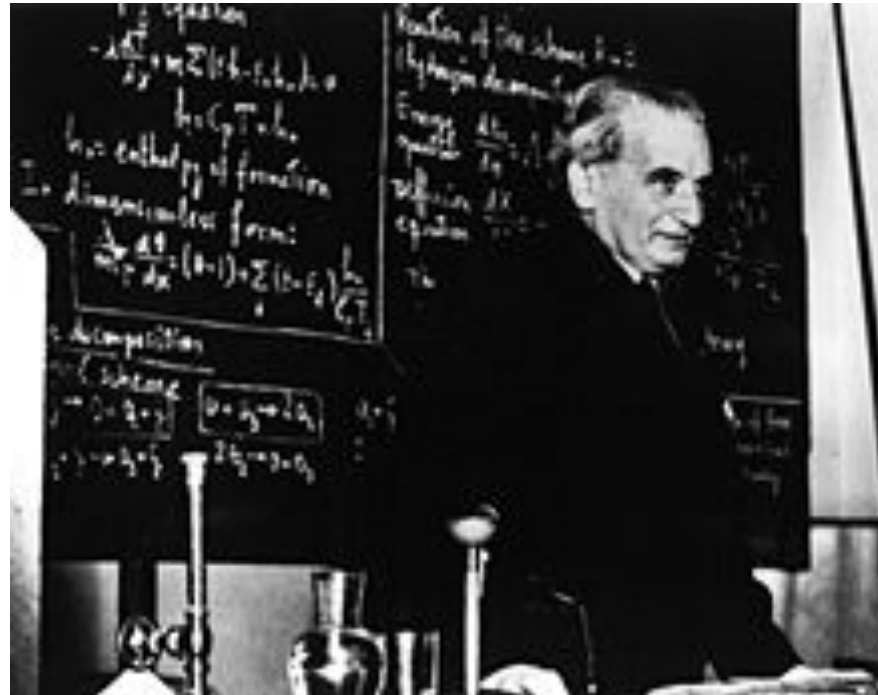
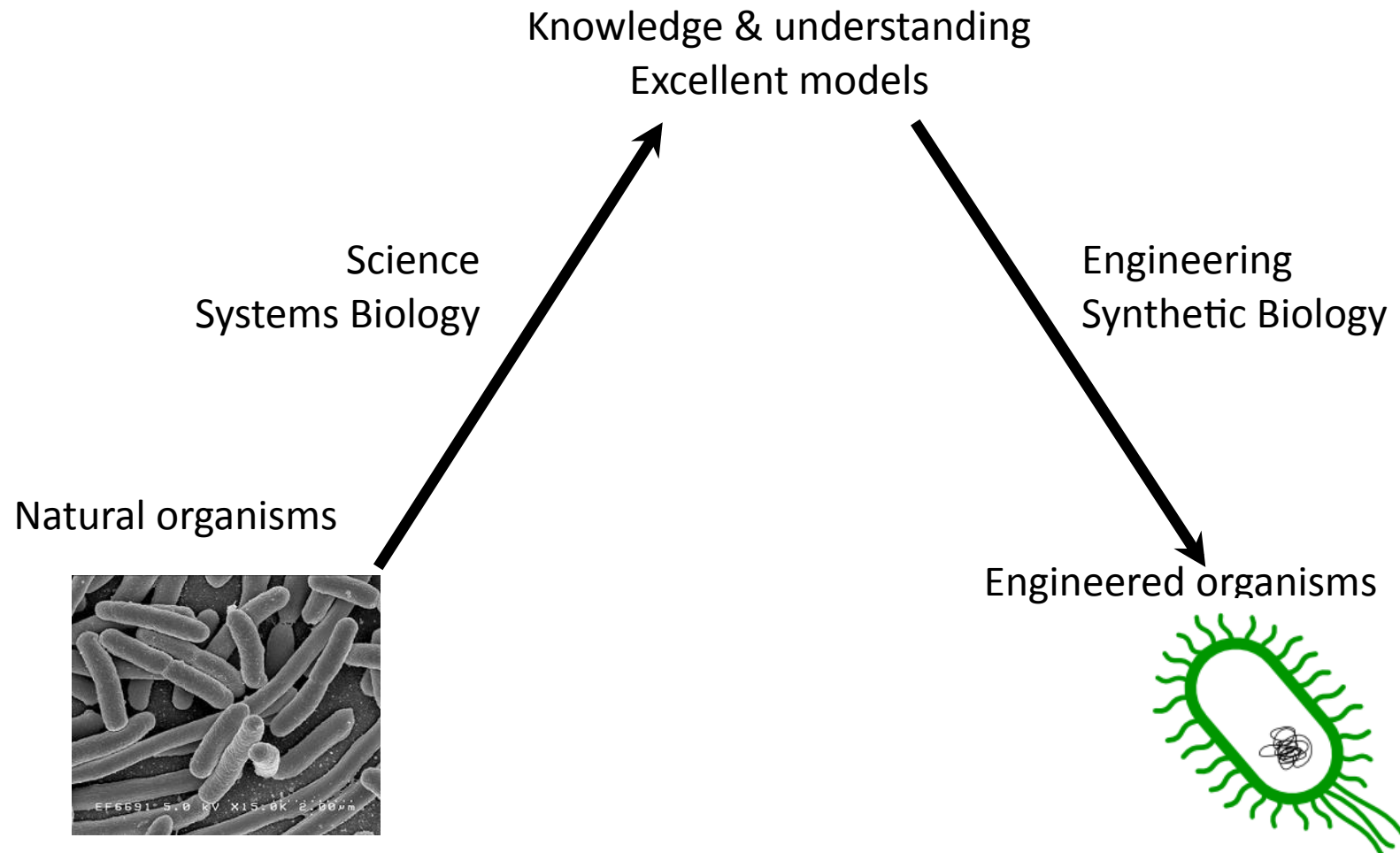


