Glowing corpses
and
Radiant excrement:
The role of bioluminescence in microbial communities

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Why do microbes glow?

“It has no primary function”

When don’t know make this argument
Nucleus
Heat -> Nucleus Incandescence
Nucleus - Heat - Nucleus

Heat - Electron

Light

Incandescence

Fluorescence

Phosphorescence

Glow in the dark paint
Heat

Fluorescence

Phosphorescence

Chemiluminescence
Luciferins

- Bacteria
  - CH$_2$ - (CHOH)$_3$ - CH$_2$ - O - P - OH
  - N
  - H
  - NH
  - H
  - N
  - O

- Diplocardia
  - O

- Latia
  - OCHO

- Coelenterate
  - O

- Vargula
  - NH$_2$

- Firefly
  - HO

- Dinoflagellate
  - CO$_2$
Phylogenetic tree of bioluminescence

- * = unsubstantiated reports of lumin.
Suckers as light organs

Kuiper-belt objects

Mahogany protein

Atmospheric CO
Stauroteuthis syrtensis
LUX Operon

Direction of gene expression

Bacterial Luciferase

Reductase  Synthetase  Transferase

Fatty Acid Reductase Enzyme Complex
Photobacterium phosphoreum

Vibrio fischeri

Shewanella woodyi

Photorhabdus luminescens
Vibrio harveyi in mixed culture experiment during continuous irradiation with UV light

Photodimer + Blue Light → Photolyase + DNA backbone

Photodimer + UV light → DNA backbone
Bacterial bioluminescence as a lure for marine zooplankton and fish
Margarita Zarubin, Shimshon Belkin, Michael Ionescu, and Amatzia Genin
PNAS | January 17, 2012 | vol. 109 | no. 3 | 853–857

Artemia salina

Apogon annularis
Infrared light illumination. *Artemia* with non-luminescent bacteria
Infrared light illumination. *Artemia* with luminescent bacteria
Pyrosoma atlanticum
Pyrosoma sp.
left, single individual; right, colony
after Neumann in Herring (1978: 234)
Sexual Dimorphism

Loose-jaw Male

Loose-jaw Female

© E. Widder
Shining tubeshoulder: *Searsia koefoedi*
caruncles
Functions of Bioluminescence:

- Finding food
- Finding mates
- Defense
  - Blinding and distraction
  - Camouflage
Cross section of hatchet fish light organ
Counterillumination
Abralia veranyi
<table>
<thead>
<tr>
<th>Total American deaths by war</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Civil War</td>
</tr>
<tr>
<td>World War II</td>
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<tr>
<td>World War I</td>
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<td>Vietnam</td>
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<td>Korean War</td>
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<td>American Revolutionary War</td>
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<td>War of 1812</td>
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<tr>
<td>Mexican American War</td>
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<tr>
<td>War on Terror</td>
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<tr>
<td>Philippine-American War</td>
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</tbody>
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Nematode
*(Heterorhabditis bacteriophora)*

Moth larvae

Bioluminescent bacteria
*(Photorhabdus luminescens)*
“As the phase of *Photorhabdus* that glows is typically only found in insect cadavers, there is no intuitive benefit of glowing to attract prey or distract a predator, as all necessary resources for survival and reproduction are present in the insect cadaver.”

“Finally, it should also be considered that bioluminescence in *Photorhabdus* has no primary function, and that the bacteria bioluminesce only because they possess the genes that allow for luminescence.”

“It may not have had sufficient time, evolutionarily speaking, to have been completely lost, and as such light is still emitted without providing any real advantage to the organism.”

Nematode
\((Heterorhabditis\ bacteriophora)\)

Moth larvae

Bioluminescent bacteria
\((Photorhabdus\ luminescens)\)

Photo: Patrick Porter, Texas A&M University

Photo: Marshall Johnson, Univ. of Hawaii

Photo: Peggy Greb
Model of the transmission cycle.

Bioluminescence in *Photorhabdus luminescens* is selectively advantageous because it functions as bioluminescent aposematism or Batesian or Müllerian mimicry protecting the insect cadaver from predators.
Functions of Bioluminescence:

- Finding food
- Finding mates
- Defense
  - Blinding and distraction
  - Camouflage
- Warning
• Aposematic warning— a warning signal to potential predators
• Aposematic warning— a warning signal to potential predators

Monarch butterfly
• Aposematic warning— a warning signal to potential predators

• Batesian mimicry – Mimic assumes conspicuous markings but lacks defense
• Aposematic warning— a warning signal to potential predators

• Batesian mimicry – Mimic assumes conspicuous markings but lacks defense

• Müllerian mimicry - Prey share effective antipredator defense and employ similar markings
Clytia languidum
Clytia languidum
Clytia languidum
Bioluminescent aposematism in millipedes

Bioluminescent aposematism in millipedes

Lango and Clarke (2010) A metabolic switch is involved in lifestyle decisions in *Photorhabdus luminescens*. Molecular Microbiology 77(6), 1394–1405
With thanks to:
Jim Case
Peter Herring
Sonke Johnsen
Bruce Robison
R/V Seward Johnson &
JSL Submersible Crew
Questions?
Courtesy of Center for Environmental Biotechnology
University of Tennessee
Dr. Gary S. Sayler, Director
Müllerian mimicry in apheloriine millipedes of the U.S. Appalachian Mountains.

Marek P E, Bond J E PNAS 2009;106:9755-9760
Photolyase repair of UV damaged DNA