Quorum Sensing

11 June 2026
BEE'26

Varuni P
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The Institute of Mathematical Sciences

Milky Seas

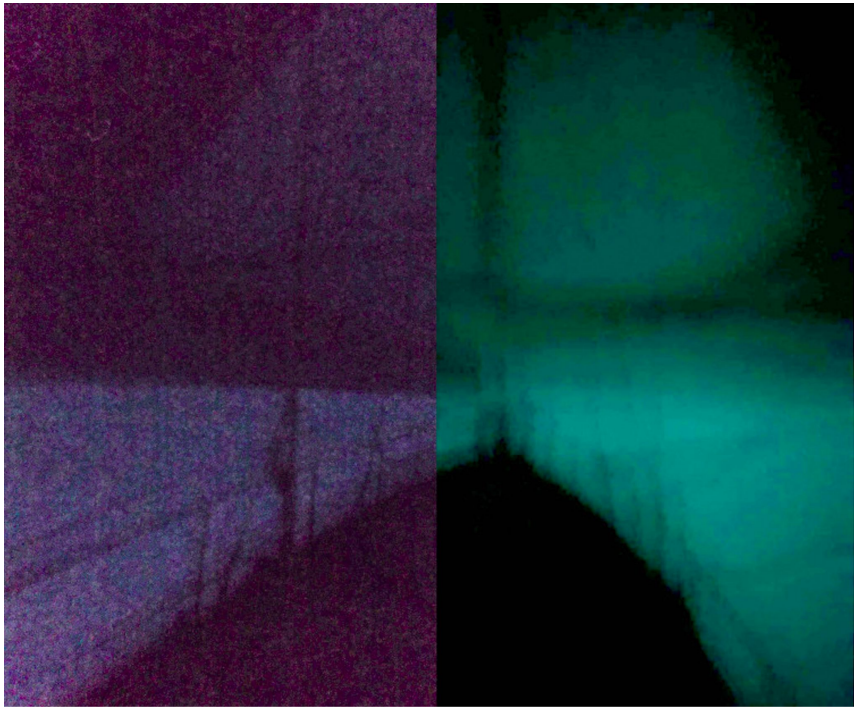
[various sailors]

July 20, 2022 | 2 min read Add Us On Google

Eerie Photo Proves the Existence of Milky Seas—A First

A night photograph taken from a sailboat near the island of Java validates a satellite image of a giant, glowing "milky sea"

BY MICHELLE NIJHUIS EDITED BY MARK FISCHETTI



Photobacterium fischeri

isolated
described
characterized

in 1889

by Martinus Beijerinckc

JOURNAL OF BACTERIOLOGY, October 1970, p. 313-322
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Vol. 104, No. 1
Printed in U.S.A.

Cellular Control of the Synthesis and Activity of the Bacterial Luminescent System[1]

KENNETH H. NEALSON, TERRY PLATT, AND J. WOODLAND HASTINGS
Biological Laboratories, Harvard University, Cambridge, Massachusetts, 02138 and Marine Biological Laboratory, Woods Hole, Massachusetts 02534

Received for publication 30 April 1970

luminescence (490nm) increases with cell density (sort of)

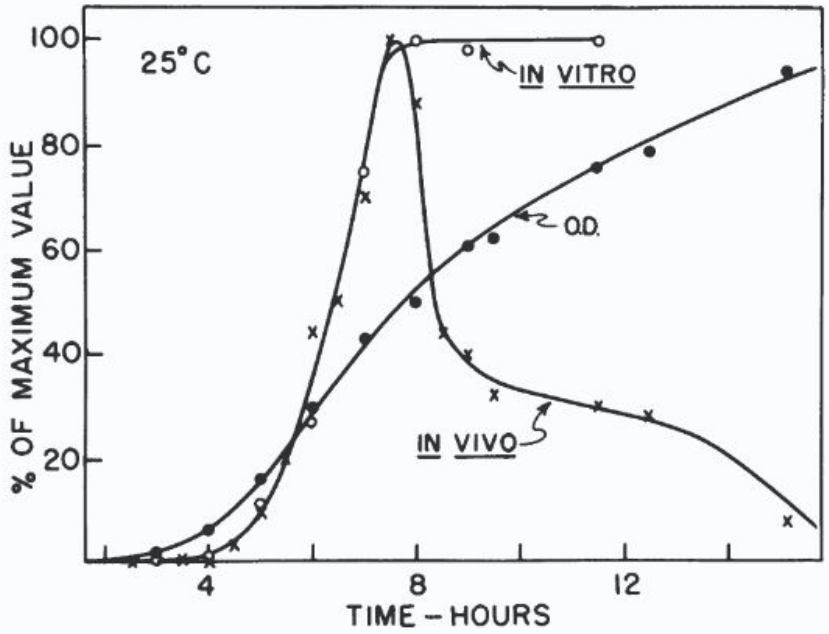

FIG. 2. *Experiment of Fig. 1 plotted on a linear scale, better illustrating the "pulse" nature of the luciferase synthesis and in vivo luminescence. The ordinate values were all normalized to the maximum and plotted as the per cent of that value.*

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does luminescence need transcription?

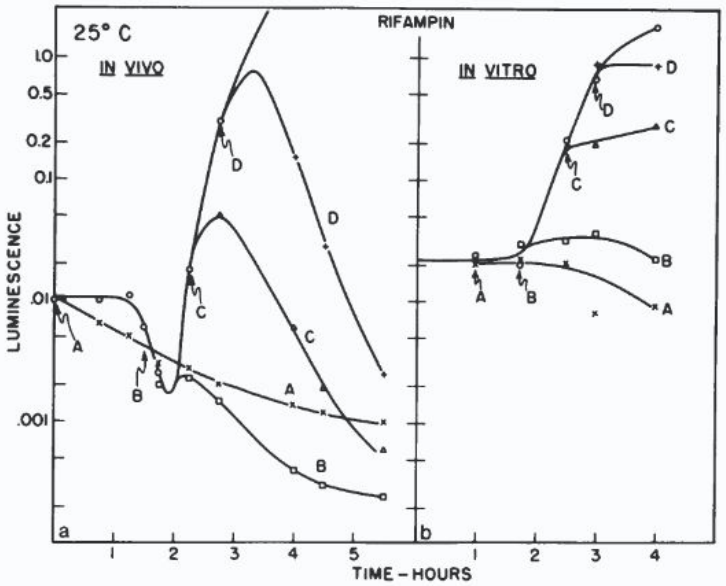

FIG. 6. *Effect of rifampin on the in vivo luminescence (a) and the extractable luciferase levels (b) when added at various times during the growth cycle. The experimental procedure was similar to that of the experiment of Fig. 5. A 500-ml broth culture growing in a 2-liter flask was used as the control. At each time indicated, 50 ml was removed and placed in a 300-ml flask containing 1 mg of rifampin.*

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does luminescence need translation?

