

The genome of a subterrestrial nematode reveals an evolutionary strategy for adaptation to heat

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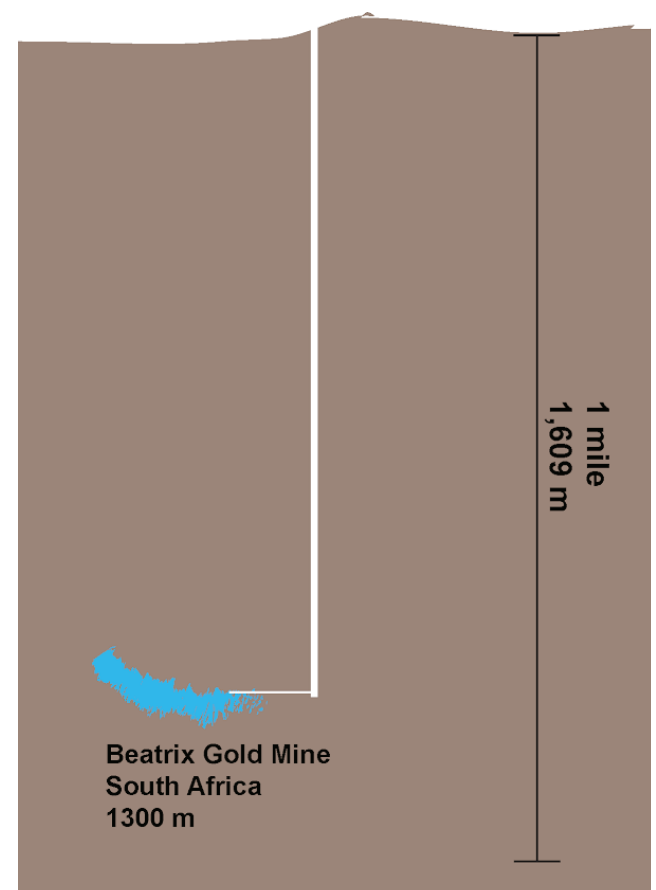
AFFILIATIONS

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ABSTRACT

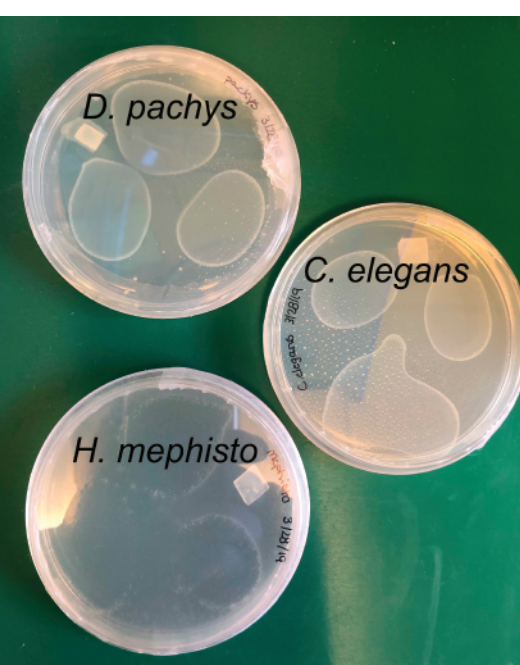
The nematode *Halicephalobus mephisto* was originally discovered inhabiting a deep terrestrial aquifer 1.3 km underground. *H. mephisto* can thrive under conditions of abiotic stress including heat and minimal oxygen, where it feeds on a community of both chemolithotrophic and heterotrophic prokaryotes in an unusual ecosystem isolated from the surface biosphere. Here we report the comprehensive genome and transcriptome of this organism, identifying a signature of adaptation: an expanded repertoire of 70 kilodalton heat-shock proteins (Hsp70) and *avrRpt2*-induced gene 1 (AIG1) proteins. We find that positive selection has driven the expansion of Hsp70 genes, which are also transcriptionally induced upon growth under heat stress. We further show that AIG1 may have been acquired by horizontal gene transfer (HGT) from a rhizobial fungus. Over one-third of the genes of *H. mephisto* are novel, highlighting the divergence of this nematode from other sequenced organisms. This work sheds light on the genomic strategies of adaptation to heat in the first complete subterrestrial eukaryotic genome.

