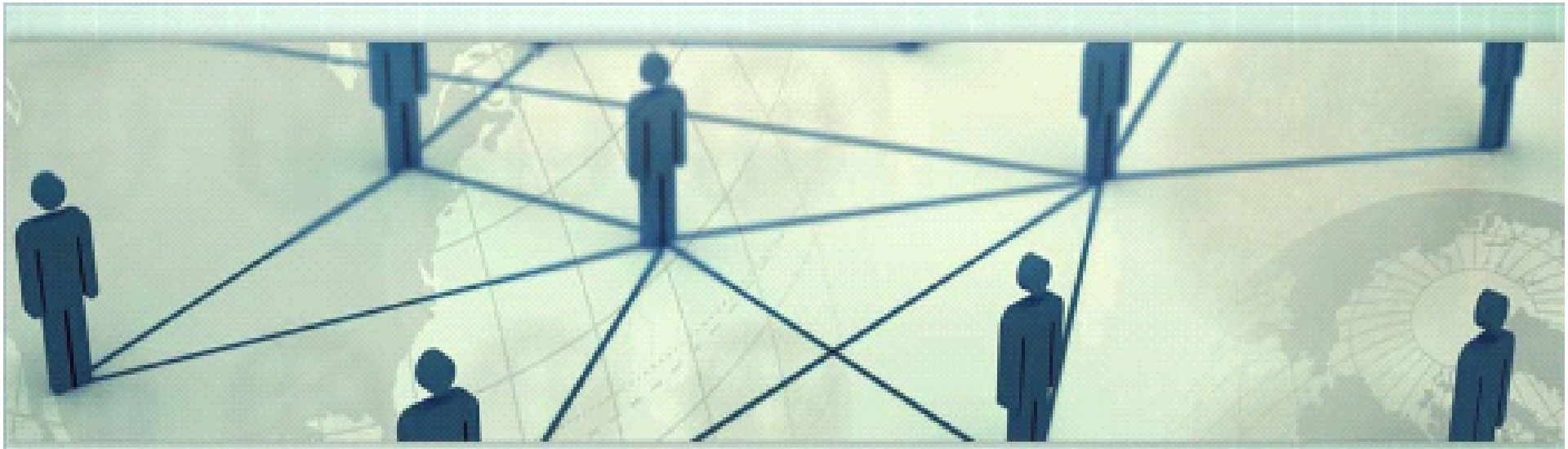
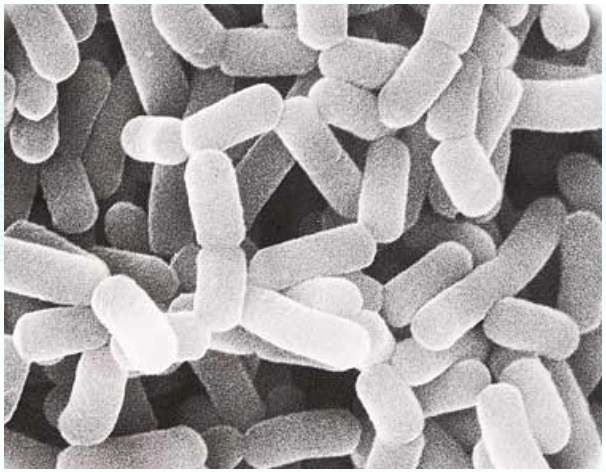


Social interaction in synthetic and natural microbial communities

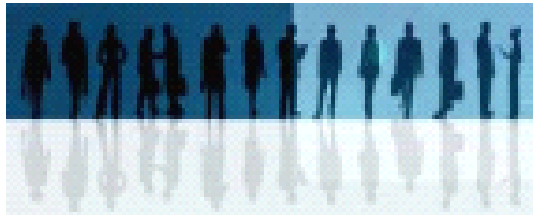
王彬忠 牛领革

?