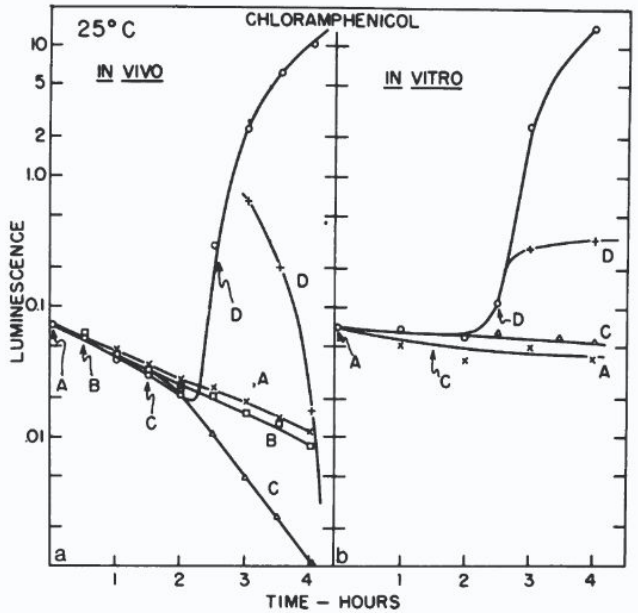

FIG. 5. *Effect of chloramphenicol on the in vivo luminescence (a) and the in vitro luciferase levels (b) when added at various times, after inoculation, A, B, C, and D, as indicated by arrows. The culture and growth conditions were similar to those of experiment of Fig. 1. The control culture (○) was a 500 ml broth culture growing in a 2-liter flask. For each addition of chloramphenicol, 50 ml of culture was removed and placed in a 300-ml flask containing 5 mg of chloramphenicol. The letters A to D serve to identify the cultures corresponding to the various times of addition.*

Arch. Microbiol. 112, 73–79 (1977)

Archives of Microbiology

Autoinduction of Bacterial Luciferase

Occurrence, Mechanism and Significance

KENNETH H. NEALSON

Scripps Institution of Oceanography, P.O. Box 1529, La Jolla, California 92093, U.S.A.

does luminescence need an ‘autoinducer’?

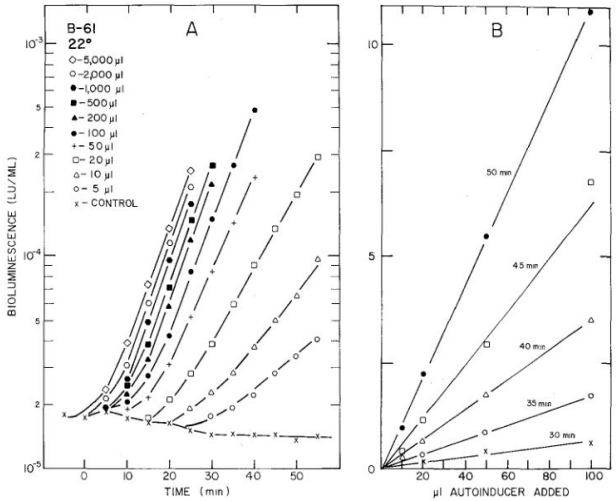

Fig. 2A and B. Bioassay of autoinducer. (A) Cells of B-61 growing in L.M. broth were diluted into a conditioned medium at time zero, and 1 ml samples placed in scintillation vials in which various amounts of autoinducer in ethyl acetate had been placed and the ethyl acetate removed by evaporation; (×——×) control with no autoinducer; all other symbols: amount of autoinducer in microliters noted on graph. (B) Bioluminescence as a function of autoinducer added; after 30 min or more, bioluminescence (above background) obtained with each amount of autoinducer in (A) is plotted as a function of the amount of autoinducer added. As shown, a linear response is obtained for the samples containing low amounts of autoinducer

MICROBIOLOGICAL REVIEWS, Mar. 1991, p. 123–142
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Vol. 55, No. 1

Molecular Biology of Bacterial Bioluminescence

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Department of Biochemistry, McGill University, 3655 Drummond Street, Montreal, Quebec, Canada H3G 1Y6

Vibrio fischeri

formerly known as
Photobacterium fischeri

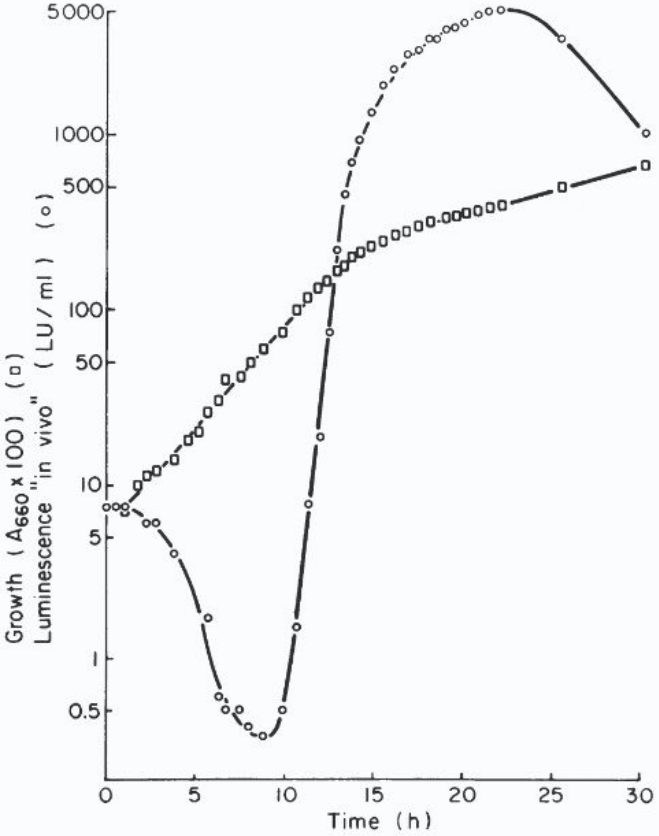

FIG. 4. Dependence of luminescence and cellular growth on time for *P. phosphoreum*. The light intensity is given in light units (LU), where 1 LU = 5×10^9 quanta per s, and growth is given by the optical density of the culture at 660 nm (A_{660}). Courtesy of L. Wall.

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So what are they doing?

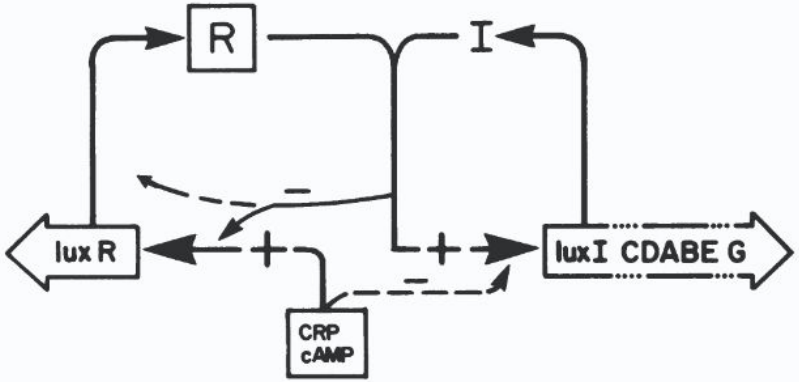

FIG. 5. Regulation of the *V. fischeri lux* system. The scheme summarizes data and models presented in the literature (37, 46, 47, 128), with the *luxR* gene product (R) and autoinducer (I) stimulating expression of the *lux* genes (*luxICDABEG*) and decreasing expression from the *luxR* gene whereas cAMP and CRP cause the reverse effects.