# Biología de sistemas y Biología Sintética: Ciencia e Ingeniería. Análisis y Síntesis.



*A Scientist discovers that which exists;  
an Engineer creates that which never was.  
-- Theodore von Karman*

# Biología de sistemas y Biología Sintética: La Biología como Ciencia y como Tecnología Reverse-engineering y Forward engineering Biology



# Biología sintética: Definiciones

Ingeniería de sistemas biológicos.

La biología como tecnología que se utiliza para fabricar dispositivos y sistemas biológicos sintéticos.

La maquinaria biológica natural como hardware con el que construir y fabricar sistemas biológicos artificiales o sintéticos.

Reprogramación de sistemas biológicos naturales

# Biología sintética: Definiciones

**Synthetic biology:** is a discipline half-way between science and engineering (Benner, 2005; De Lorenzo, 2006; ETC group, 2007). It is concerned with:

- The design, construction and modification of biomolecular systems and organisms to perform specific functions.
- To get a better understanding of biological mechanisms.

# Biología sintética: Definiciones

“Synthetic biology is concerned with applying the engineering paradigm of systems design to biological systems in order to produce predictable and robust systems with novel functionalities that do not exist in Nature.”

“...the major change that the field of synthetic biology will bring is the synergistic integration of existing disciplines: not just biology and engineering, but also computer modelling, information technology, control theory, chemistry and nanotechnology.

Ultimately, it is likely that the analytical and synthetic approaches to biology (that is, systems and synthetic biology), as well as the in vitro and in vivo (‘bottom-up’ and ‘top-down’) approaches, will fully complement each other.”

# Pioneros de la Computación con ADN y la Biología Sintética: Ron Weiss y Tom Knight. MIT



"Engineered Communications for Microbial Robotics" Ron Weiss,  
Tom Knight. Proceedings of the Sixth International Meeting on  
DNA Based Computers (DNA6), June 2000

# Pioneros de la Computación con ADN y la Biología Sintética: Yaakov Benenson y Ehud Shapiro. Inst. Weizmann. Israel



Benenson, Y., Paz-elizur, T., Adar, R., Keinan, E., Liben, Z., & Shapiro, E. (2001). Programmable and autonomous computing machine made of biomolecules. *Nature*, 414, 430-434.