Discovery of *Halicephalobus mephisto*



Conditions in subterrestrial aquifer:

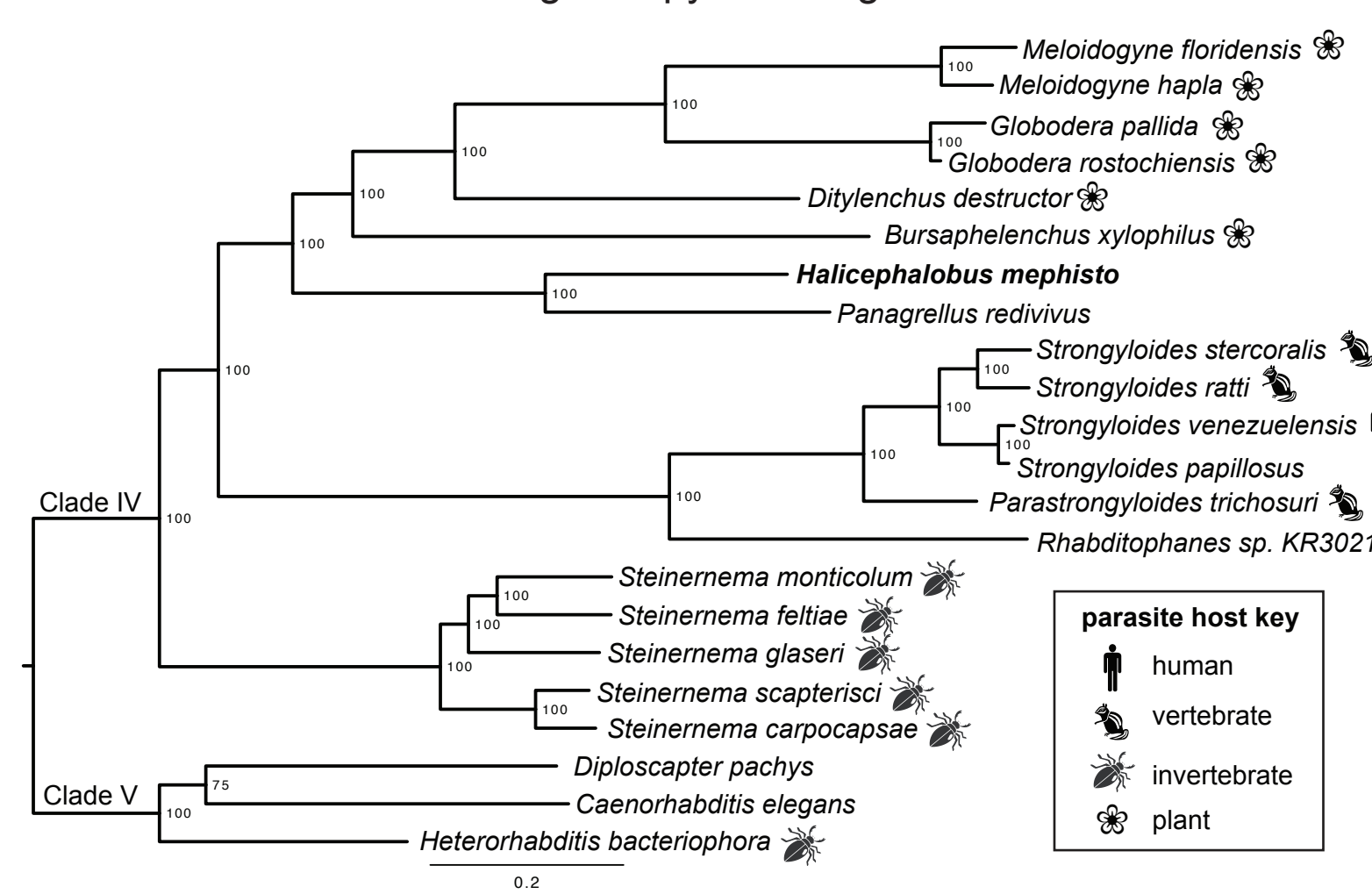
- warm (37°C)
- hypoxic (0.42 - 2.3mg/L dissolved O₂)
- high methane
- thriving microbial communities



