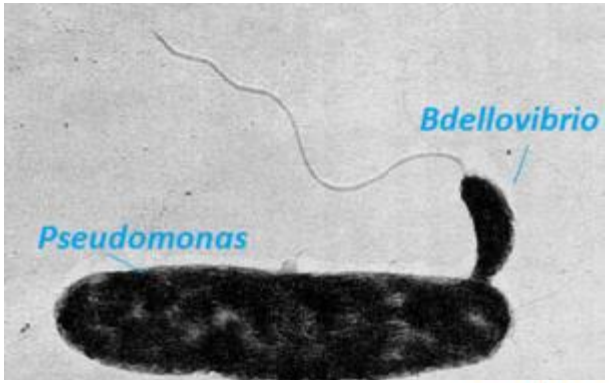
Modelo de interação *V. cholera* e *P. aeruginosa:*

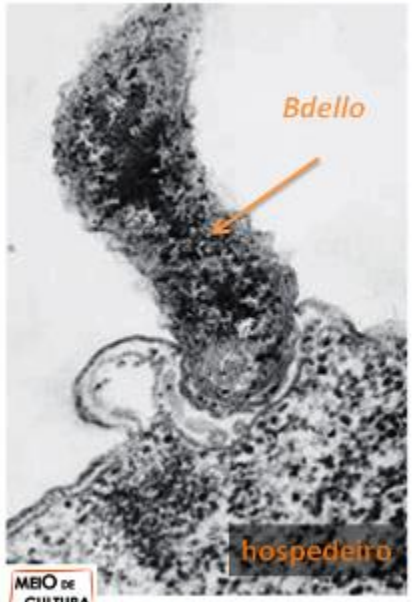
- Ataque de *V. cholerae* via T6SS é percebido pela trasdução de sinais TagQRST (amarelo) de *P. aeruginosa*.
- TagQRST ativa PpkA kinase a fosforilar Fha1 (vermelho).
- Fha1 fosforilado organiza o T6SS próximo aoponto de ataque
- Contração da bainha (violeta) dispara o injector (verde escuro) e libera o efetor Tse1 (peptidioglycan amidase)
- Tse1 leva a célula de *V. cholera* a lise
- A ATPase e desfosforilação de Fha1 induz a desorganização do T6SS.