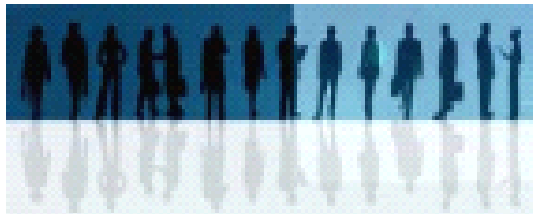
!

- 通常我们看待微生物都是以个体去看待，但是实际上微生物都是以群体生长的，并且依赖于这种群体水平的特征去生存
- 如细菌以群体的方式分泌毒素因子才可以使其壮大，或者当产生胞外聚合物的时候才能产生菌膜；啤酒酵母的蔗糖转化都是需要群体作用



content

1. Cooperation and conflict in microbial populations
2. Social evolution theory
3. Extending Hamilton's rule
4. Synthetic biology models of ecosystems
5. Spatial interactions
6. Molecular mechanisms that stabilize social interaction
7. Clinical implications
8. Beyond microbes—social interaction in cancer evolution and immune system dynamics



Social interaction among cells is essential for multicellular complexity.

How do

molecular networks within individual cells confer the ability to interact 个体细胞中的分子网络如何赋予其交互的能力

those same networks evolve from the evolutionary conflict between individual and population-level interests那些相同的网络如何从个体和全体利益之间的进化冲突中进化

Illustration

Fast

but wasteful growth

Slow growth rates with a

high yield

more economic

conflict balance

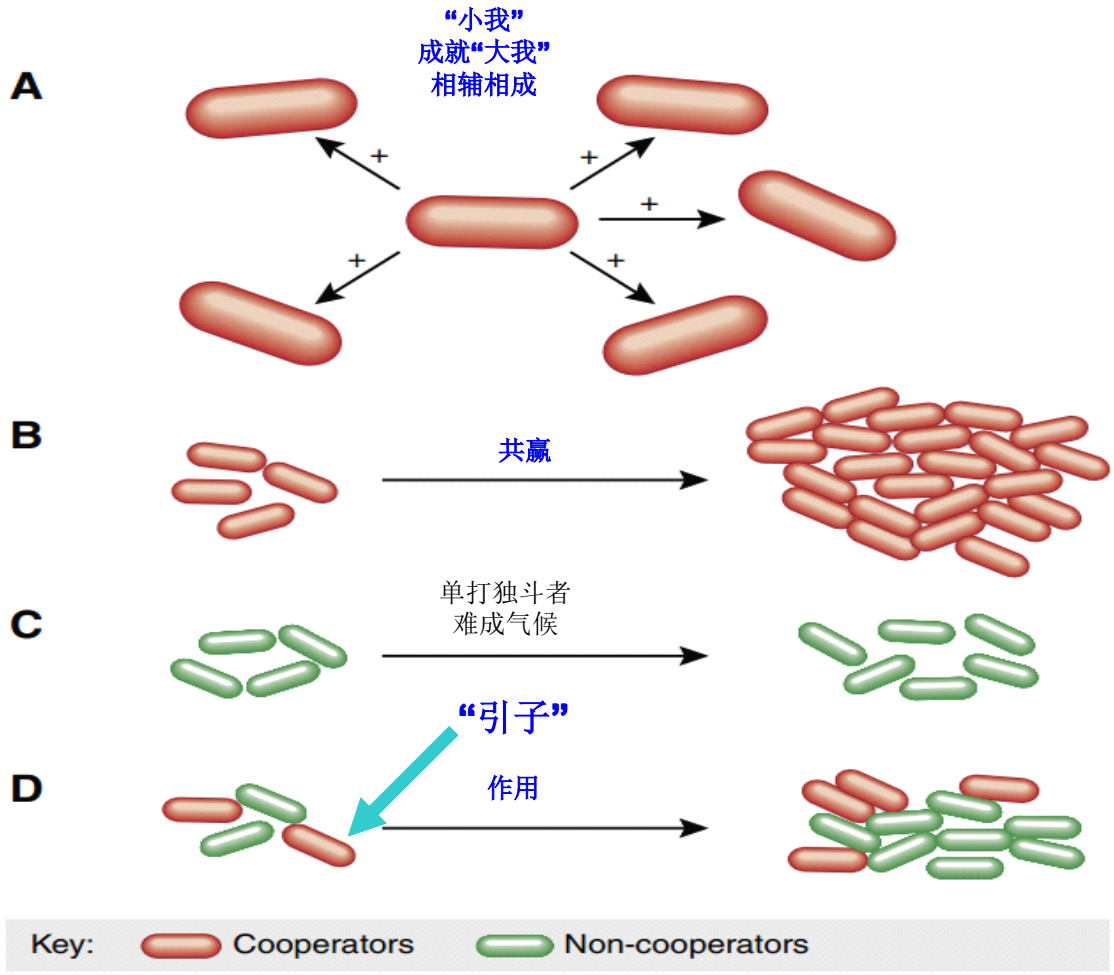
? !