4-day culture at 37°C

Nematode Phylogeny

99 Single-Copy Ortholog ML



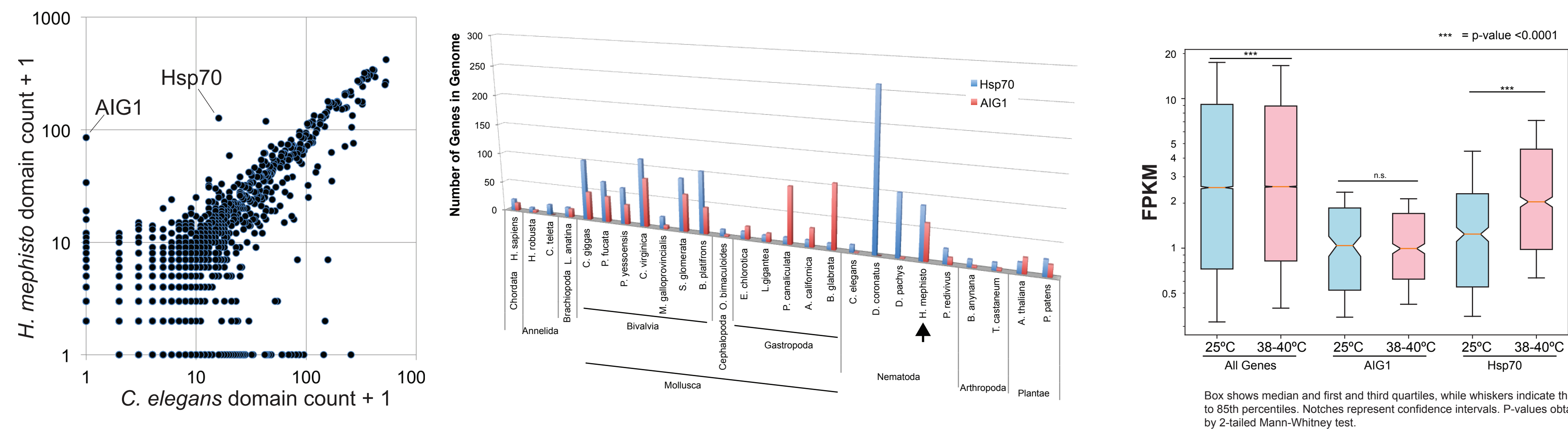
References

Borgonie G, García-Moyano A, Litthauer D, Bert W, Bester A, van Heerden E, Möller C, Erasmus M, Onstott TC. Nematode from the terrestrial deep subsurface of South Africa. Nature. 2011 Jun 2;474(7349):79-82.