Predação de bactéria por bactéria

Bdellovibrio bacteriovorus

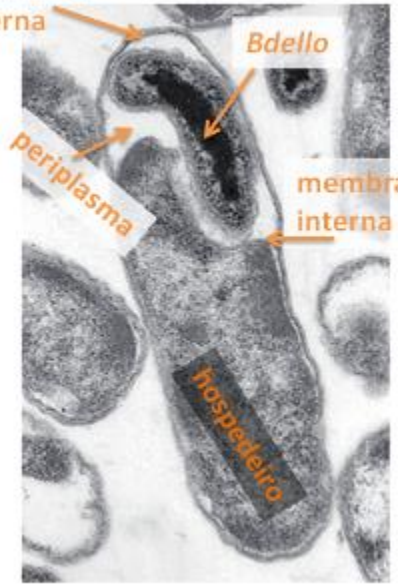






Adesão

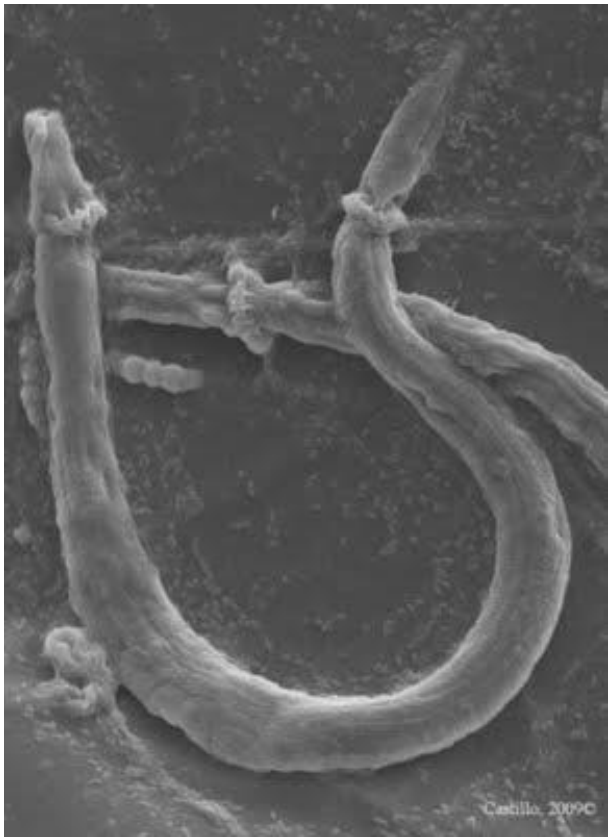
Penetração



Estabelecimento

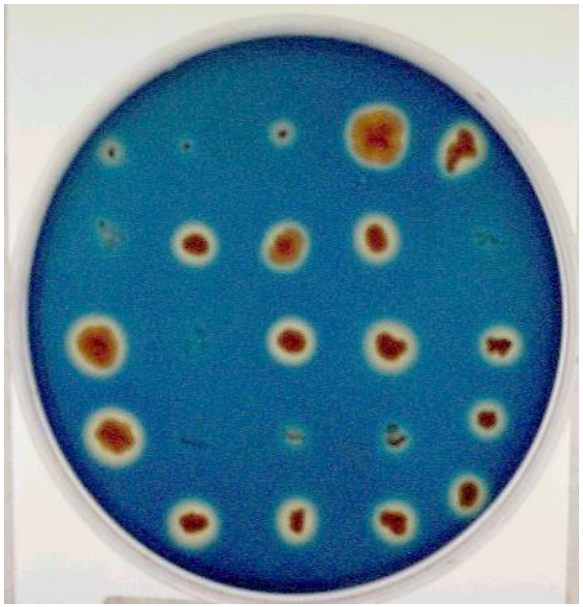
Predação de eucarioto por fungos

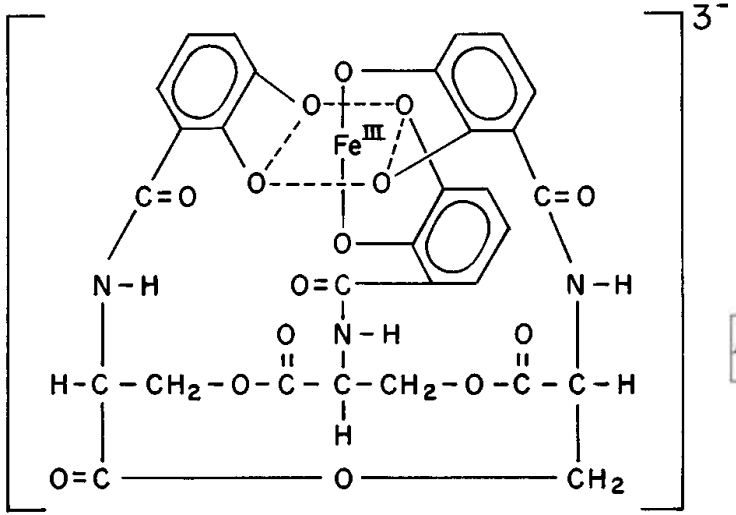
Alga sendo predada por fungo

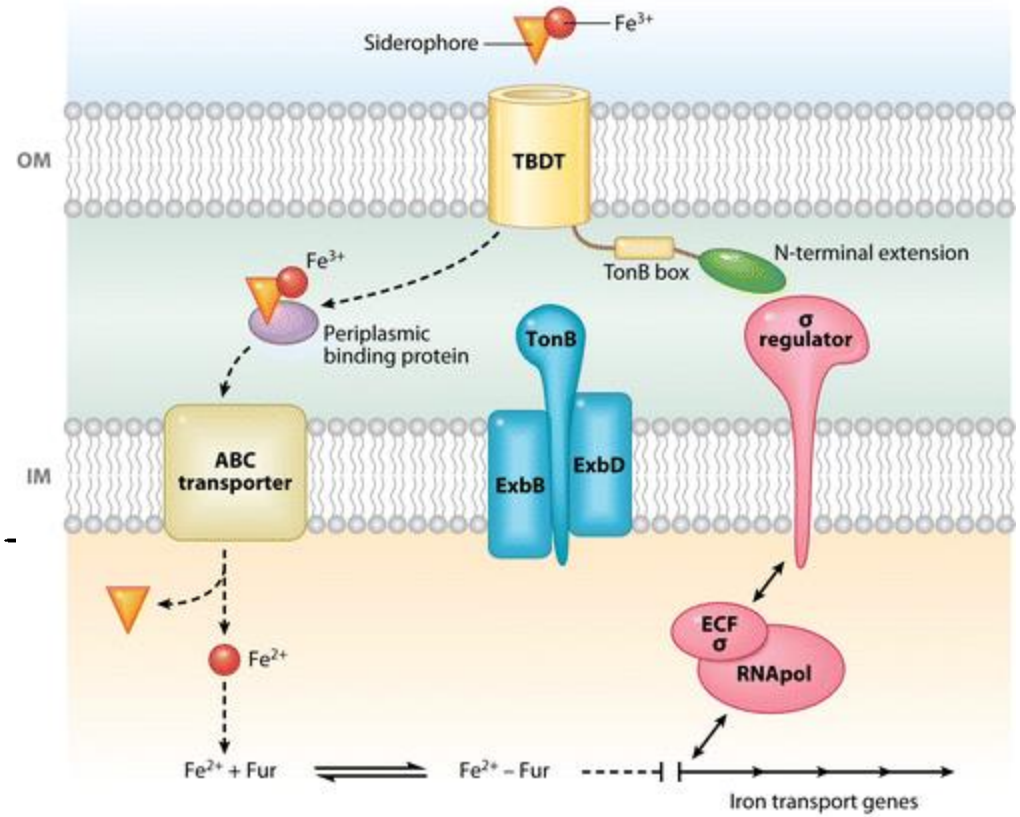


Principalmente pelo fungo *Paecilomyces* spp.
Formação de anel de constrição

Mecanismos envolvidos na interação – produção de sideróforos (obtenção de ferro)



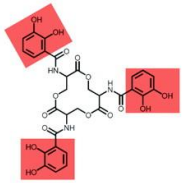




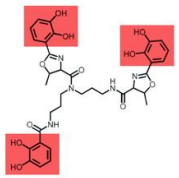
Noinaj N, et al. 2010.
Annu. Rev. Microbiol. 64:43–60

Representative examples of different siderophores and their natural producers

Catecholate Type

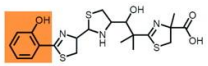


Enterobactin
(enteric bacteria, *Streptomyces* spp.)

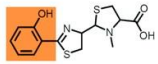


Vibriobactin
(*Vibrio cholerae*)

Phenolate Type



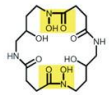
Yersiniabactin
(*Yersinia pestis*, *Yersinia enterocolitica*)



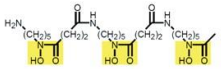
Pyochelin
(*Pseudomonas aeruginosa*)

Small weight compounds that have a high affinity for Fe (III).
Help with Iron Transport.
Three subunits of siderophore's chelating groups.

Hydroxamate Type

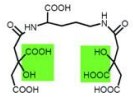


Alcaligin
(*Alcaligenes denitrificans*, *Bordetella pertussis*, *Bordetella bronchiseptica*)

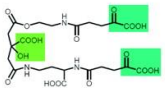


Desferrioxamine B
(*Streptomyces pilosus*)

Carboxylate Type



Staphyloferrin A
(*Staphylococcus* spp.)