Benenson, Y., Gil, B., Ben-Dor, U., Adar, R., & Shapiro, E. (2004). An autonomous molecular computer for logical control of gene expression. *Nature*, 429, 423-429.

# Convergencia “DNA Computing” y “Synthetic Biology”: año 2001. Autómata de Benenson

## Convergencia

- Computación con ADN: “Cell-free synthetic biology”. 1994 (L. Adleman) – 2001 (Autómata biomolecular de Benenson).
- Biología Sintética: 2000 (“toggle switch” y “Repressilator”).



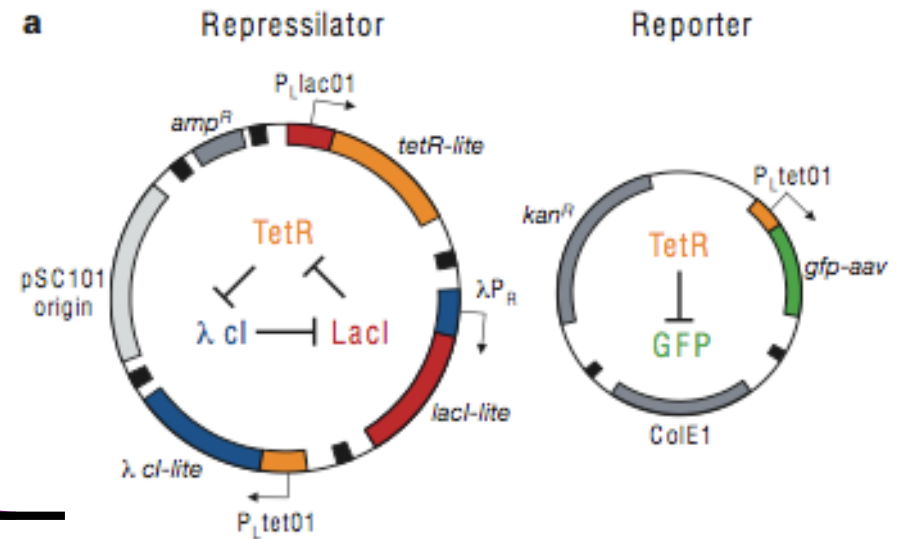
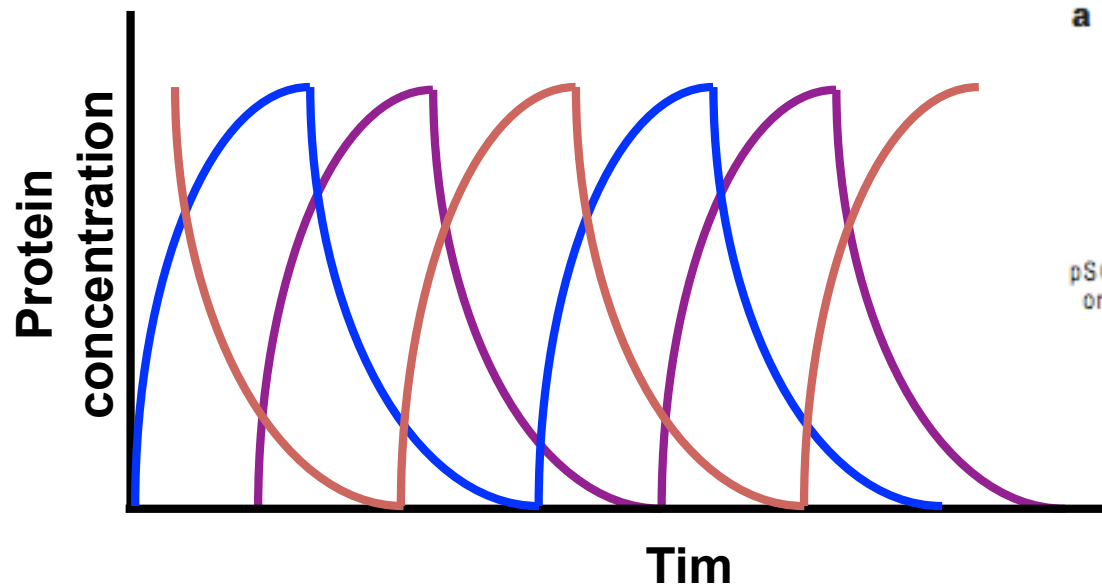
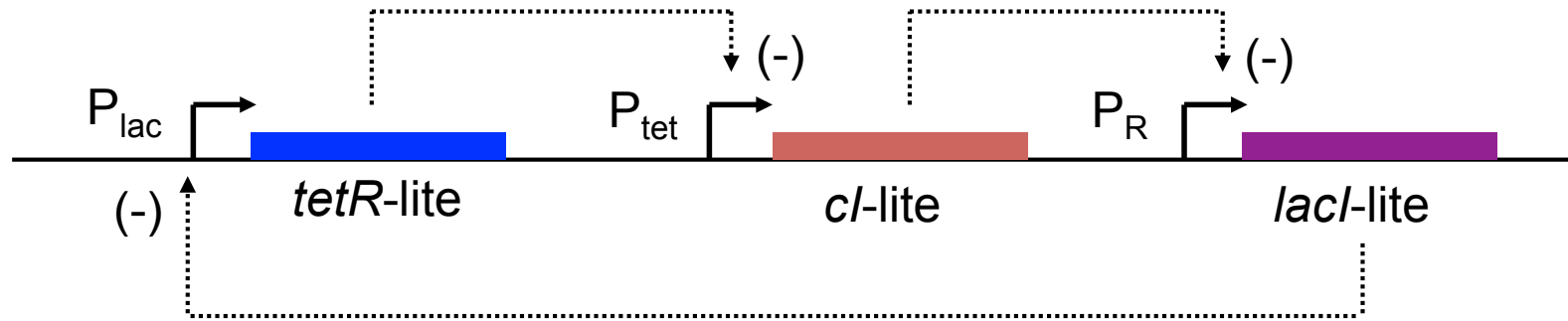
# Pioneros de la Biología Sintética: M. Elowitz, J. Collins



