

Reconstructing the early evolution of segmented annelid worms



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NSF Award 0342393

- **NSF Program**
 - Biocomplexity in the Environment (GEN-EN)
- **NSF Org and Program Manager**
 - EAR and H. Richard Lane
- **Awarded Amount to Date**
 - \$1,095,513
- **Award Start Date**
 - June 4, 2003 (originally October 1, 2001)
- **Expires**
 - September 30, 2006 (estimated)

WormNet Investigators

- **Ken Halanych, Auburn University**
- **Mark Martindale, University of Hawaii**
- **Elaine Seaver, University of Hawaii**
- **Damhnait McHugh, Colgate University (PUI)**
- **Jeff Boore, Joint Genome Institute**
- **Dan Rokhsar, Joint Genome Institute**

Goals

- **Develop a robust phylogenetic hypothesis for the annelids**
 - Six nuclear genes and two mt genes
 - Complete mitochondrial genome sequences
- **Characterize patterns of expression for segmentation genes**
 - Six segmented annelids and unsegmented forms
 - Segment polarity and pair-rule genes

Questions

- **What is the membership of the Annelida?**
- **What are the relationships among groups within the Annelida?**
- **What was the body form of basal annelids?**
- **What is the pattern of change in segmentation throughout annelid evolution?**
- **Does segmentation have a common origin in annelids and arthropods?**

Phylogenetic analyses of gene sequences

- **Investigators responsible**

- Ken Halanych
- Damhnait McHugh

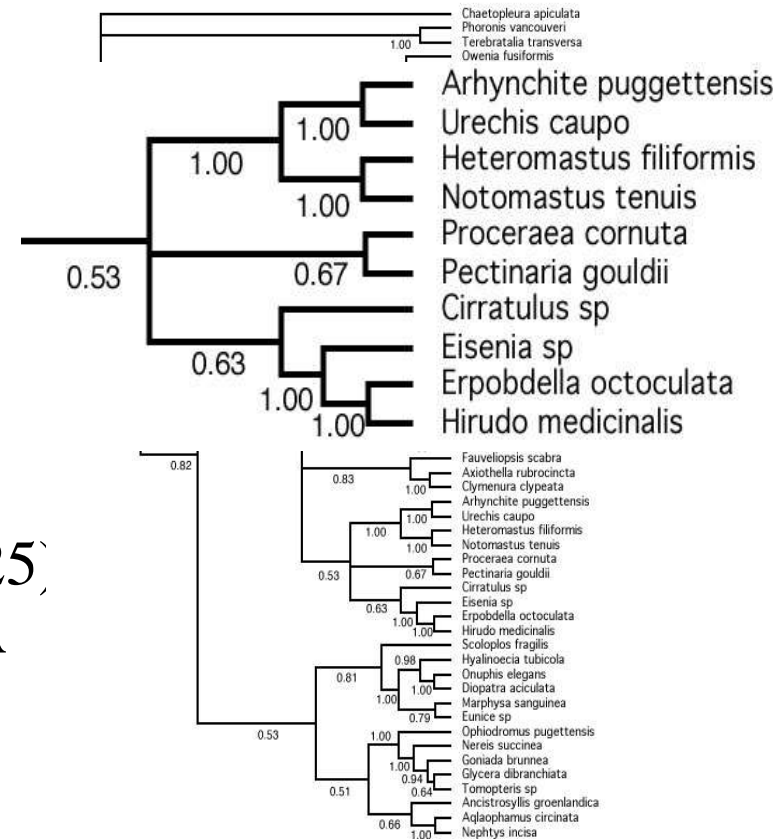
- **150 taxa**

- **Nuclear markers**

- EF-1 α (64) , EF-2 (32), Myosin II (25)
RNA polymerase II (30) , 18S rRNA
(hundreds), 28S rRNA (56)

- **Mitochondrial markers**

- 16S rRNA, COI



Mitochondrial genomes

- **Investigators responsible**
 - Jeff Boore and Dan Rokhsar
 - Ken Halanych
- **80 taxa**
 - Polychaetes, clitellates
 - Unsegmented echiurid, sipunculid
- **Complete genome sequencing**
 - Several complete
 - Over 20 underway
- **Analysis**
 - gene order and gene sequences