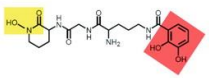


Achromobactin
(*Erwinia chrysanthemi*)

Moieties involved in iron coordination are highlighted as follows: catecholates are in red, phenolates are in orange, hydroxamates are in pale yellow, α-hydroxy-carboxylates (deriving from citrate units) are in light green, and α-keto-carboxylates (deriving from 2-oxo-glutarate units) are in blue-green.

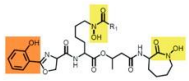
Mixed Types

Catecholate-Hydroxamate



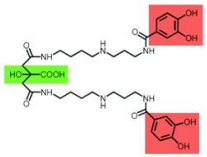
Heterobactin B
(*Rhodococcus erythropolis*)

Phenolate-Hydroxamate



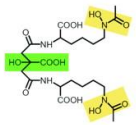
Mycobactin T
(*Mycobacterium tuberculosis*)

Citrate-Catecholate



Petrobactin
(*Bacillus anthracis*, *Bacillus cereus*, *Marinobacter hydrocarbonoclasticus*)

Citrate-Hydroxamate



Aerobactin
(*Enterobacter* spp., *Escherichia coli*, *Shigella flexneri*)

Miethke M , and Marahiel M A Microbiol. Mol. Biol. Rev. 2007;71:413-451

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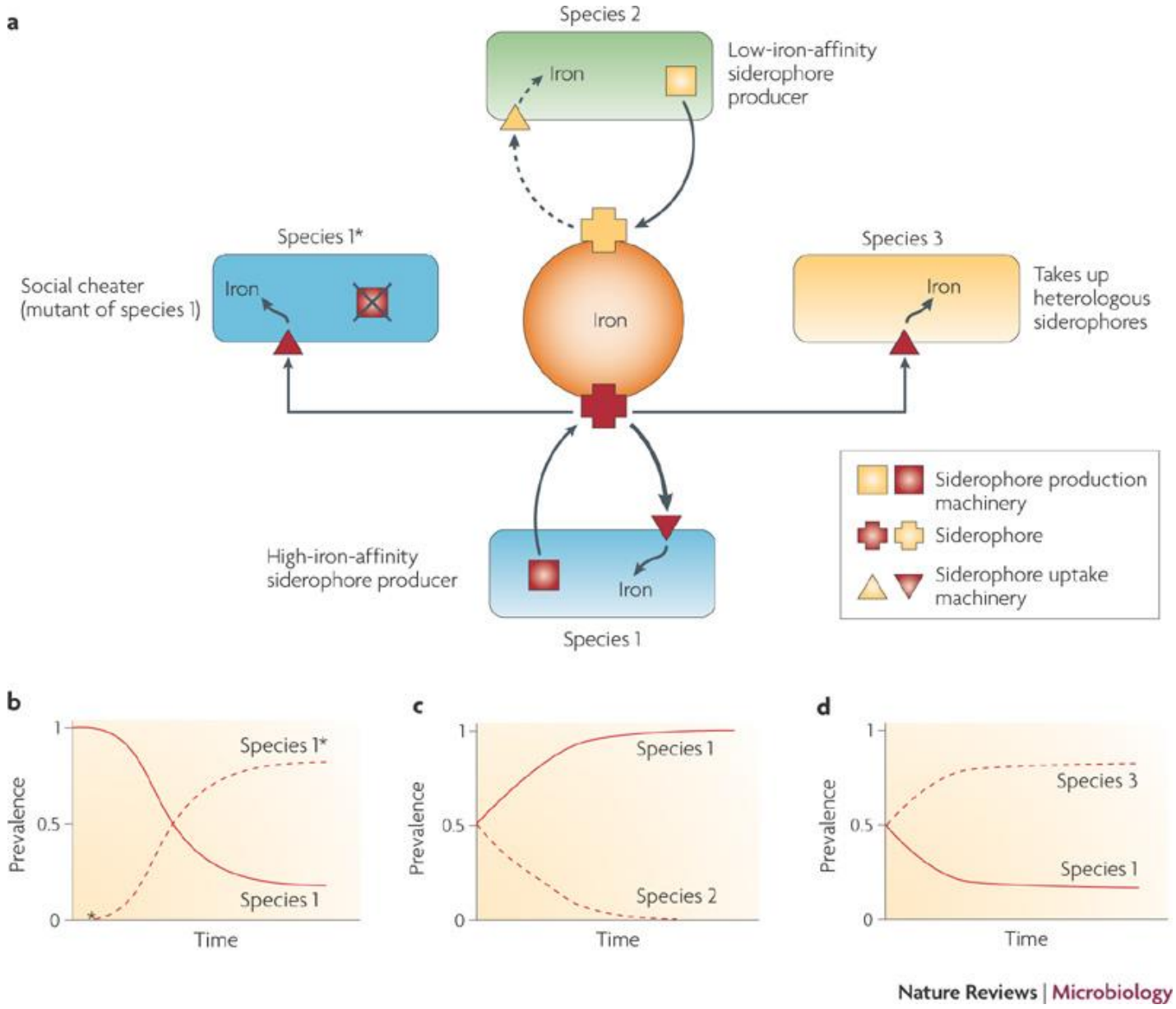
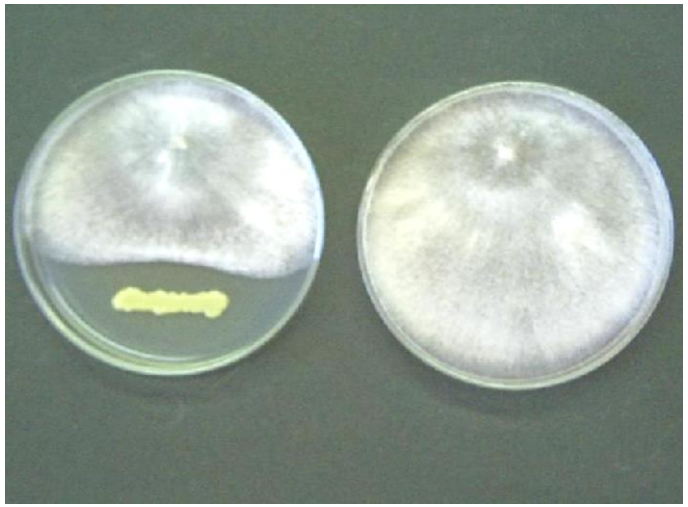
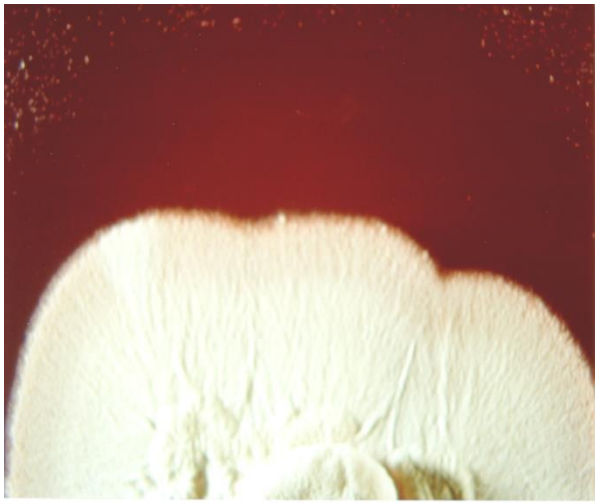
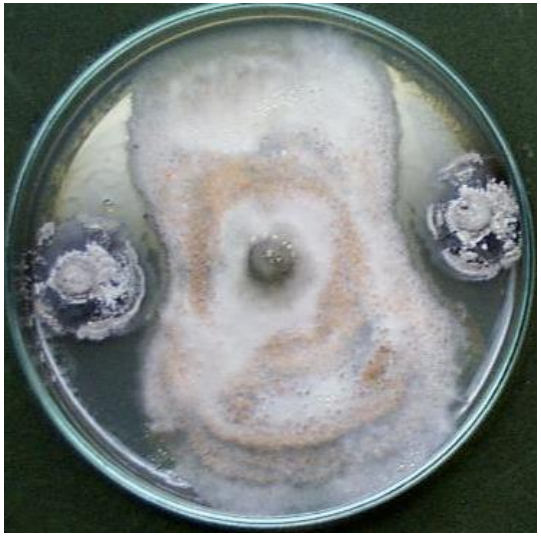