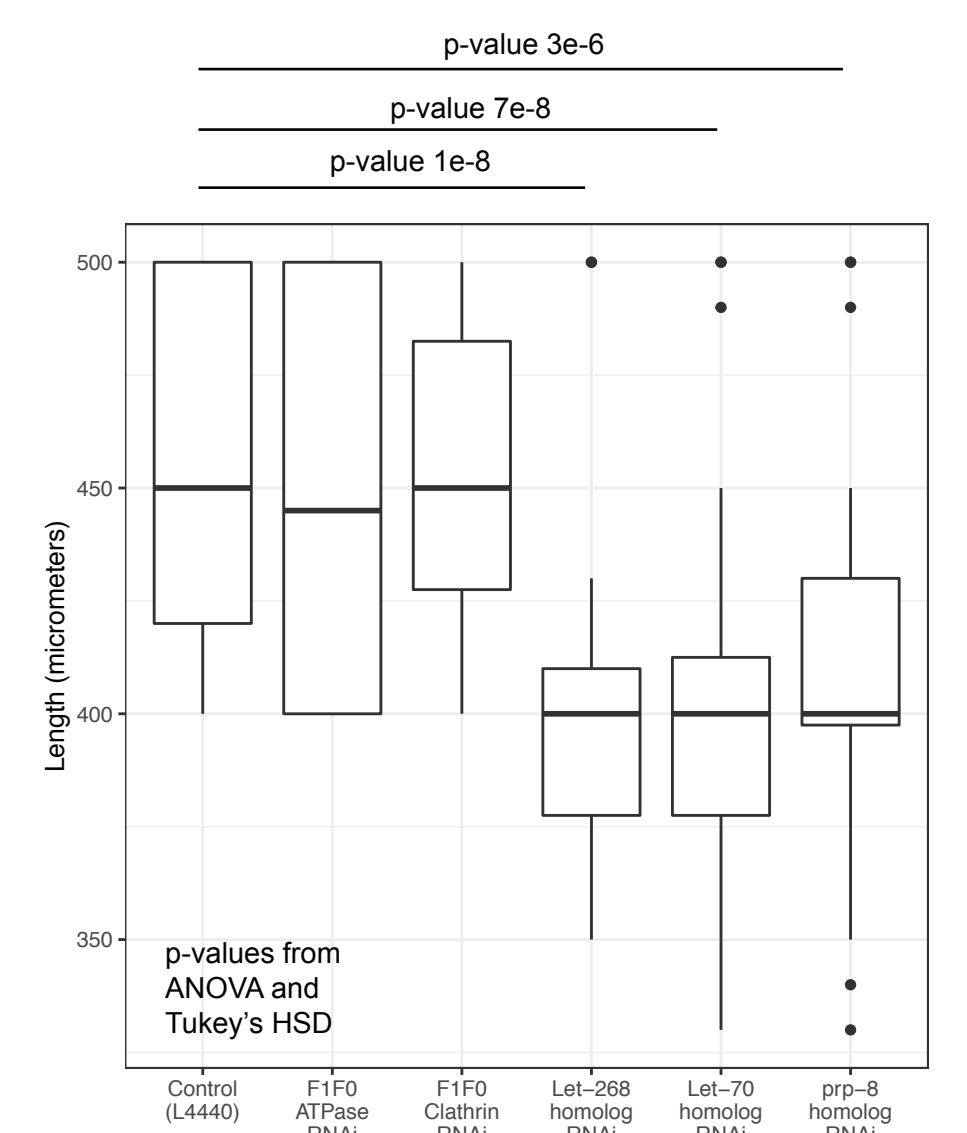
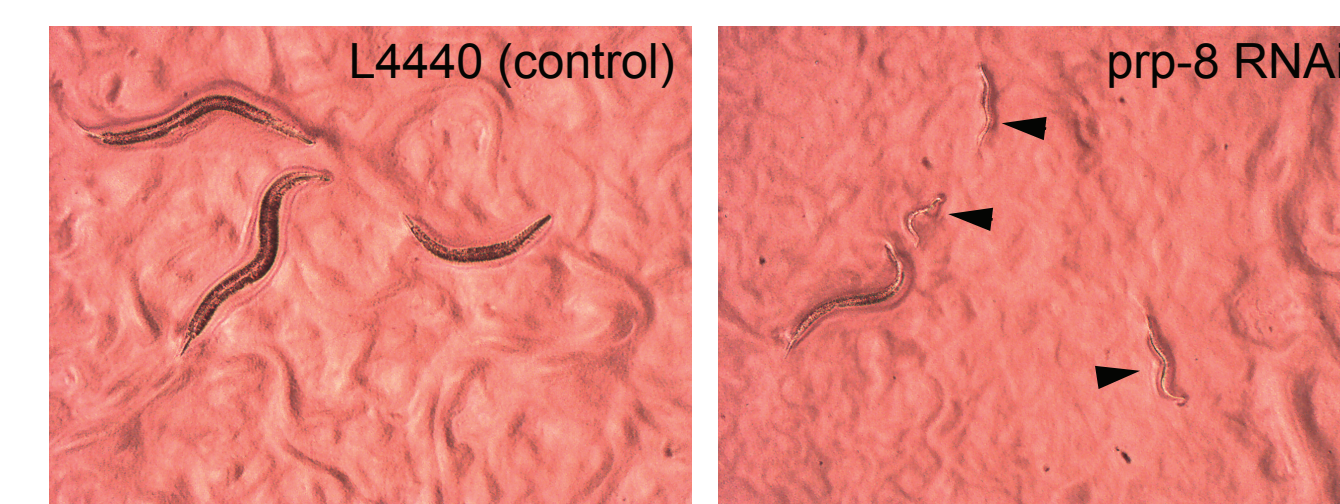
Guerin MN, Weinstein DJ, Bracht JR. Stress-adapted Mollusca and Nematoda exhibit convergently expanded Hsp70 and AIG1 gene families. Journal of Molecular Evolution. In press.