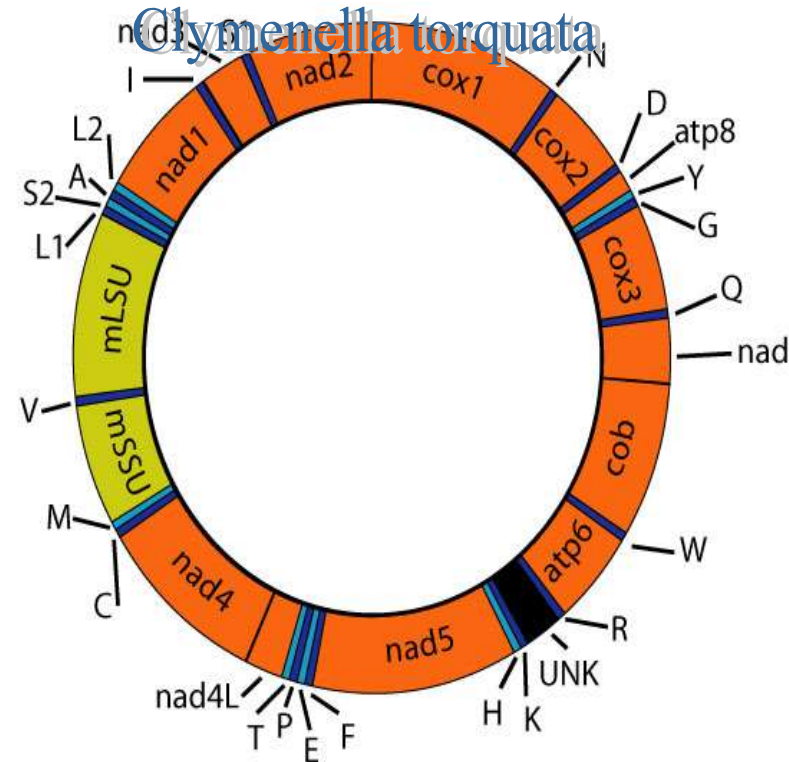


Figure 1. Mitochondrial genome of *Clymenella torquata*. Abbreviations are as explained in the text. All genes are transcribed in the same direction, regardless of the orientation of their names here. Protein coding genes are in orange, RNA genes in green, and tRNAs in shades of blue.

Jennings and Halanych, in press

Gene expression patterns

- **Investigators responsible**

- Mark Martindale
- Elaine Seaver

- **Six taxa**

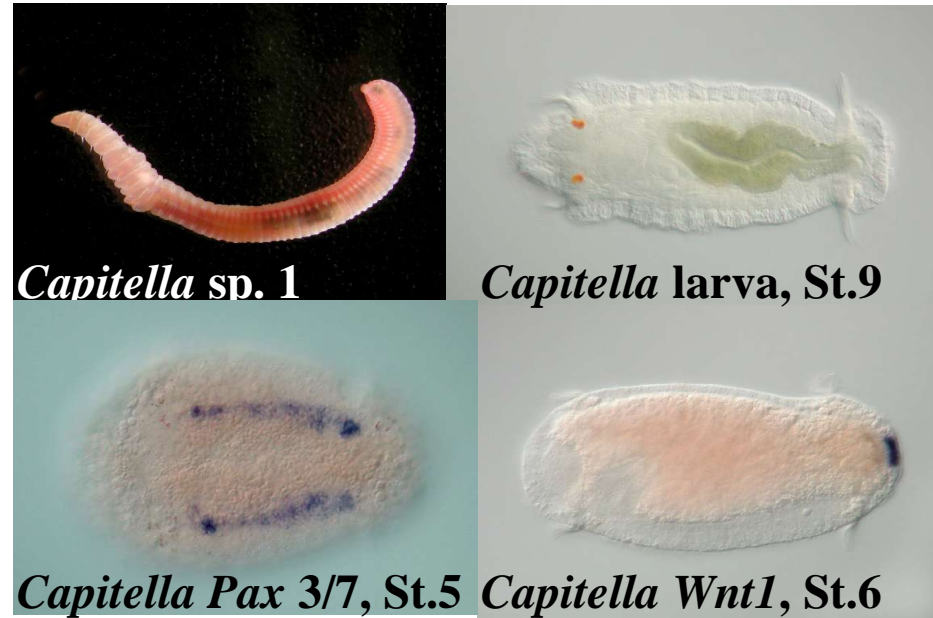
- Polychaetes
- Unsegmented echiurid

- **Segmentation genes**

- *Capitella* sp. 1,
- *Chaetopterus variopedatus*,
- *Hydroides elegans*
- *Eve*, *paired*, *runt*, *wg*, *hh* and *en*