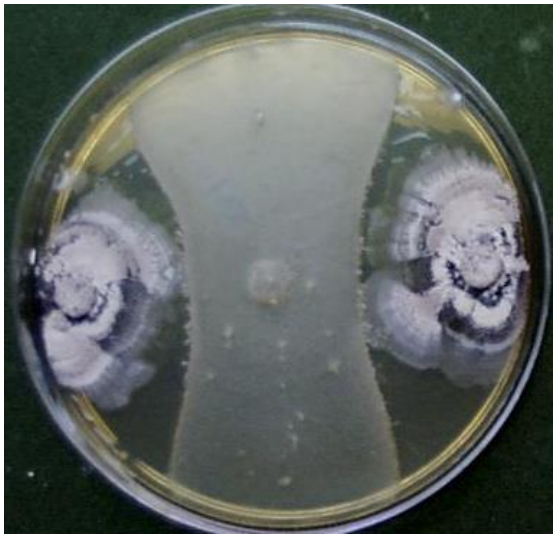
Species 1* has lost the ability to produce siderophore but keep the ability to use this siderophore. Species 1 produces a higher-affinity siderophore than species 2. Species 3 has evolved the ability to use the heterologously produced siderophore from species 1. b – d) The predicted outcome of competition in iron-limiting conditions.