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What are other bacteria doing?

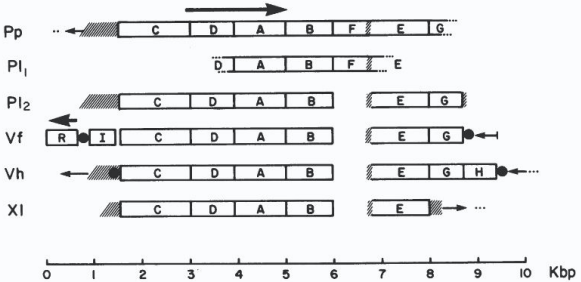

FIG. 1. *lux* gene organization for *P. phosphoreum* (Pp), *P. leiognathi* (Pl), *V. fischeri* (Vf), *V. harveyi* (Vh), and *X. luminescens* (Xl). The nucleotide sequences have been determined for all regions represented. Only the genes that have been demonstrated to be part of the *lux* systems are labeled with letters. Transcription for most genes is from left to right unless indicated otherwise (by arrows). Extended regions of DNA with only short coding regions (<40 codons) are indicated by the diagonal lines. Open reading frames not identified as part of the *lux* system and unrelated to the other genes are shown by arrows with the dots representing incomplete coding regions. The 5′ and 3′ ends of the *lux* mRNA that have been located by S1 nuclease and/or primer extension are shown by the solid circles. Currently, nucleotide sequences are published for *P. phosphoreum* (*luxF* [136]), *P. leiognathi* (Pl_1) (*luxABF* [6, 65]), *V. fischeri* (*luxIR* [30, 47], *luxCDABE* [6, 53], and *luxG* [141]), *V. harveyi* (upstream and *luxC* [94, 100], *luxD* [97], *luxAB* [25, 70], *luxE* [69], and *luxGH* and downstream [142]), and *X. luminescens* (*luxAB* [143]). In addition, locations of genes based on nucleotide sequence data completed on *P. leiognathi* (Pl_2), *P. phosphoreum*, and *X. luminescens* strains in our laboratory and not yet published are included. The strains are *P. phosphoreum* NCMB 844, *P. leiognathi* (Pl_1) 741 and 554 (two closely related strains), *P. leiognathi* (Pl_2) ATCC 25521 (neotype strain), the related *V. fischeri* MJ-1 and ATCC 7744 (neotype strain), *V. harveyi* B392, and *X. luminescens* ATCC 29999. Other *X. luminescens* strains have been cloned that are closely related (54, 69a) as well as *lux* genes from a symbiont of the flashlight fish, *K. alfredi* (63).

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What else can *we* use the system for?

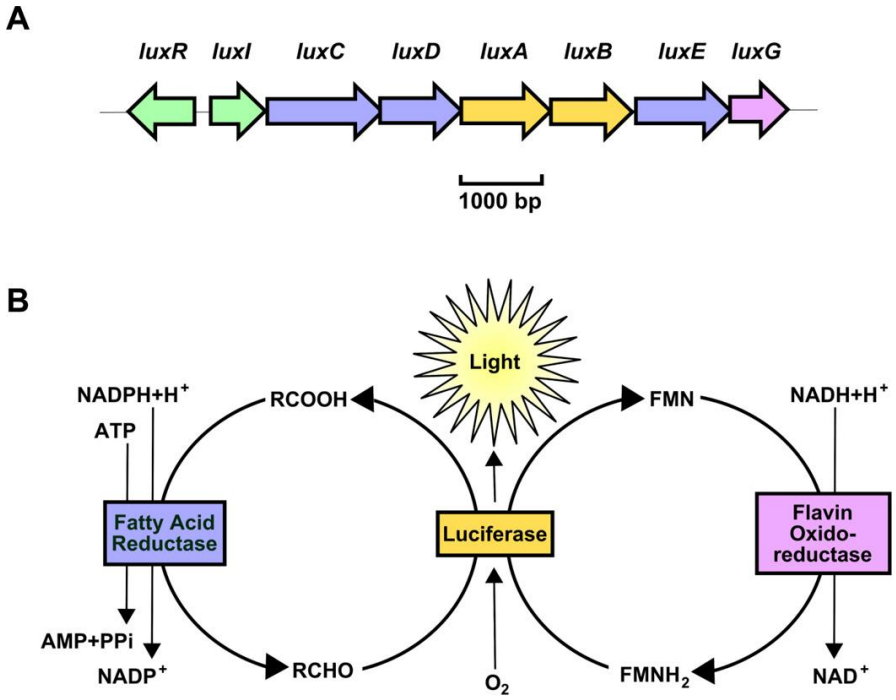
The expression of the *lux* genes in different bacterial species also provides a simple and sensitive system for monitoring the growth and distribution of the bacteria in the environment. In plants, the bacterial luminescent phenotype has been used to observe the movement of *Xanthomonas* species causing black rot in cauliflower (129), the infection of potato slices by *Erwinia* species (129), and the distribution of *Bradyrhizobium* species in soybean root nodules (106).

Mol Microbiol. 2012 June ; 84(5): 795–806. doi:10.1111/j.1365-2958.2012.08065.x.

Shedding light on bioluminescence regulation in *Vibrio fischeri*

Tim Miyashiro* and **Edward G. Ruby**
Department of Medical Microbiology and Immunology, University of Wisconsin School of Medicine and Public Health, 1550 Linden Drive, Madison, WI 53706-1521, USA

lux operon structure



How bacteria talk to each other: regulation of gene expression by quorum sensing
Bonnie L Bassler

Vibrio harveyi:
new quorum, who dis?