(A)
A cooperative interaction provides a fitness benefit to recipients.

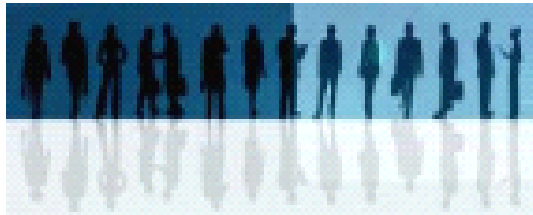
(B)
A population of cooperators has a higher productivity than one

(C)
a population of non-cooperators.

(D)
Non-cooperators can exploit cooperators in mixed populations by benefiting from cooperation without contributing.



Cooperative social interactions that provide a population-level benefit often come at a cost to individual’s cells



The biofilms are examples of cooperation evolving de novo from within a population

wild-type P. fluorescens is incapable of forming such biofilms

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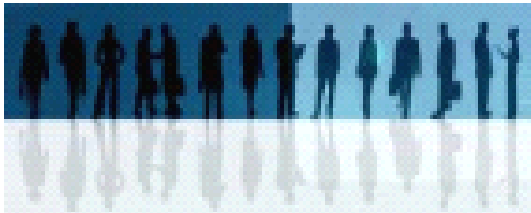
9. Conclusions and outlook



- cooperation can evolve if cooperators preferentially favor other, related individuals (Hamilton,1964)

- A cooperative trait is favored

if $br - c > 0$ （Hamilton's rule）

c is the fitness cost to the actor （作用者的适应性代价）

b is the fitness benefit to the recipient （接受者的适应性收益）

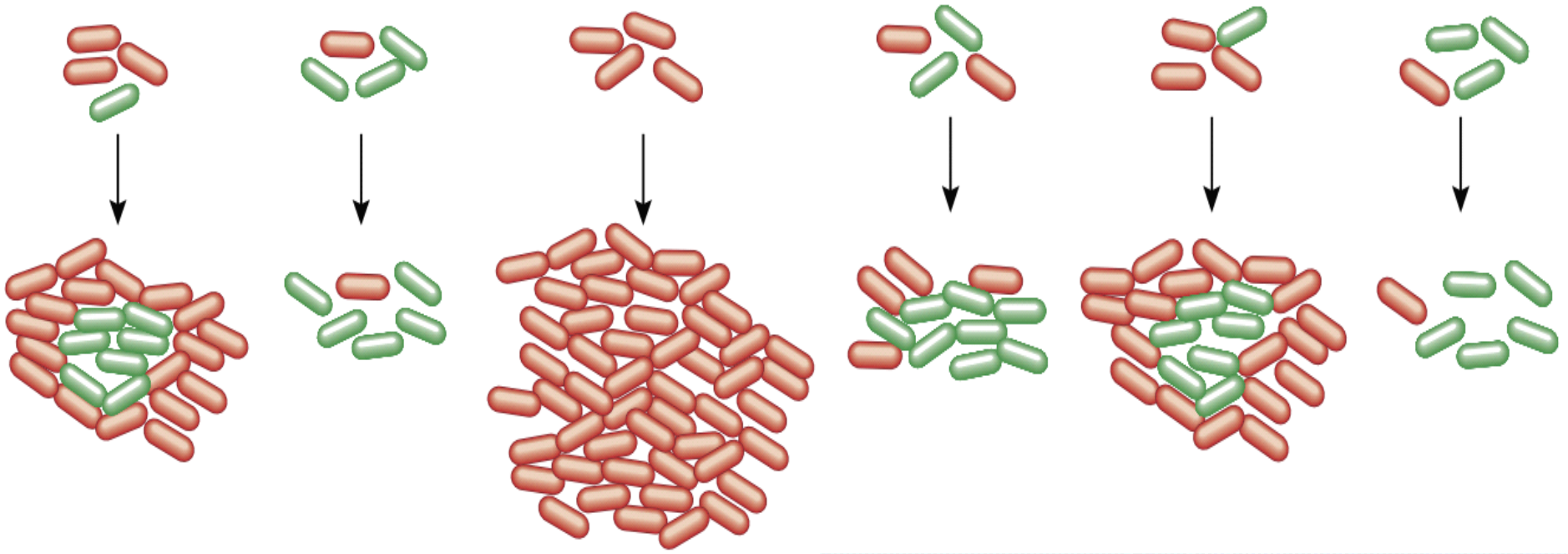
r is the correlation between the genotypes of actors and recipients