Mecanismos envolvidos na interação – produção de antimicrobianos

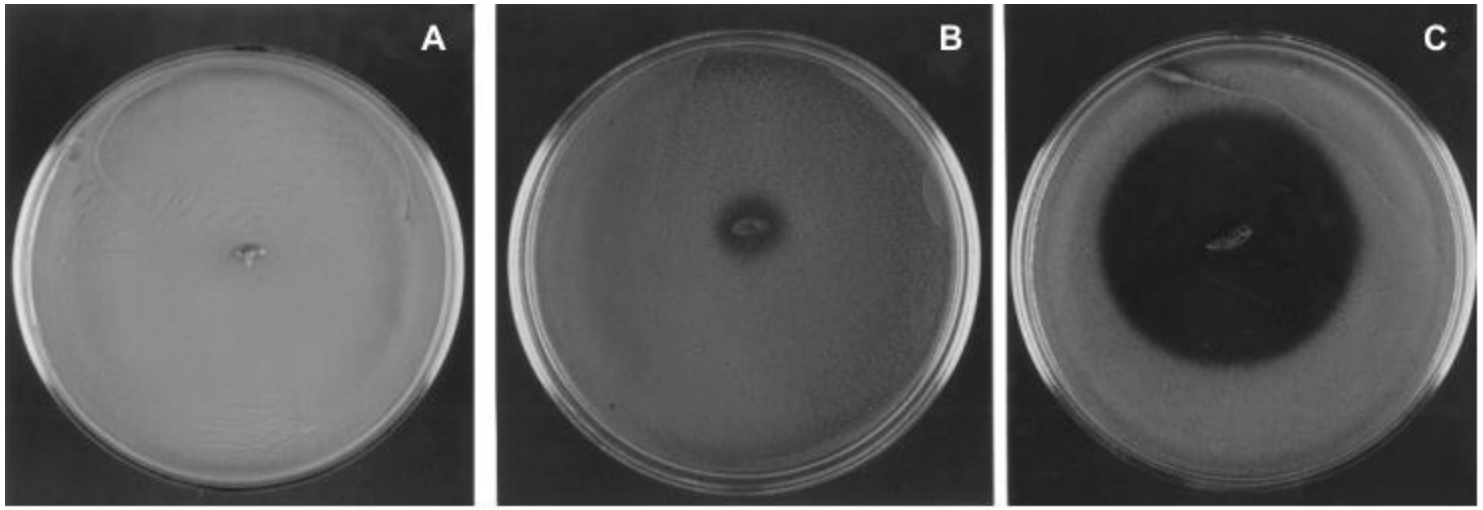


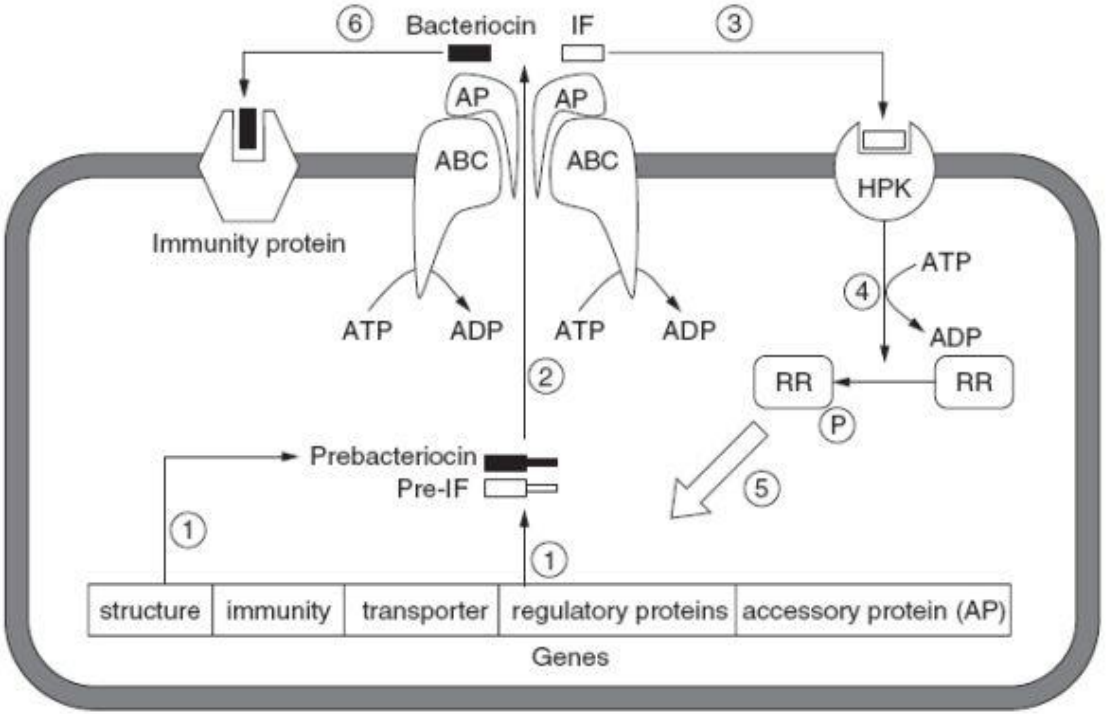






Mecanismos envolvidos na interação – bacteriocinas



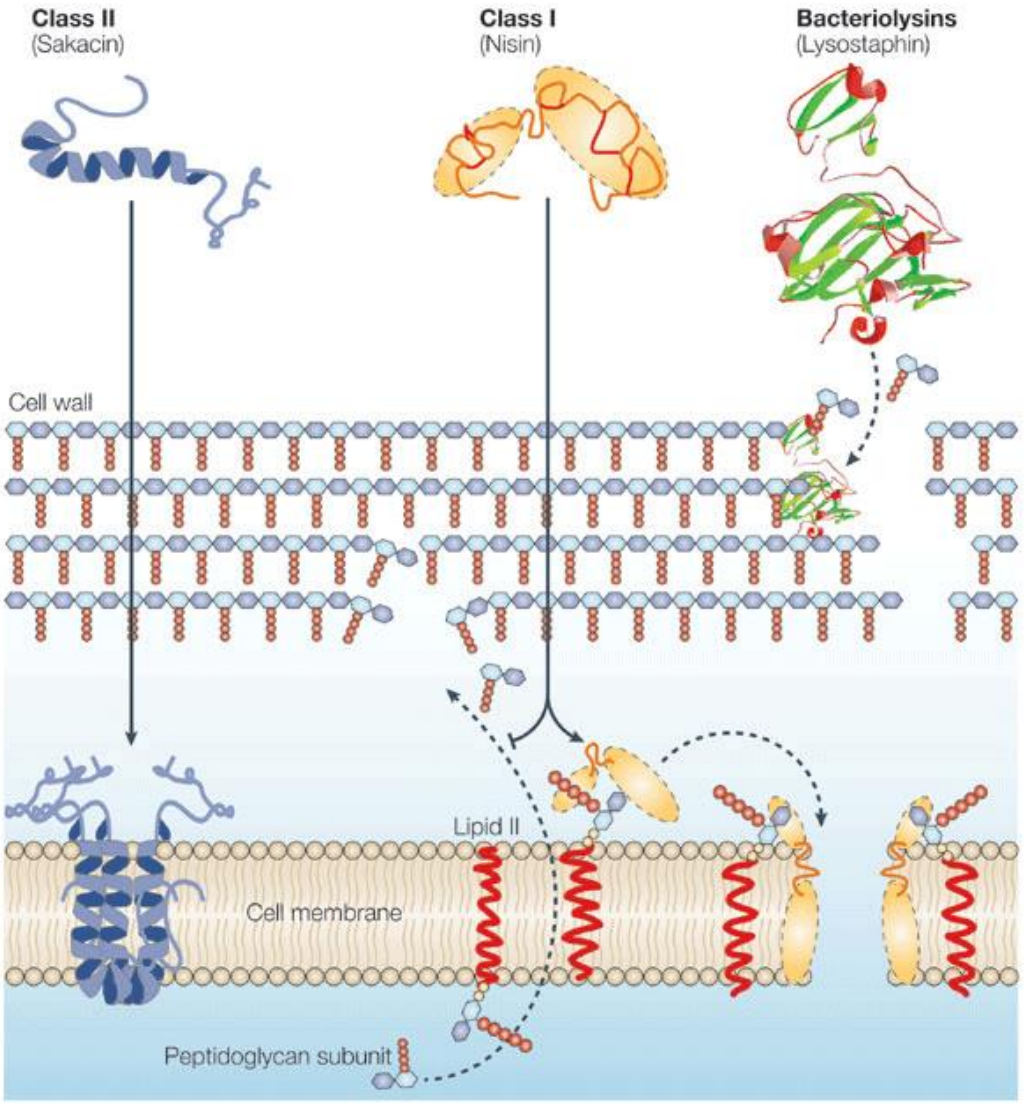


Bacteriocin

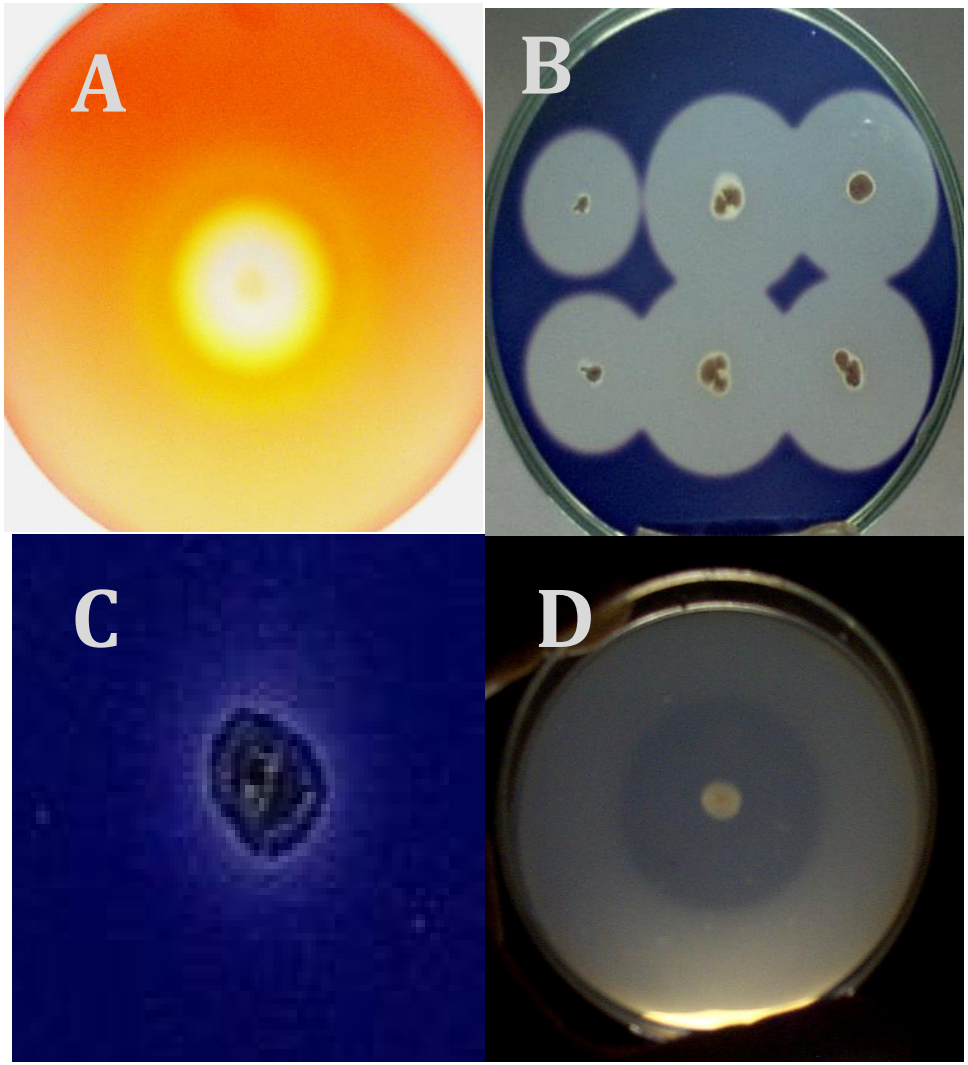
- **Antimicrobial peptides produced by bacteria which kill or inhibit the growth of other bacteria**
- **Natural preservatives**
- **Bacteriocin vs. antibiotics**

Characteristics	Bacteriocin	Antibiotics
Producer	Bacteria (LAB, *E. coli*)	Usually fungi (not always)
Chemical composition	Proteinaceous	Complex ring structure
Antimicrobial activity	Narrow spectrum (specific)	Varying spectrum (less specific)
Host cell immunity	Yes	No
Application	Food and plant protection	Clinical

Modo de ação de bacteriocinas de bactérias lácticas



Mecanismos envolvidos na interação – produção de enzimas



Capacidade de obter nutrientes e/ou competição

Microrganismos produtores de enzimas:

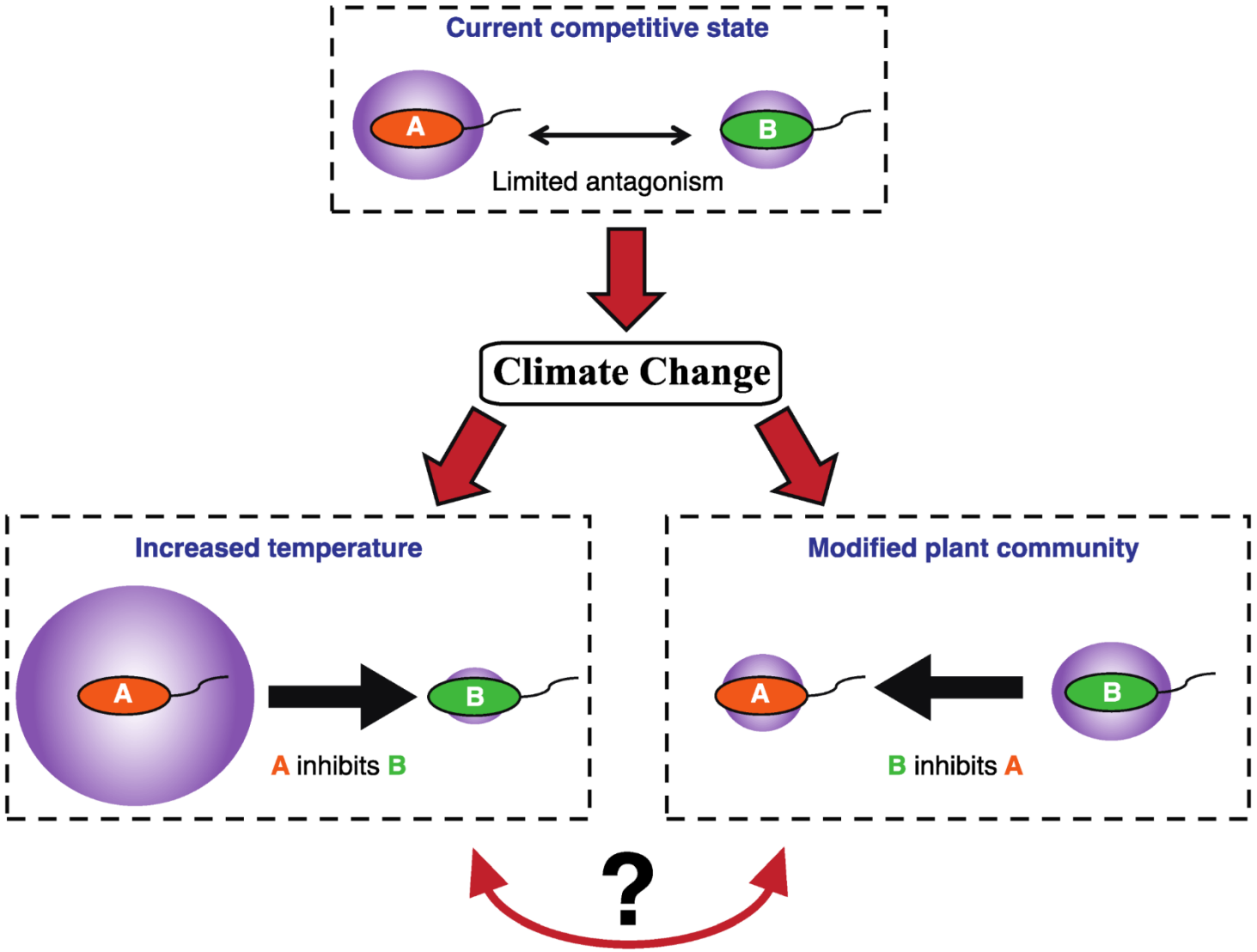
A) Endoglicanase (celulose);

B) Amilase (amido);

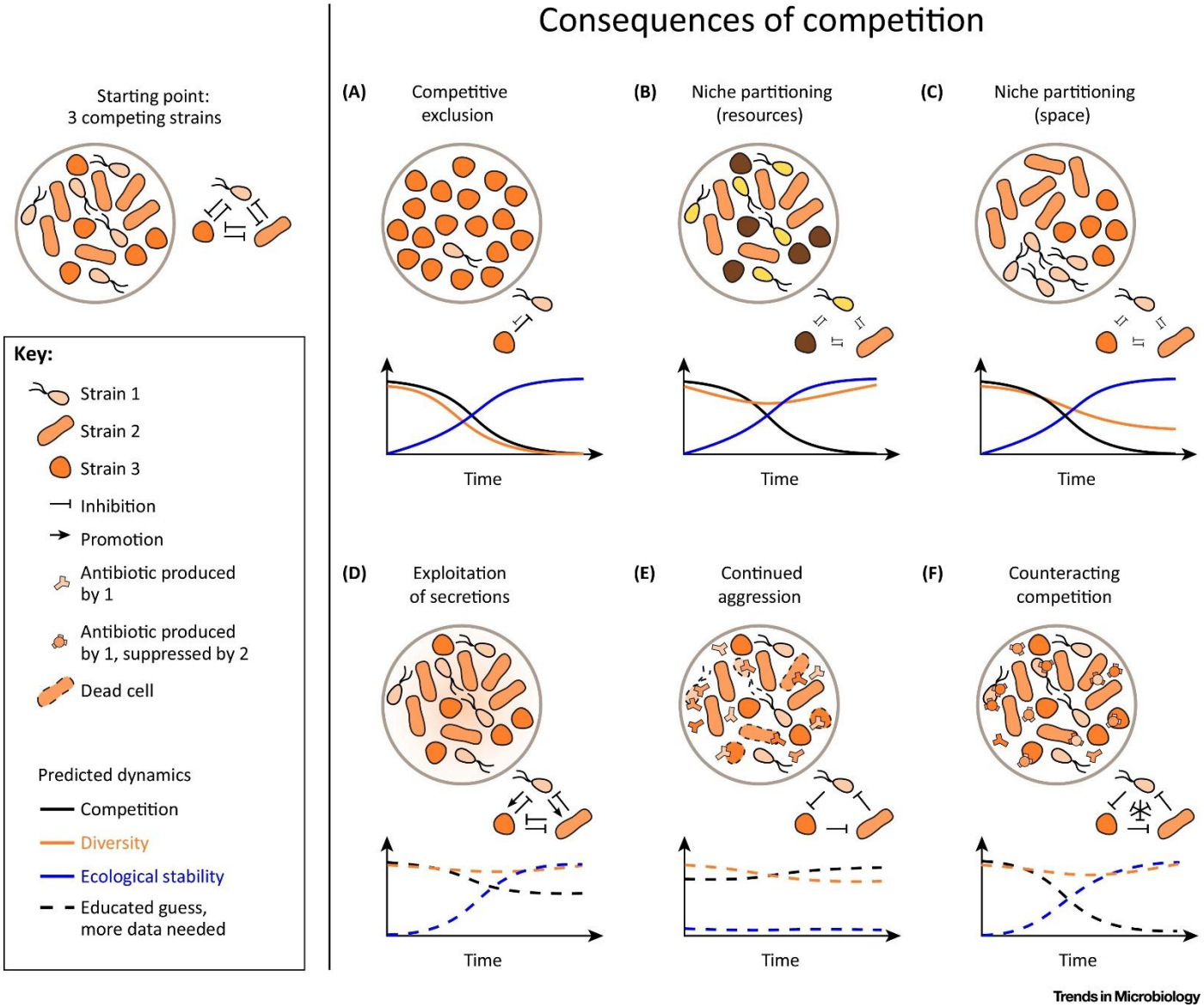
C) Protease (proteína);