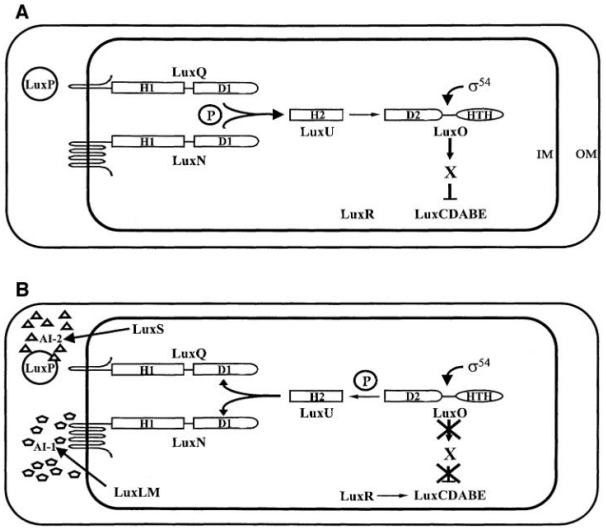


Fig. 1. The *V.harveyi* quorum-sensing system. The low and high cell density states of the *V.harveyi* quorum-sensing system are shown (**A** and **B**, respectively). The components and their putative interactions are described in the text. H, D, IM, OM and H-T-H denote histidine, aspartate, inner membrane, outer membrane and helix–turn–helix, respectively. The 'P' in the circle signifies that signal transduction occurs by phosphorelay. Phosphate flow in the forward direction goes from histidine (H1) to aspartate (D1) to histidine (H2) to aspartate (D2). AI-1 and AI-2 are depicted as pentagons and triangles, respectively.

The EMBO Journal Vol. 22 No. 4 pp. 870–881, 2003

Vibrio harveyi quorum sensing: a coincidence detector for two autoinducers controls gene expression

Kenny C.Mok, Ned S.Wingreen[1] and Bonnie L.Bassler[2]

Department of Molecular Biology, Princeton University, Princeton, NJ 08544-1014 and [1]NEC Laboratories America, Inc., 4 Independence Way, Princeton, NJ 08540, USA

[2]Corresponding author
e-mail: bbassler@molbio.princeton.edu

commonly is a member of the commensal microflora; however, *V.harveyi* is also a potent shrimp pathogen (Alvarez *et al.*, 1998). Most Gram-negative bacterial quorum-sensing systems are composed of a LuxI-dependent acyl homoserine lactone (HSL) signal molecule and a LuxR-type autoinducer-binding transcriptional regulator protein. In contrast, the *V.harveyi* quorum-sensing circuit consists of a multichannel two-component phosphorelay

What all can be regulated?

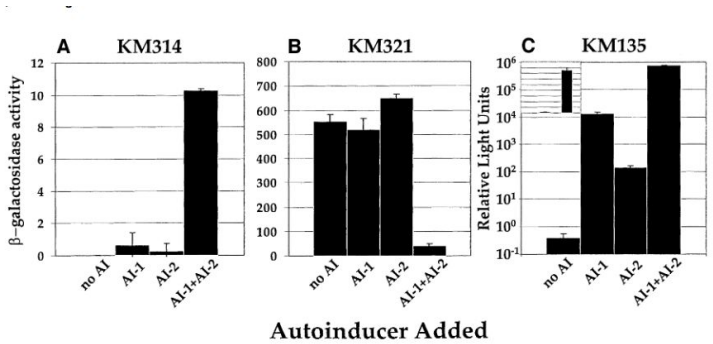


Fig. 4. AI-1 and AI-2 act synergistically. β-Gal activities of the fusions in the *luxS*, *luxLM* derivatives of strains KM87 (KM314) and KM114 (KM321), and light production of the *luxLM*, *luxS* (AI-1⁻, AI-2⁻) strain KM135 are shown in (**A**), (**B**) and (**C**), respectively. The following *V.harveyi* cell-free culture fluids were added at 10% (v/v): MM77 (no AI), MM30 (AI-1), BB152 (AI-2), BB120 (AI-1 + AI-2). Note the logarithmic scale in (C); the inset shows the identical data plotted on a linear scale. Relative light units (RLU) are defined as c.p.m. × 10^3/c.f.u./ml.

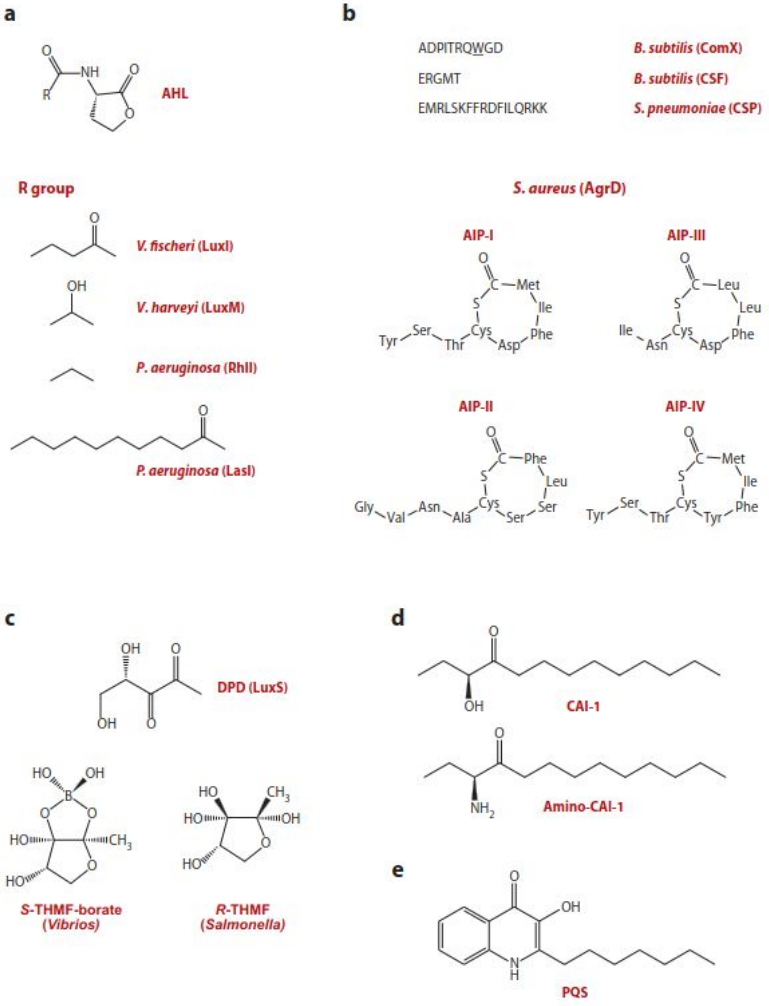
Bacterial Quorum-Sensing Network Architectures

Wai-Leung Ng[1] and Bonnie L. Bassler[1,2]

[1]Department of Molecular Biology, Princeton University, Princeton, New Jersey 08544-1014; email: bbassler@princeton.edu

[2]Howard Hughes Medical Institute, Chevy Chase, Maryland 20815-6789

How many languages to talk?



