From tiny babies to giant tubeworms – thiotrophic symbiosis at deep-sea hydrothermal vents

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www.hydrothermalvent.com
beneficial microbial symbiosis is ubiquitous


Bright & Bulgheresi Nature Rev Microbiol 2010
the most diverse type of symbiosis in the sea

Desbruyeres D, Segonzac M, Bright M. 2006 Handbook of Deep-Sea Hydrothermal Vent Fauna
thanks to hydrogen sulfide thiotrophic symbiosis

chemosynthetic environments at oxic - anoxic interfaces
Sv. Jerney
Zoothamnium niveum - Cand. Thiobios zoothamnicoli

Ciliophora, Oligohymenophora, Peritrichida

Gammaproteobacteria

Thiotrophic ciliate mutualism – cooperation goes empirical

August 2012 – July 2015
Collaboration with

Vlado Malacic
Valentina Turk, Patricija Mozetic, Branko Cermelj
Gasper Polajnar
Cultivation in flow through respirometer systems
Riftia pachyptila - Cand. Endoriftia persephone
Polychaeta, Siboglinidae, Vestimentifera
Gammaproteobacteria

to get together
to live together
to separate

HOV Alvin
ASCT - volcanic eruptions
Chemosynthesis

\[ \text{O}_2 + \text{H}_2\text{S} \rightarrow \text{SO}_4^{2-} \]

\[
\text{ADP} \quad \text{ATP}
\]

\[ \text{CO}_2 \rightarrow \text{org. carbon} \]
Giant tubeworms
to live with the chosen - the trophosome
the trophosome – LM and SEM
the trophosome - TEM
the trophosome - reconstruction

Blood flow

Periphery

Center

Bright & Sorgo Invertebrate Biology 2003
host cell cycle with terminal differentiation

BrdU, phosphohistone H3, AIF, caspase 3, cytokeratin 18, LC3

dna synthesis & mitosis - center & middle

apoptosis in periphery

Pflugfelder, Cary, Bright 2009 Cell and Tissue Research
1 phylootype – FISH with symbiont-specific probe
3 morphotypes – TEM

rods small cocci large cocci
Carbon fixation – translocation through release and digestion

$^{14}$C bicarbonate experiments, tissue autoradiography

Bright, Keckeis, Fisher Mar Biol 2000
To live with the chosen

- host proliferation rates match those of cancer cells
- fastest growing invertebrate we know of
- extremely high carbon fixation rates in symbiont
- symbiont feeds host through release of organic carbon and digestion

- symbiont - one phylotype
- high capacity carbon and sulfur storage to deal with fluctuating environmental conditions
- proliferation of symbiont is controlled by host cell cycle
everybody starts small
TASCs tubeworm artificial settlement cubes
To find each other

TASCs tubeworm artificial settlement cubes
Reconstruction of aposymbiotic larvae
FISH and TEM

Reconstruction of infected larvae
FISH and TEM

Reconstruction of juvenile FISH and TEM

To find the free-living symbiont FRIES field recruitment isolation settlement

off-axis near tubeworms among tubeworms

Harmer, Rotjan, Nussbaumer, Bright, Ng, DeChaine, Cavanaugh, 2008 AEM
To find the free-living symbiont 16S rRNA sequencing and FISH

Harmer, Rotjan, Nussbaumer, Bright, Ng, DeChaine, Cavanaugh, 2008 AEM
To find each other

- transmission horizontal from environment
- transmission in larve only
- infection through skin is very similar to pathogen infections


Bright, Klose, Nussbaumer 2013 Current Biology
Can the symbionts leave the host upon host death?

high pressure flow through vessel experiments
FISH of symbionts colonizing glass slides

bacterial probe

DAPI

symbiont-specific probe + DAPI

Klose, Schimak, Bright unpublished
To escape

- escape is fast and occurs under simulated hydrothermal vent and deep-sea conditions

Several facts point to active process

- population structure colonizing symbionts differs from the population structure in trophosome

- many colonizing symbionts are dividing and build small colonies

Klose, Schimak, Bright unpublished
Acknowledgements

11 cruises/submersible time EPR


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