Elowitz, M. B., & Leibler, S. (2000). A synthetic oscillatory network of transcriptional regulators. *Nature*, 403, 335-338.

Gardner, T. S., Cantor, C. R, & Collins, J. J. (2000). Construction of a genetic toggle switch in *E. coli*. *Nature*, 403, 339-342.

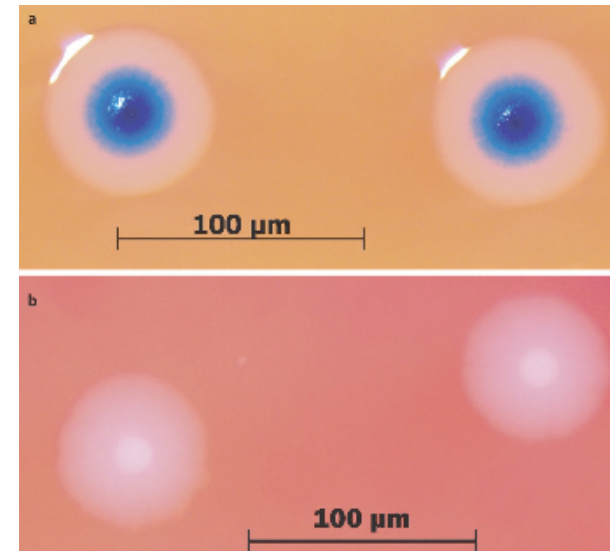
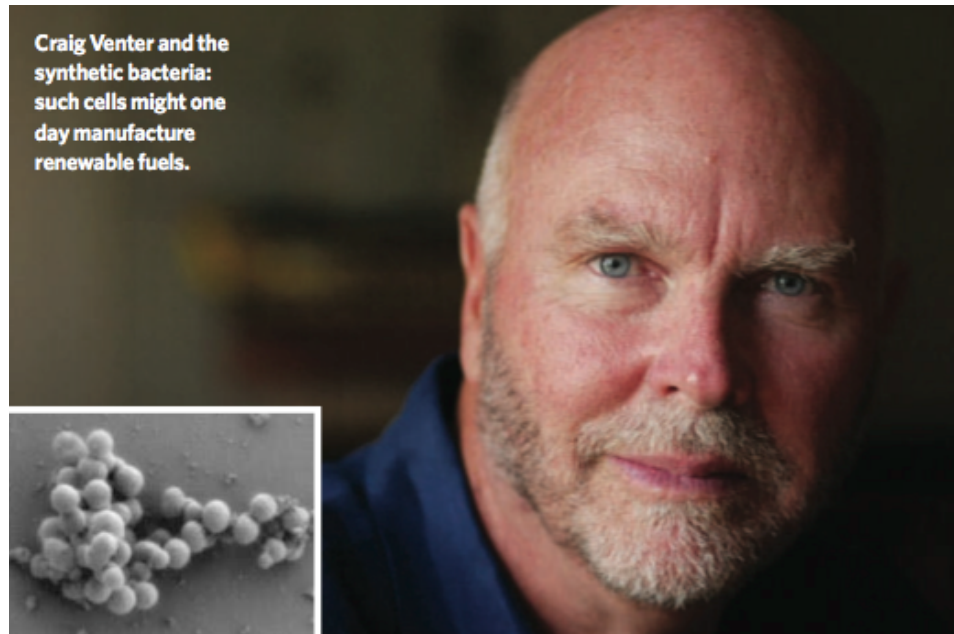
# Oscilador sintético formado por 3 genes: “Repressilator”



# Video del “Repressilator” en acción



# Pionero de la Biología Sintética: John Craig Venter



*Mycoplasma Mycoides* JCVI-syn 1.0

# Mycoplasma mycoides JCVI-syn1.0



Gibson, D. G., J. I. Glass, C. Lartigue, V. N. Noskov, R.-Y. Chuang, M. A. Algire, G. A. Benders, M. G. Montague, L. Ma, M. M. Moodie, C. Merryman, S. Vashee, R. Krishnakumar, N. Assad-Garcia, C. Andrews-Pfannkoch, E. A. Denisova, L. Young, Z.-Q. Qi, T. H. Segall-Shapiro, C. H. Calvey, P. P. Parmar, C. A. Hutchison III, H. D. Smith, and J. C. Venter. 2010. Creation of a bacterial cell controlled by a chemically synthesized genome. *Science*, Published online May 20 2010.

**J. Craig Venter**  
INSTITUTE



¿Realmente, el JCVI ha creado la “primera forma sintética de vida” a partir de materiales inertes?

¿Qué tiene Mycoplasma Mycoide JCVI-syn 1.0 de “Célula artificial” o “Célula sintética”?

**Jim Collins**

Professor of biomedical engineering,  
Boston University

Frankly, scientists do not know enough about biology to create life. Although the Human Genome Project has expanded the parts list for cells, there is no instruction manual for putting them together to produce a living cell. It is like trying to assemble an operational jumbo jet from its parts list — impossible. Although some of us in synthetic biology may have delusions of grandeur, our goals are much more modest.

Relax — media reports hyping this as a significant, alarming step forward in the creation of artificial forms of life can be discounted. The work reported by Venter and his colleagues is an important advance in our ability to re-engineer organisms; it does not represent the making of new life from scratch.

The microorganism reported by the Venter team is synthetic in the sense that its DNA is synthesized, not in that a new life form has been created. Its genome is a stitched-together copy of the DNA of an organism that exists in nature, with a few small tweaks thrown in.

# Principios de ingeniería aplicables a la biología sintética

- abstracción
- Jerarquía
- modularidad
- estandarización
- encapsulamiento
- flexibilidad

# Nuevos principios de ingeniería para la biología sintética

Hay errores y ruido.

Los componentes fallan (mutan)

Los componentes y los dispositivos evolucionan.

Los dispositivos se auto-organizan y se auto-reparan.