D) Xantanase (Goma xantana).

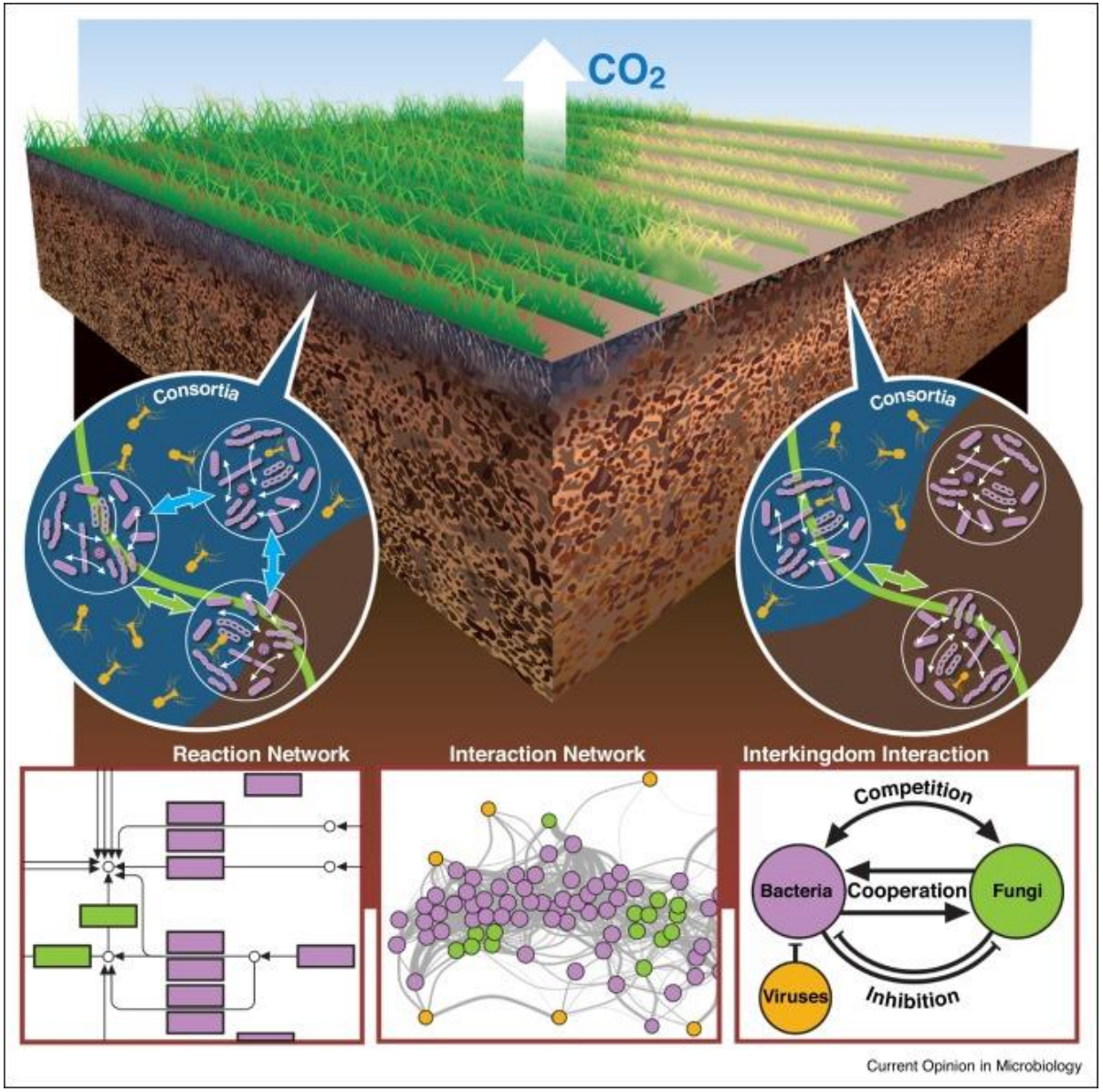
Mecanismos envolvidos na interação – competição



Mecanismos envolvidos na interação – competição



Comunidade microbiana do solo



Hora de descansar……. Boa tarde