- **Whole mount *in situ* hybridization in larvae**

Capitella sp. 1



E. Seaver (unpub. data)

Training

- **Auburn University**

- **Postdoc**

- Torsten Struck

- **M.Sc. student**

- Adrienne Brunette

- **UG research students**

- Tiffany Kusen '05, Emily Hickman '06

- **Visiting graduate students**

- Christoph Bleidorn (University of Berlin, Germany),
Deborah Lanterbecq (University of Mons, Belgium),
Joana Silva (George Washington
University/NMNH)



Training

- **Colgate University**

- **Postdoc (half time)**

- Nancy Schult

- **UG research students**

- Jamie Knowles '03, Caitlyn Houck '03, Christina Oliveros '03, Jesse Czekanski-Moir '04, Emily Wenink '04, Rebecca Ortolano, '04, Will Martin '04, Heather McKay '04, Kristin Girouard '04, Nicholas Federico '04

- **Visiting graduate students**

- Mario Londono-Mesa, Mexico



<http://www.ees.adelaide.edu.au/people/enviro/greg>

Training

- **University of Hawaii**
 - **Ph.D. student**
 - Michael Boyle
- **Joint Genome Institute/UC Berkeley**
 - **Ph.D. student**
 - Yvonne Valles
- **Woods Hole Oceanographic Institution**
 - **Ph.D. student**
 - Rob Jennings



Photo: K. Halanych

Research cruises

- **UNOLS-funded collection expeditions**
- *R/V Point Sur*
 - March 2003
 - Monterey Bay and northern CA coast
- *R/V Oceanus*
 - June 2003
 - Southern New England coast
- **Collected ~ 200 annelid species**



Meetings of *WormNet* participants

- *Society for Integrative and Comparative Biology*
 - New Orleans, January 2004
 - Attended by K. Halanych, D. McHugh, M. Martindale, E. Seaver, T. Struck, A. Brunette

- *International Polychaete Conference*
 - Madrid, July 2004
 - Attended by K. Halanych, D. McHugh, T. Struck, A. Brunette, Y. Valles

- *Society for Integrative and Comparative Biology*
 - San Diego, January 2005
 - Will be attended by K. Halanych, D. McHugh, M. Martindale, E. Seaver, T. Struck, A. Brunette, Y. Valles

Outreach activities

- **ANNELIDA List**
 - <http://biocollections.org/pub/worms/ANNELIDA-list.html>
 - An open public mailing list for discussion of research into Annelida and allied groups
- ***Chaetopterus variopedatus* BAC library**
 - Complete
- ***WormNet* webpage**
 - http://www.auburn.edu/academic/science_math/biology/faculty/halanych/wormnet.html
 - Under Construction!
- **International symposium hosted by Society for Integrative and Comparative Biology, San Diego, January 2005**
 - Recent advances in annelid systematics, development, and evolution
 - Proceedings to be published in *Integrative and Comparative Biology*

***WormNet*: Recent advances in annelid systematics, development, and evolution**

- | | |
|--|---|
| Kenneth M. Halany ch | <i>WormNet</i>: Progress towards understanding annelid phylogeny |
| Yvonn e Valles &
Jeffrey L. Boore | Annelids in the mist: The influence of a new marker |
| Damh nait McHugh | Phylogenetic analyses of ann elid relationships using nuclear coding genes |
| James R. Garey &
James A. Lake | Simulating DNA e volution: Application to genomi c analysis |
| Torsten H. Struck | Annelid rDNA phy logeny and implications for progenetic origins |
| Sally A. Woodi n &
Rachel A. Merz | Setal function, phylogeny, and lifestyle revelations among the worms |
| Guenter Purschke | Evolution of bo dy wall musculature |
| Bruno Pernet | Evolutionary qu estions prompted by the diversity of form an d function of ann elid larvae |
| Alexa E. Bely | Evolution of an nelid regeneration and asexual reprodu ction |
| Robert M. Savag e | The divergent roles of the segme ntation gene <i>hunchback</i> in annelids an d arthropods |

Thanks!