LuxIR

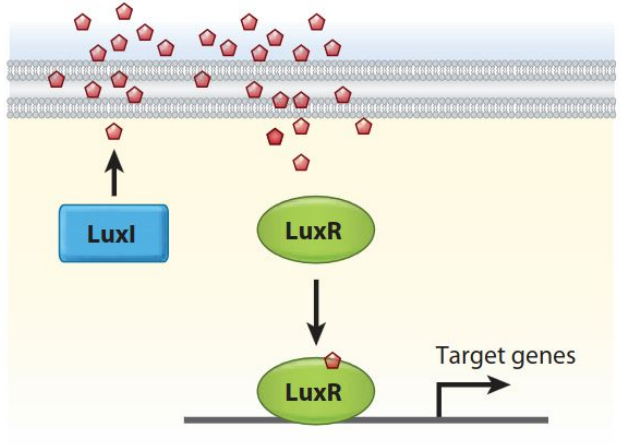


Figure 2

A canonical Gram-negative LuxIR-type quorum-sensing system. Red pentagons denote AHL autoinducers.

two component

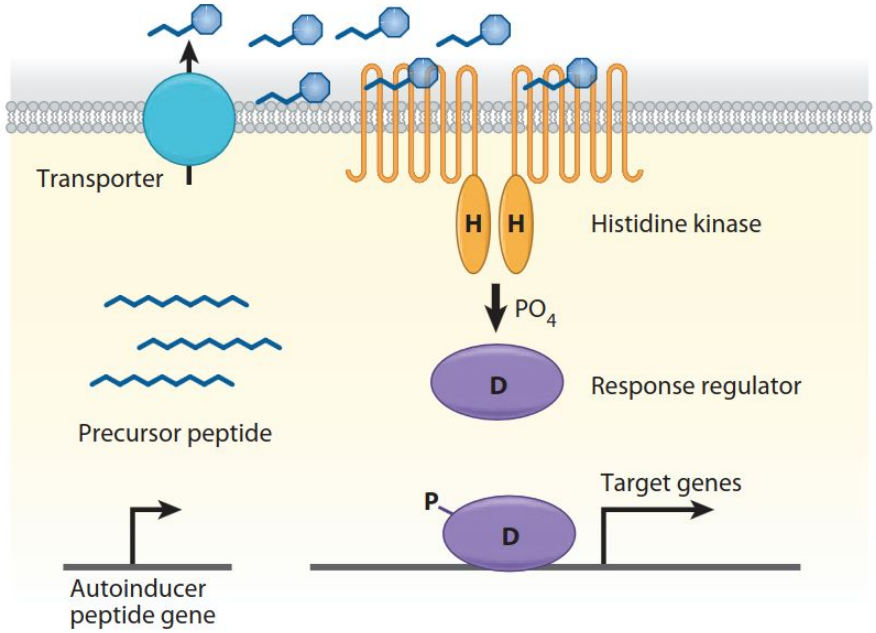
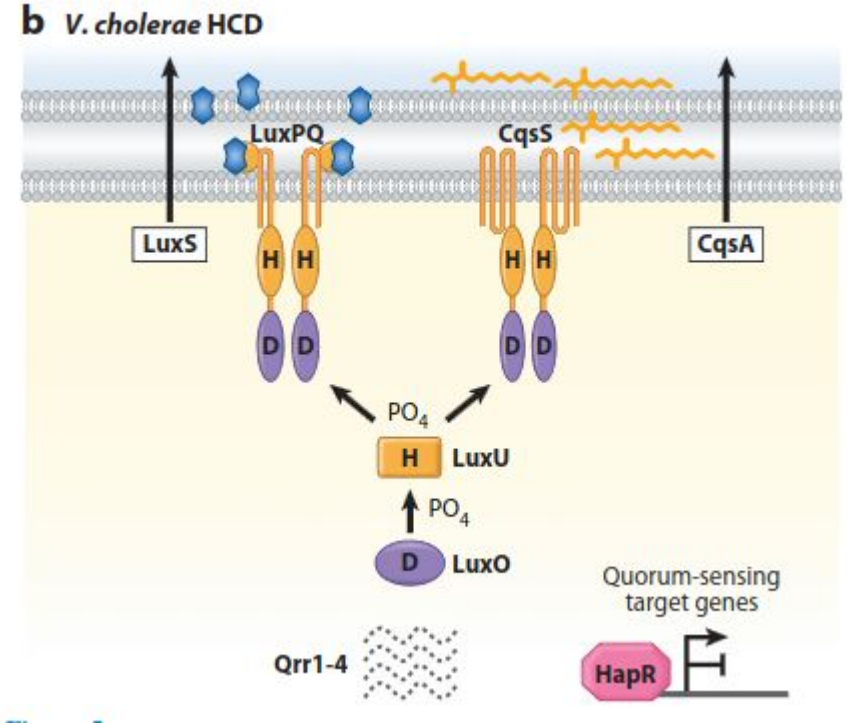


Figure 3

A canonical Gram-positive two-component-type quorum-sensing system. Blue octagons denote processed/modified peptide autoinducers.

multi input


b V. cholerae HCD
LuxPQ
CqsS
LuxS
CqsA
H
H
H
H
D
D
D
D
PO4
H
LuxU
PO4
D
LuxO
Quorum-sensing
target genes
Qrr1-4
HapR

multi circuit

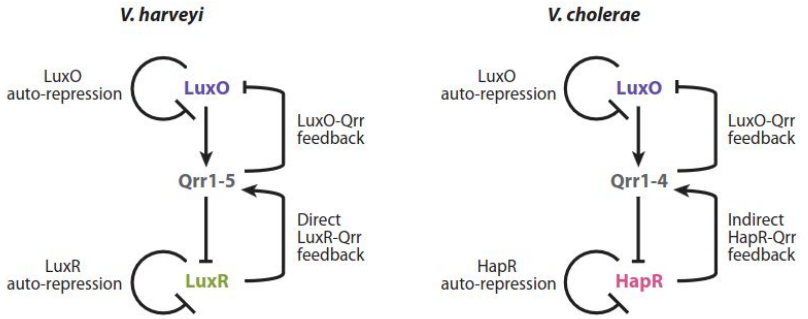


Figure 7

Feedback loops identified in the *V. harveyi* and *V. cholerae* quorum-sensing networks. Four different feedback loops are integrated into the *V. harveyi* and *V. cholerae* quorum-sensing circuits. Arrows denote activation. T-shape arrows denote repression.

different quorum
different genes

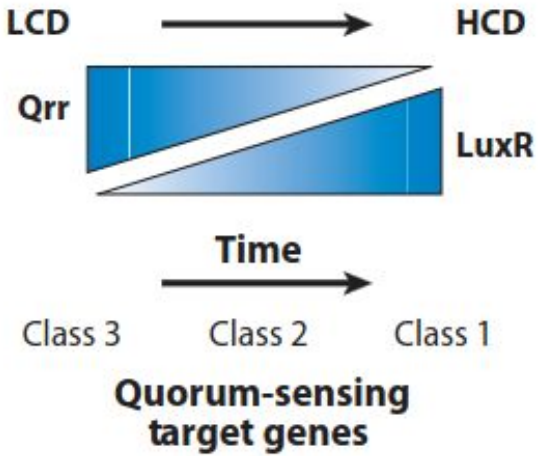


Figure 6

Reciprocal production of *V. harveyi* Qrr sRNAs and LuxR leads to temporal control of quorum-sensing target genes. From LCD to HCD, Qrr sRNA concentrations decrease and LuxR concentrations increase. As a consequence, Class 3 quorum-sensing target genes, whose promoters have the highest affinity for LuxR, are activated/repressed first, followed by Class 2 genes, and finally Class 1 genes.