（作用者和接受者之间的相关性系数）

the siderophores of *P. aeruginosa*

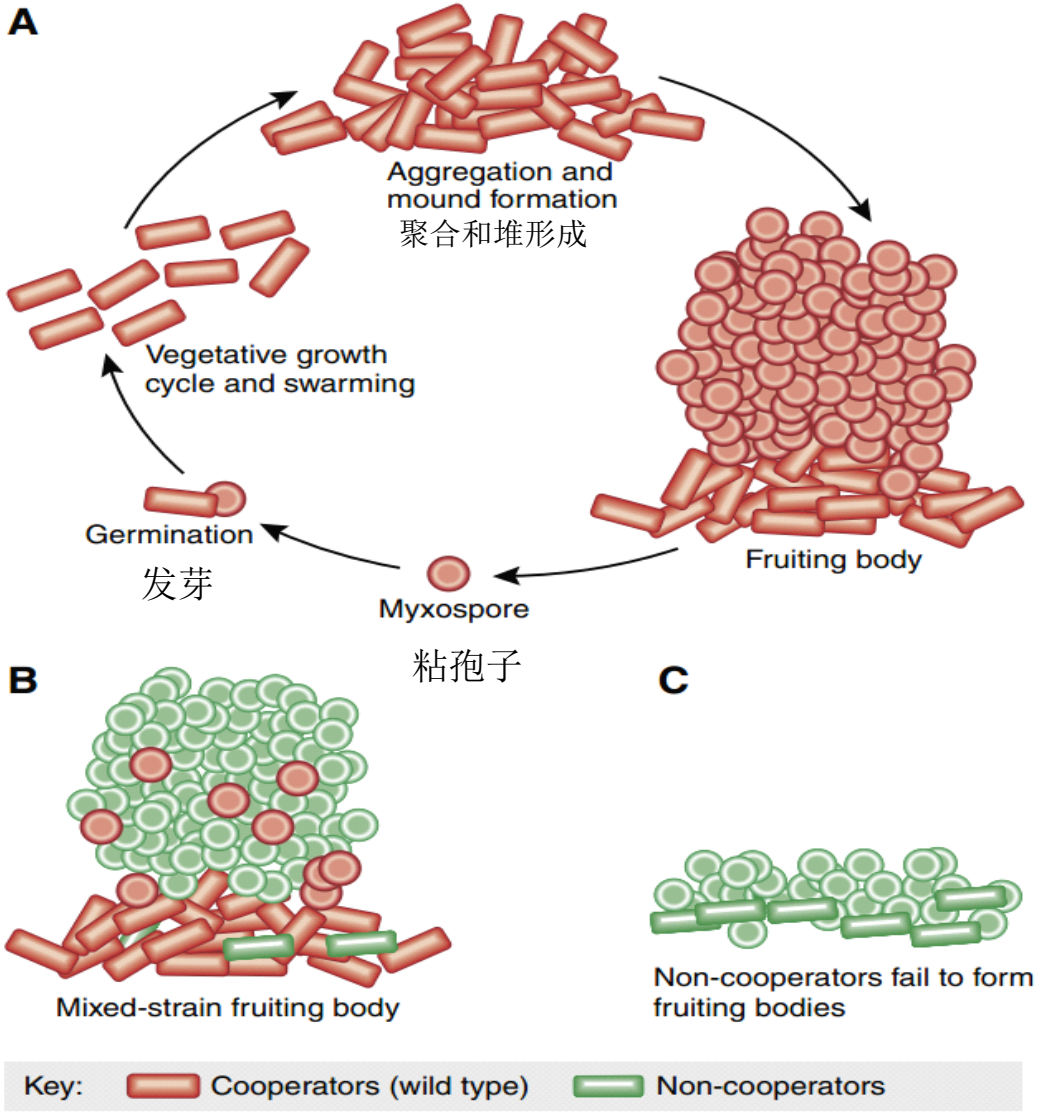
if r>c /b

- 引入内含适合度的概念
- 决定进化成功的关键，一方面要考虑对作用物的直接影响（直接适合度）另一方面也要考虑对相关拥有相同基因的作用物的（内含适合度）影响
- 对铁载体的产出是有利的



多水平的选择是微生物中合作者进化的实质

合作者的对策在全局群体中有一个进化上具有优势，尽管相同的策略在局部范围内不利于亚群体的进化。这一情况的发生是由于，高比率的合作者有更大的产率，因此对整个基因库的贡献最大



Cooperation and conflict in fruiting body formation

(A)

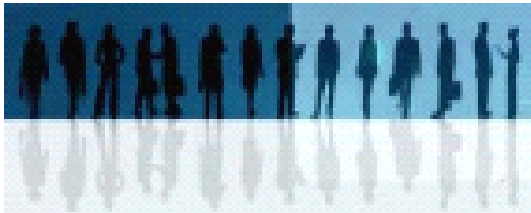
The life cycle of M. xanthus（黄色粘球菌）(Zusman et al , 2007)

(B)

Non-cooperators preferentially differentiate into spores and have an advantage when mixed with wild-type cooperators.

(C)

Non-cooperators fail to form proper fruiting bodies when alone.



- Populations of interacting cells face a major challenge to their functioning: the emergence of conflict from within.

  运作中最大的挑战

- All cell populations are prone to exploitative individuals that may not contribute to shared resources, yet still benefit from them.