# Programación de poblaciones de bacterias: ecosistemas bacterianos sintéticos

Robots microbianos que se comunican y toman decisiones de manera colectiva.

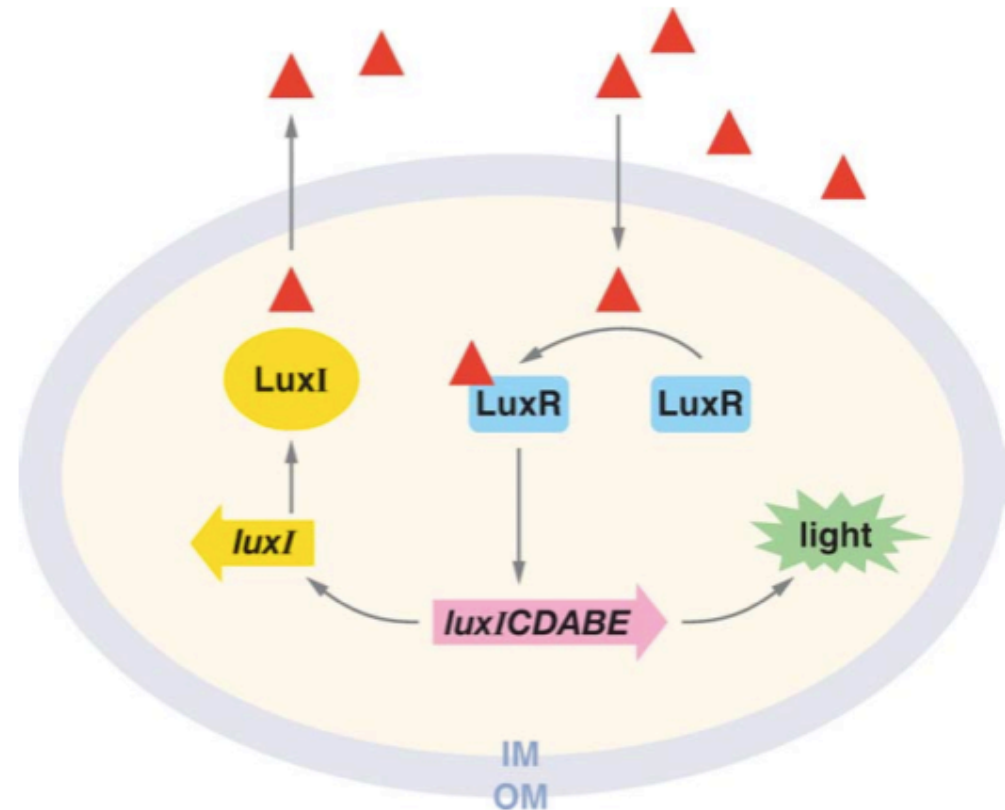
Comunicación bacteriana

Quorum Sensing

Conjugación

De la biología a la ecología sintética

# Quorum Sensing: *Vibrio Fischeri* y el calamar de Hawai.



Waters, C.M. & Bassler, B.L. Quorum sensing: cell-to-cell communication in bacteria. *Annual Review of Cell and Developmental Biology* 21, 319-346 (2005).