ANNUAL REVIEWS

Annual Review of Microbiology

Signal Transduction Network Principles Underlying Bacterial Collective Behaviors

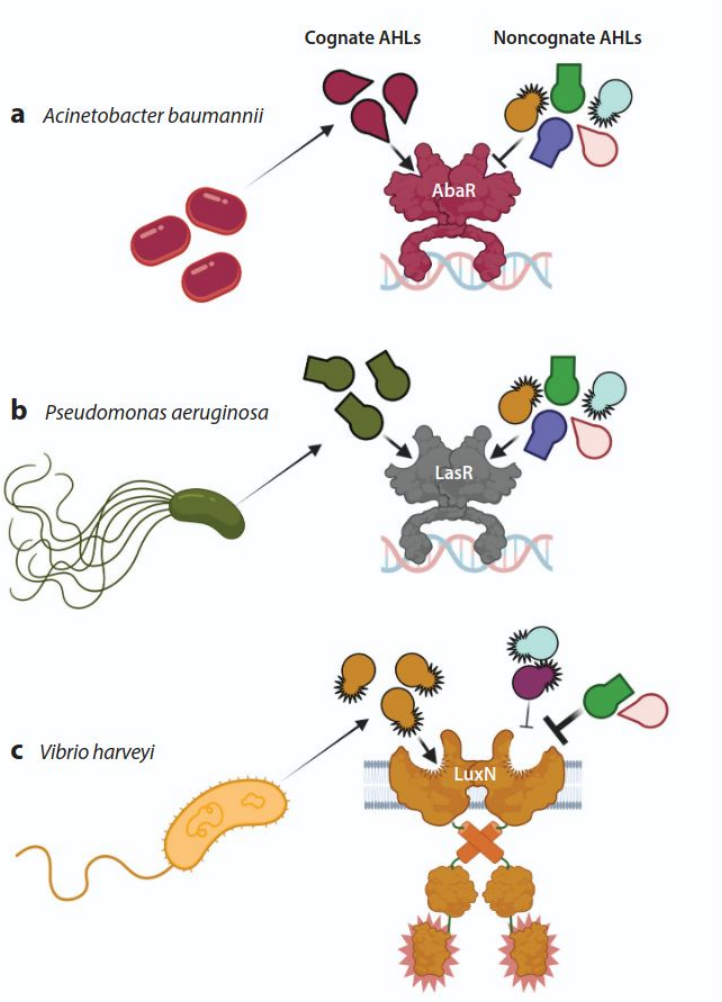
Andrew A. Bridges,[1] Jojo A. Prentice,[1]
Ned S. Wingreen,[1,2] and Bonnie L. Bassler[1,3]

[1]Department of Molecular Biology, Princeton University, Princeton, New Jersey, USA; email: andrewab@princeton.edu, josephap@princeton.edu, wingreen@princeton.edu, bbassler@princeton.edu

[2]Lewis-Sigler Institute for Integrative Genomics, Princeton University, Princeton, New Jersey, USA

[3]Howard Hughes Medical Institute, Chevy Chase, Maryland, USA

there are other bacteria in the world



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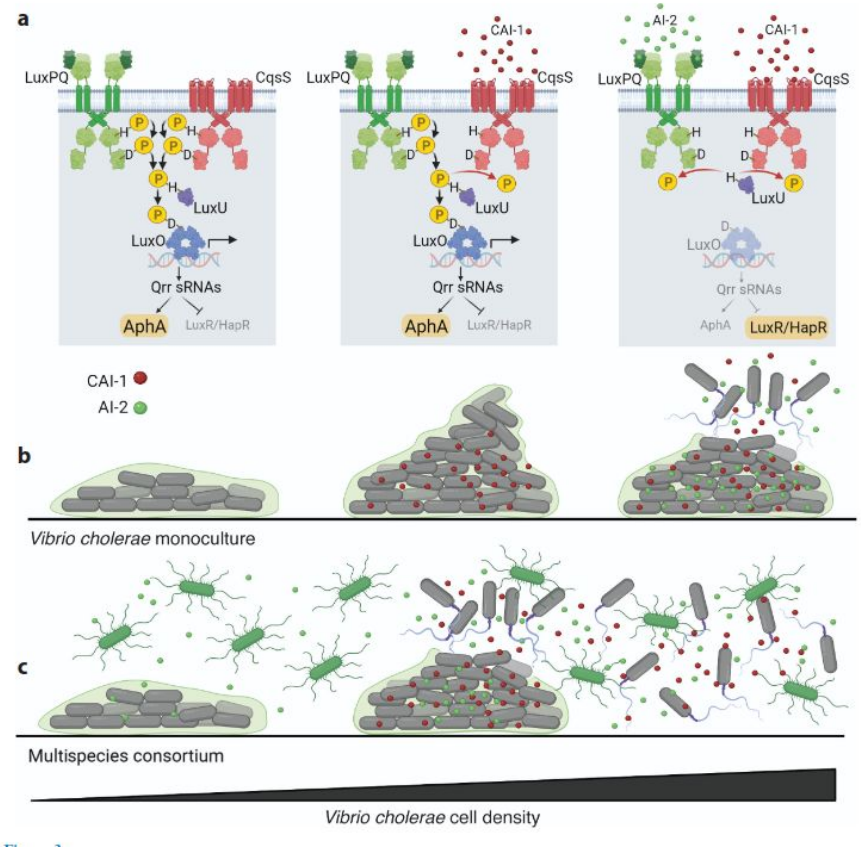
[2]Lewis-Sigler Institute for Integrative Genomics, Princeton University, Princeton, New Jersey, USA

[3]Howard Hughes Medical Institute, Chevy Chase, Maryland, USA

there are other things to do in the world



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[2]Lewis-Sigler Institute for Integrative Genomics, Princeton University, Princeton, New Jersey, USA

[3]Howard Hughes Medical Institute, Chevy Chase, Maryland, USA

remember,
there is still
sRNA inside!

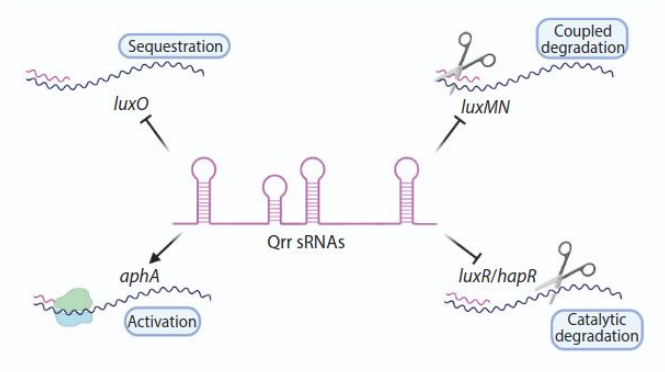

Figure 4

The Qrr sRNAs control quorum-sensing target genes. The Qrr sRNAs function by four posttranscriptional regulatory mechanisms. They activate translation by facilitating ribosome binding. They repress translation by sequestration, coupled degradation, and catalytic degradation of target mRNAs. One representative target mRNA that is controlled by each mechanism is shown. Figure adapted from images created with BioRender.com. Abbreviation: sRNA, small RNA.