  开发“自私的”个体

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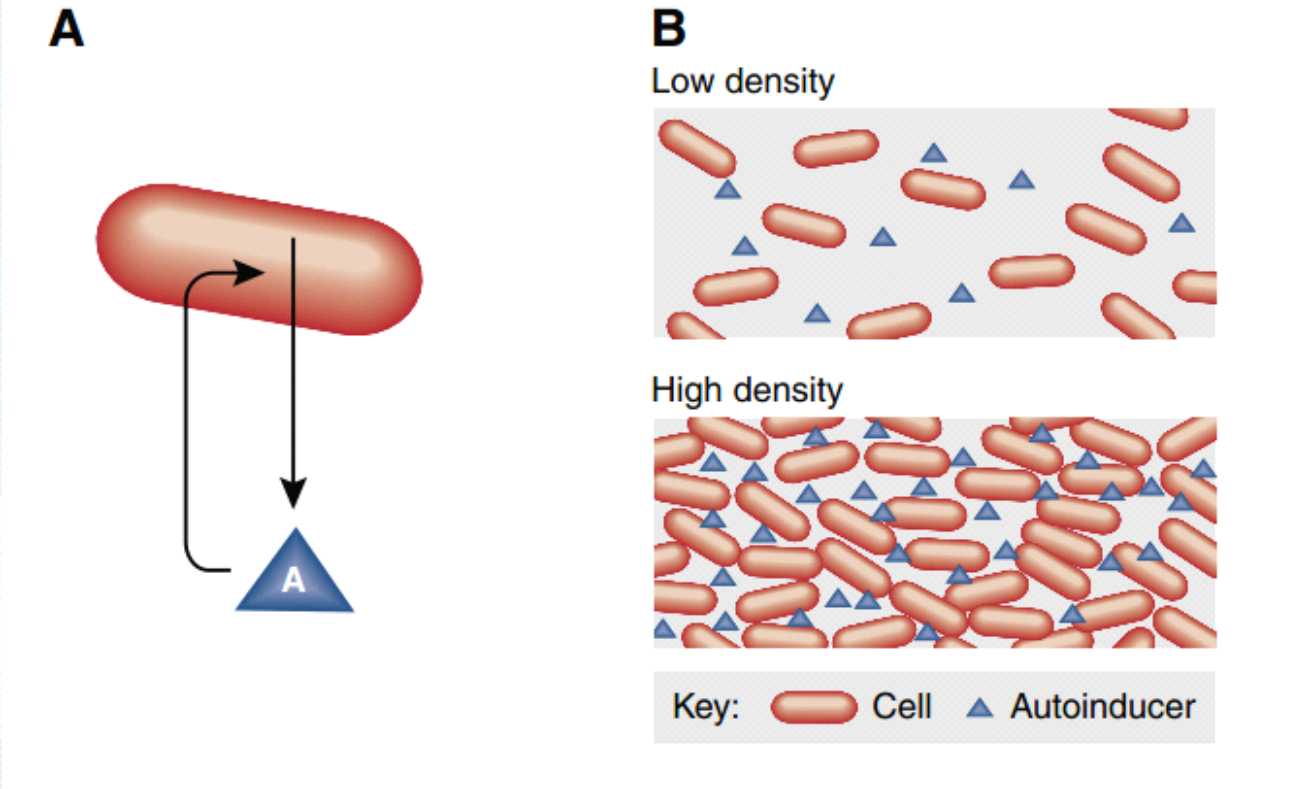