# Pioneros de la Computación con ADN y la Biología Sintética: Ron Weiss y Tom Knight. MIT

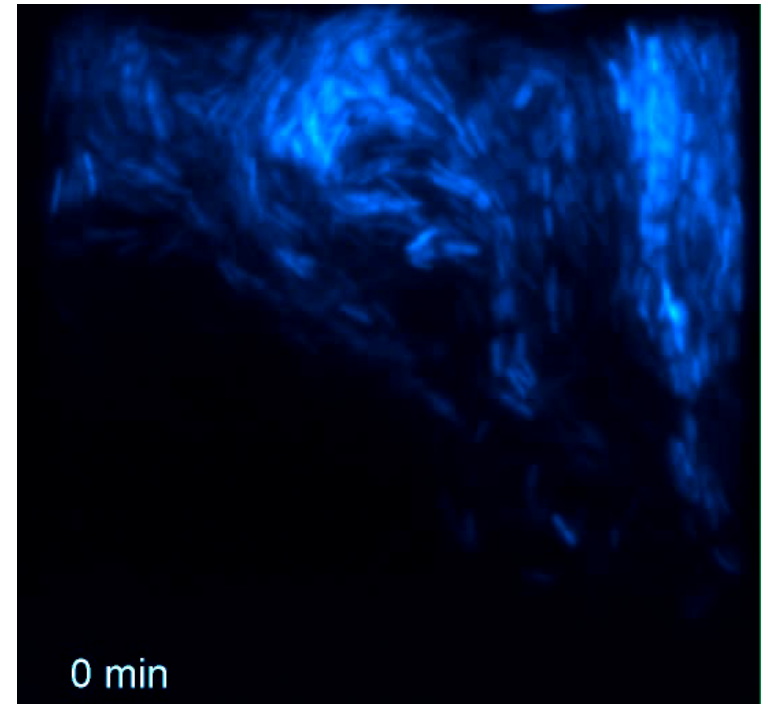
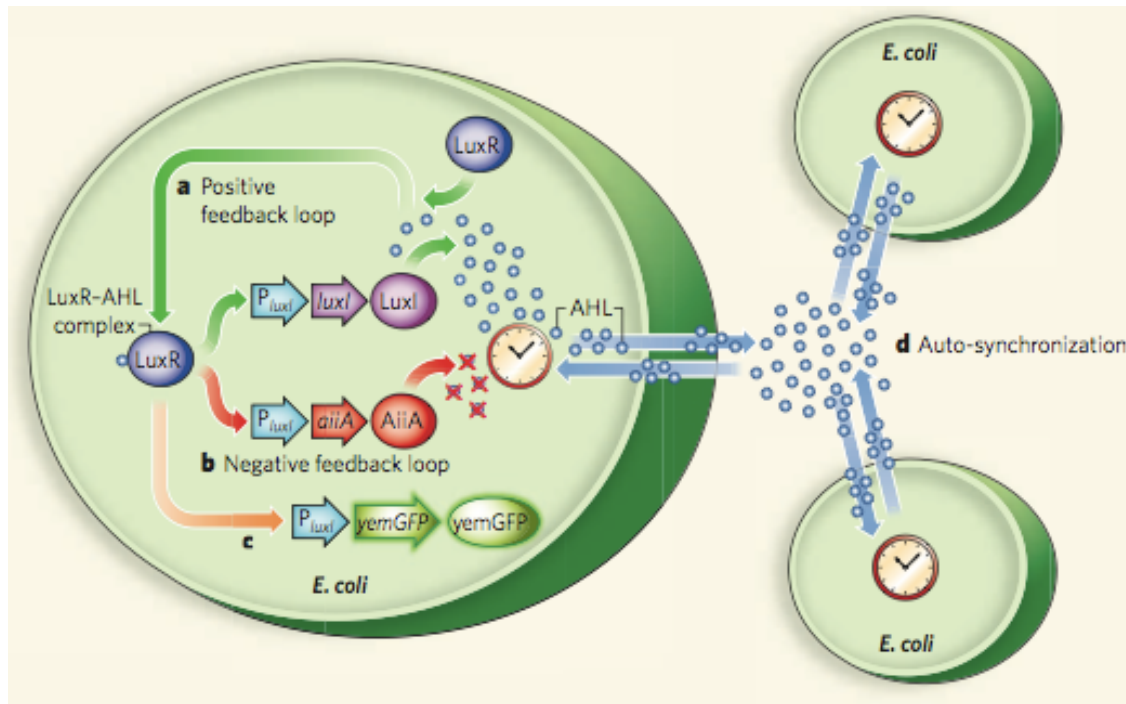