ANNUAL REVIEWS

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Signal Transduction Network Principles Underlying Bacterial Collective Behaviors

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felt real,
might delete later

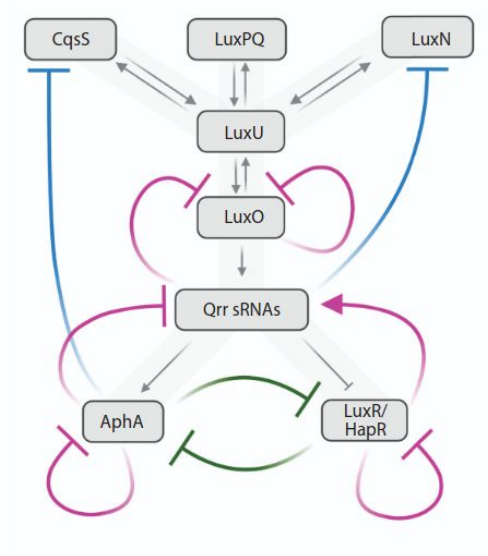


Figure 5

Autoregulatory feedback loops in the *Vibrio harveyi/Vibrio cholerae* quorum-sensing circuit. Negative autoregulatory feedback loops are magenta, and positive autoregulatory feedback loops are green. Two additional regulatory loops exist that control receptor levels and are shown in blue. Abbreviation: sRNA, small RNA. Figure created with BioRender.com.

Journal of Mathematical Biology (2022) 84:5
https://doi.org/10.1007/s00285-021-01705-z

Mathematical Biology

Quorum-sensing induced transitions between bistable steady-states for a cell-bulk ODE-PDE model with lux intracellular kinetics

Wesley Ridgway[1] · Michael J. Ward[1] · Brian T. Wetton[1]

Received: 7 January 2021 / Revised: 13 October 2021 / Accepted: 17 November 2021 /
Published online: 20 December 2021

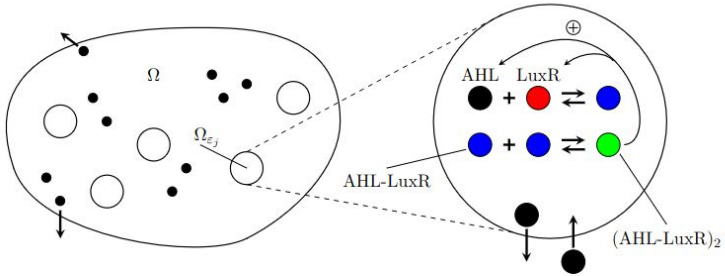


Figure 1.1: Schematic diagram depicting the model geometry and intracellular reactions. The circular regions on the left are cells, while the black dots represent AI molecules. The chemical reactions described by (1.5) occur in each cell, as depicted in the magnified cell on the right. The diffusible AHL molecules that are secreted and absorbed by the cells undergo bulk decay and are allowed to leak out of the bulk domain.

PEARLS

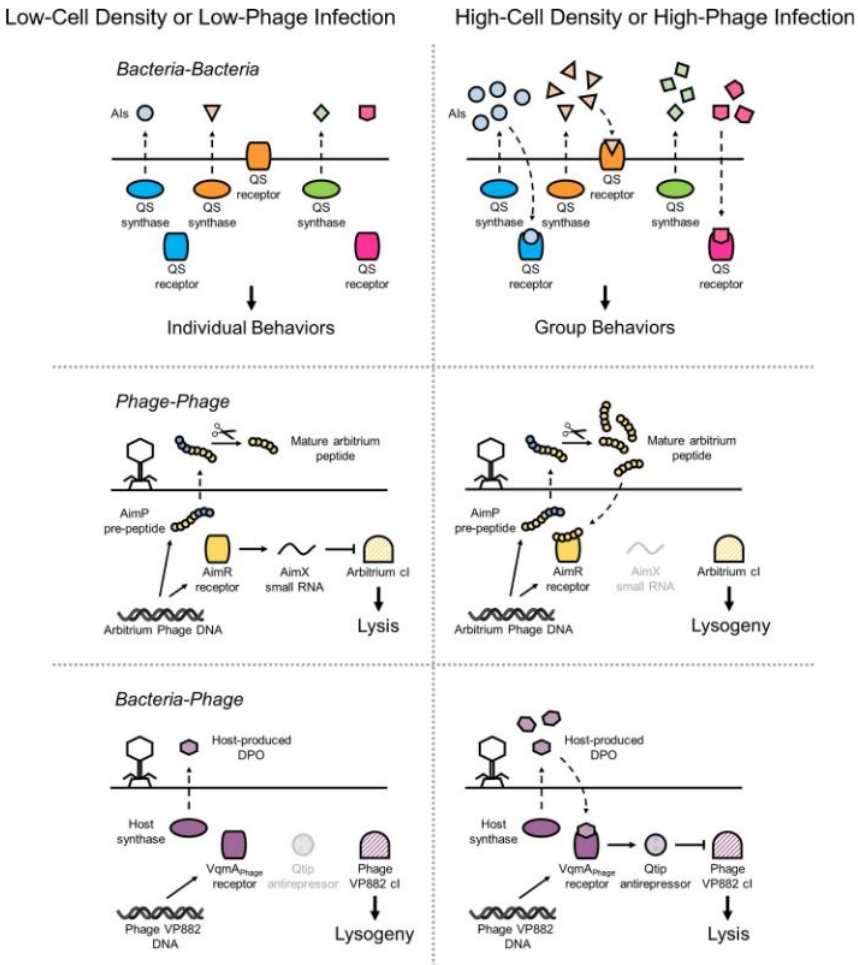
Quorum sensing across bacterial and viral domains

Olivia P. Duddy[1], **Bonnie L. Bassler**[1,2]*

1 Department of Molecular Biology, Princeton University, Princeton, United States of America, **2** Howard Hughes Medical Institute, Chevy Chase, United States of America

* bbassler@princeton.edu

where there's bacteria
theres phage



Lighting the way:

how the *Vibrio fischeri* model microbe reveals the complexity of Earth's "simplest" life forms