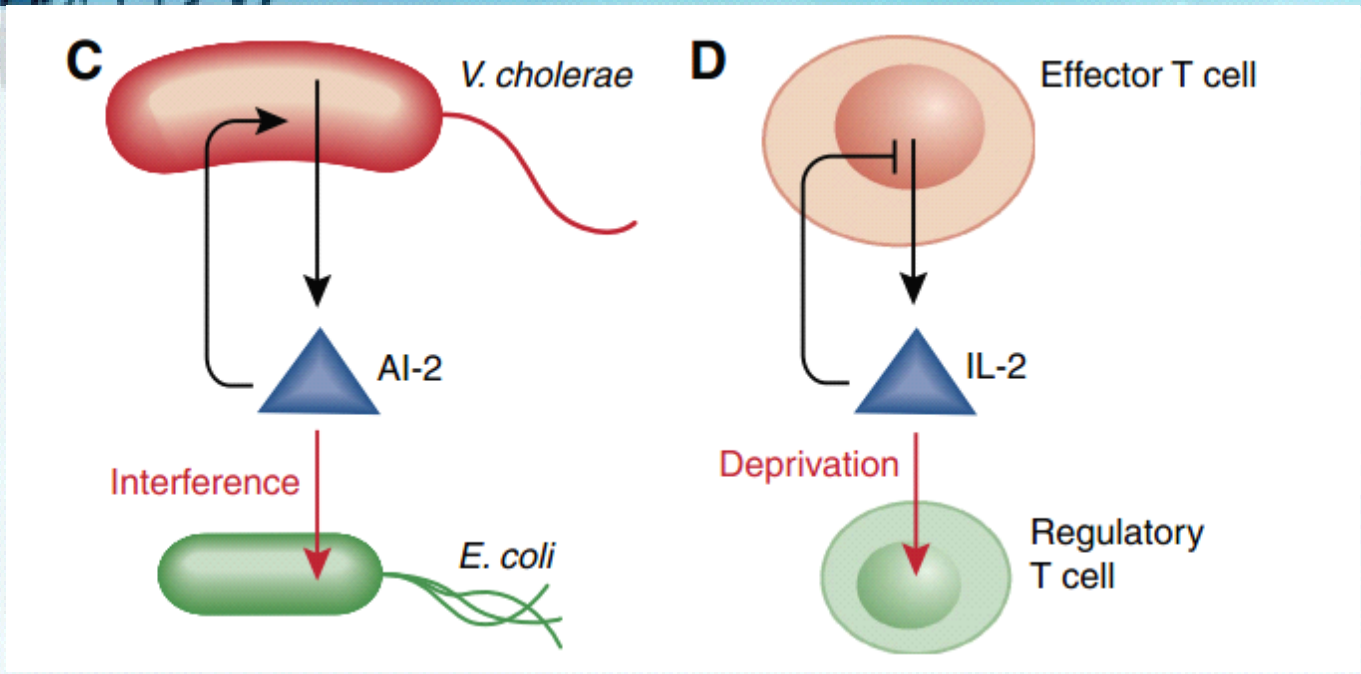
Quorum sensing as a social interaction motif