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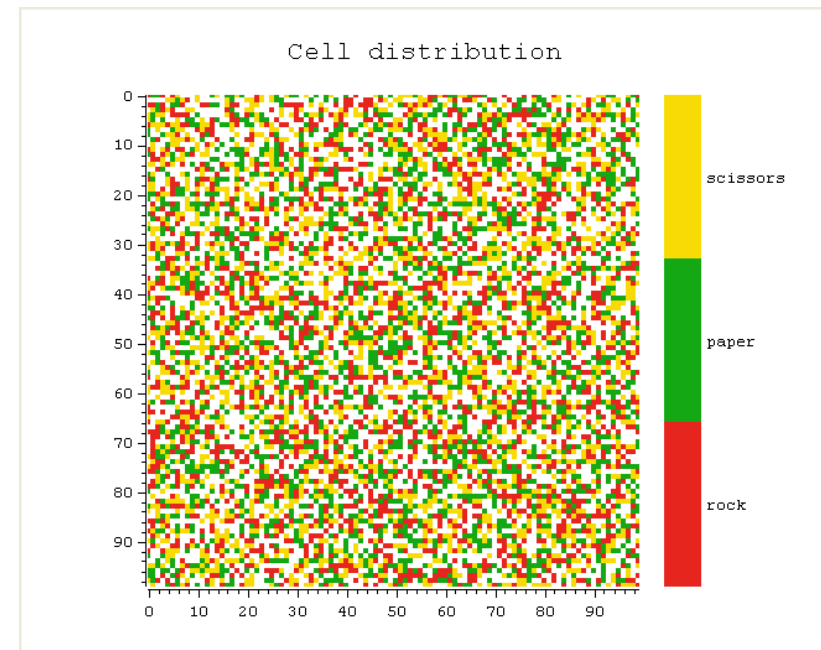
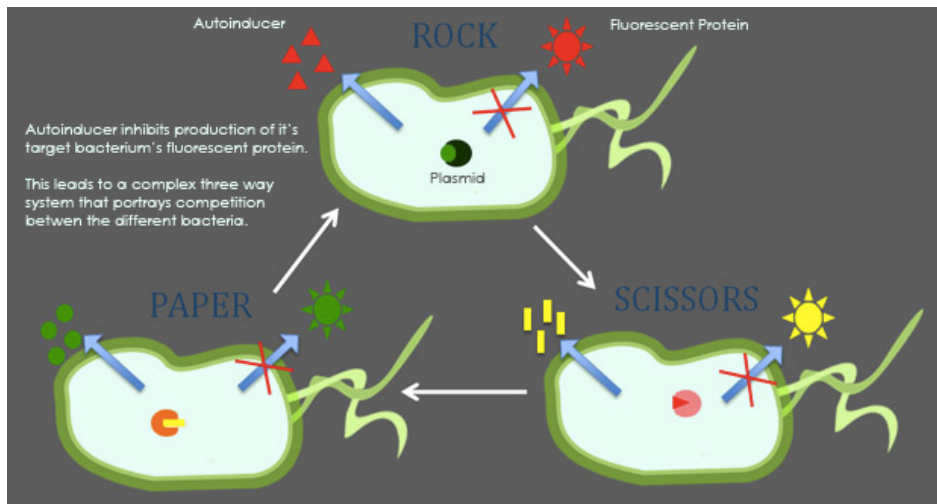
# Quorum Sensing en ecología sintética

- QS: Osciladores sincronizados. Jeff Hasty.

NATURE | Vol 463 | 21 January 2010



# Piedra-papel-tijera



# BACTOCOM

(Bacterial Computing with engineered populations) [www.bactocom.eu](http://www.bactocom.eu)

In vitro/vivo evolution of genetic circuits

1. Distribuir diferentes programas/circuitos (plásmidos) en una población de bacterias (conjugación).
2. Favorecer la reproducción de las bacterias y la transmisión de aquellos programas que se comporten bien y aporten una ventaja competitiva a las bacterias que los portan.

# Proyecto europeo BACTOCOM

**BECA:** Doctorado (y post-doctoral)

- Proyecto BACTOCOM: [www.bactocom.eu](http://www.bactocom.eu)
- Interesados. E-mail: [arpaton@f.upm.es](mailto:arpaton@f.upm.es)
- Grupo LIA en la UPM (Madrid):  
[www.lia.upm.es](http://www.lia.upm.es)