Alecia N. Septer, Karen L. Visick

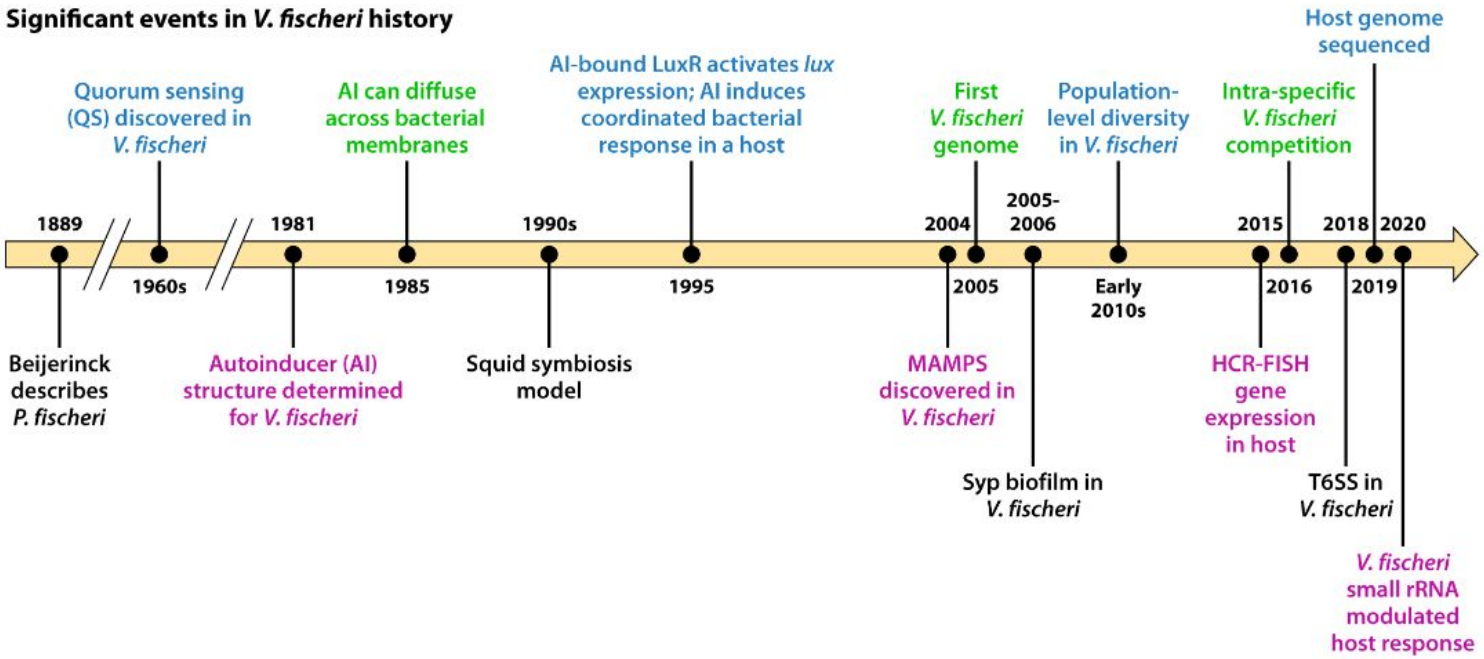


FIG 1 Time line of *V. fischeri* history. Key events and discoveries made using *V. fischeri* as a model microbe.

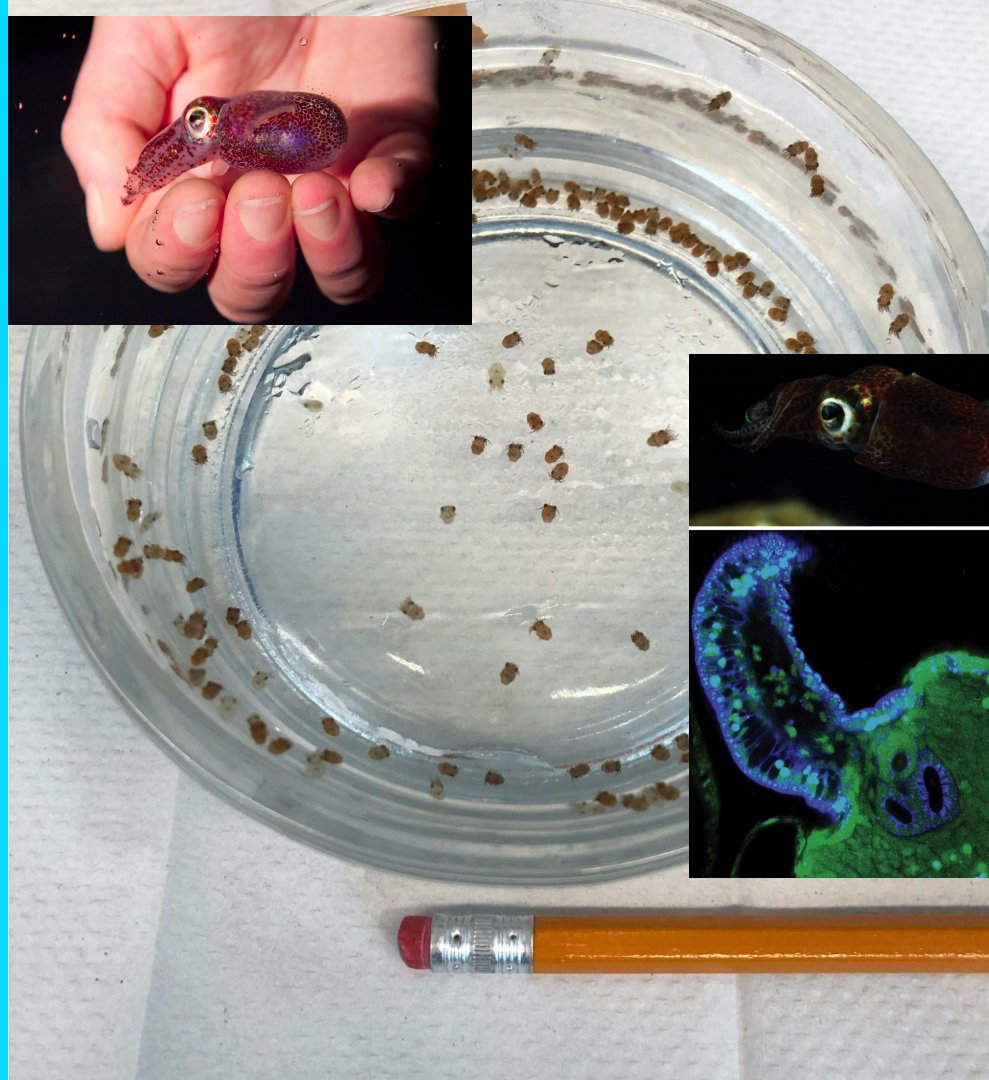
Euprymna scolopes

+

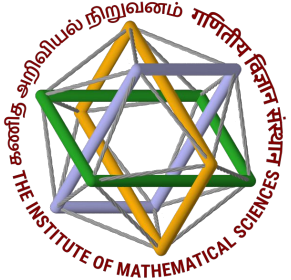
*Aliivibrio fischeri**

*formerly known as
V. fischeri

Margaret J. McFall-Ngai, Carnegie Institution for Science/California Institute of Technology, and Edward G. Ruby, California Institute of Technology.



why / how / when to quorum?



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