(A) The ability of a cell to produce a signaling molecule (an autoinducer 自诱导物) and sense its extracellular concentration can enable the cell to sense changes in population density

(B) Quorum sensing can be found in diverse systems such as



(C) pathogenic bacteria (Vibrio cholerae) and
(D) the adaptive immune system of mammals with common principles but different molecular players. Interestingly, quorum sensing in both V. choleraeand effector T cells is perturbed by competitor cells that sequester the signaling molecule. The enteric E. coli interferes with V.cholerae by taking up the autoinducer AI-2 (Xavier and Bassler, 2005). The immune response is mediated by IL-2 quorum sensing in effector T cells, but IL-2 deprivation by regulatory T cells is important to prevent autoimmune responses. An important difference between the T-cell system and others is that the feedback on signal production is negative (Feinerman et al , 2010)

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Molecular mechanisms that stabilize social interaction

- Discrimination is an important mechanism governing the evolution of social behavior, and microbial interaction is no exception. For example, quorum sensing can be a form of molecular discrimination as it cannot be 'eavesdropped' by cells lacking a cognate receptor.

区别是控制社会行为进化的重要机制

群体应答就是一种分子机制形式

不能被缺少同源受体

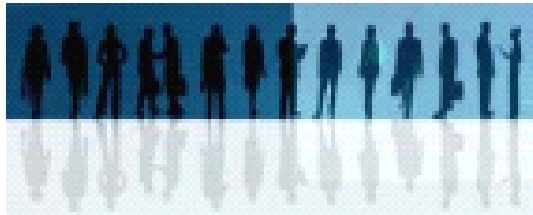
Conclusions and Outlook

The current focus is in the census of the bacteria that make up the communities, but more biologically significant is to understand how these species interact in a mechanistic way (Blaser, 2010). There is a flood of potential applications of microbiome ecology to the environmental and medical fields

目前关注最多是对细菌组成的群体普查，但是更具有生物学意义的是这些物种（群体）间的作用机制，也是微生物生态学在环境和医疗的潜在应用。

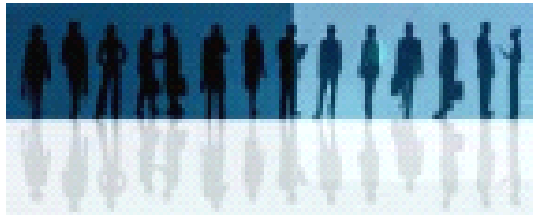
挑战：1.首先必须去彻底弄清楚管理微生物合成动态学和功能的生态过程

2.要超越现有两个群体社会交互作用的小模型研究，去研究自然微生物系统中的社会交互网络



‘public good’

quorum sensing　　群体感应



thanks for your attention