Weinstein DJ, Lau M, Allen S, Magnabosco C, Borgonie G, Erasmus M, Van Heerden E, Onstott T, Sebra B, Deikus G, Goldman A, Onstott TC, Bracht, JR. The genome of a subterrestrial nematode reveals an evolutionary strategy for adaptation to heat. Under revision.

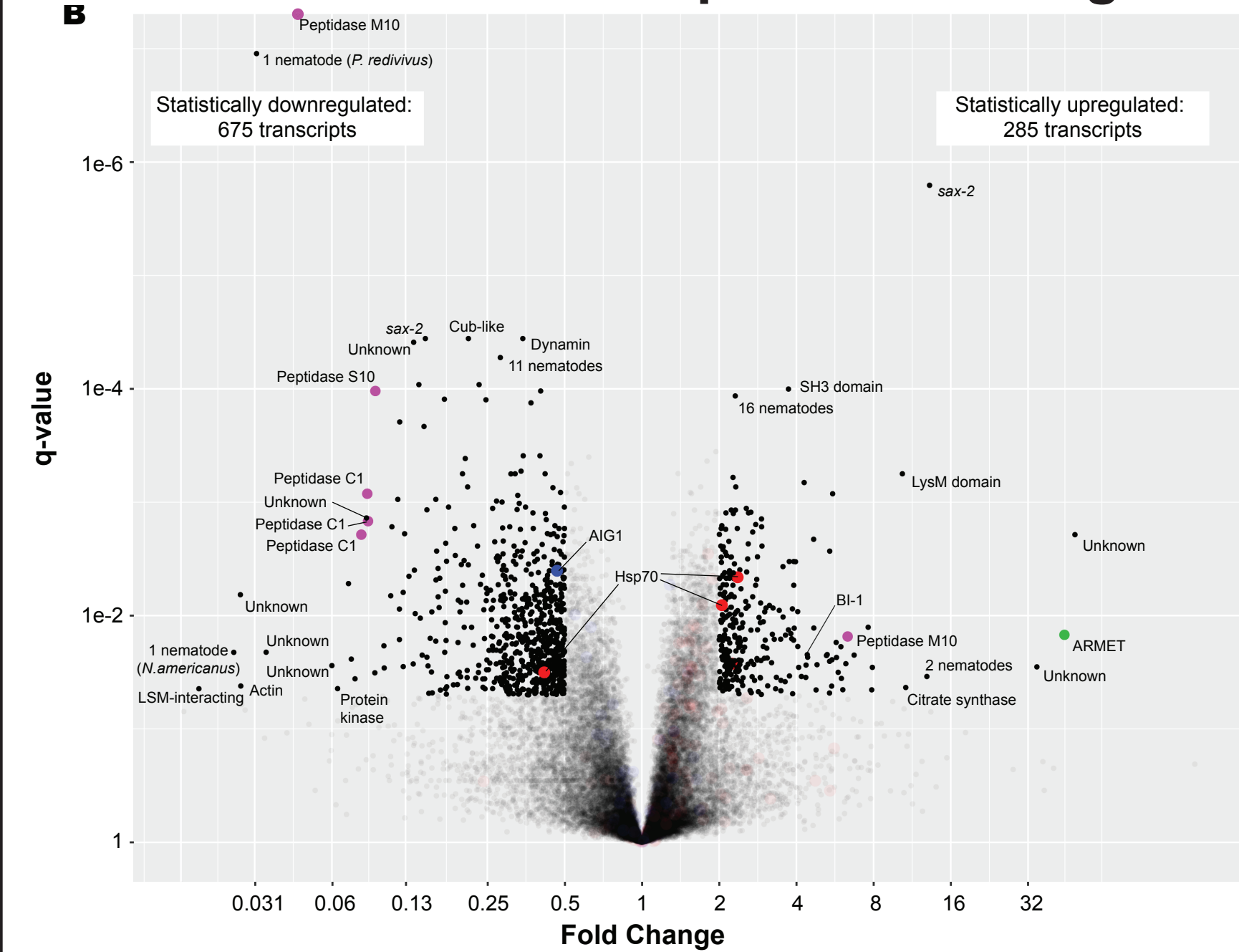
A Signature of Stress Adaptation: Hsp70 + AIG1 expansion



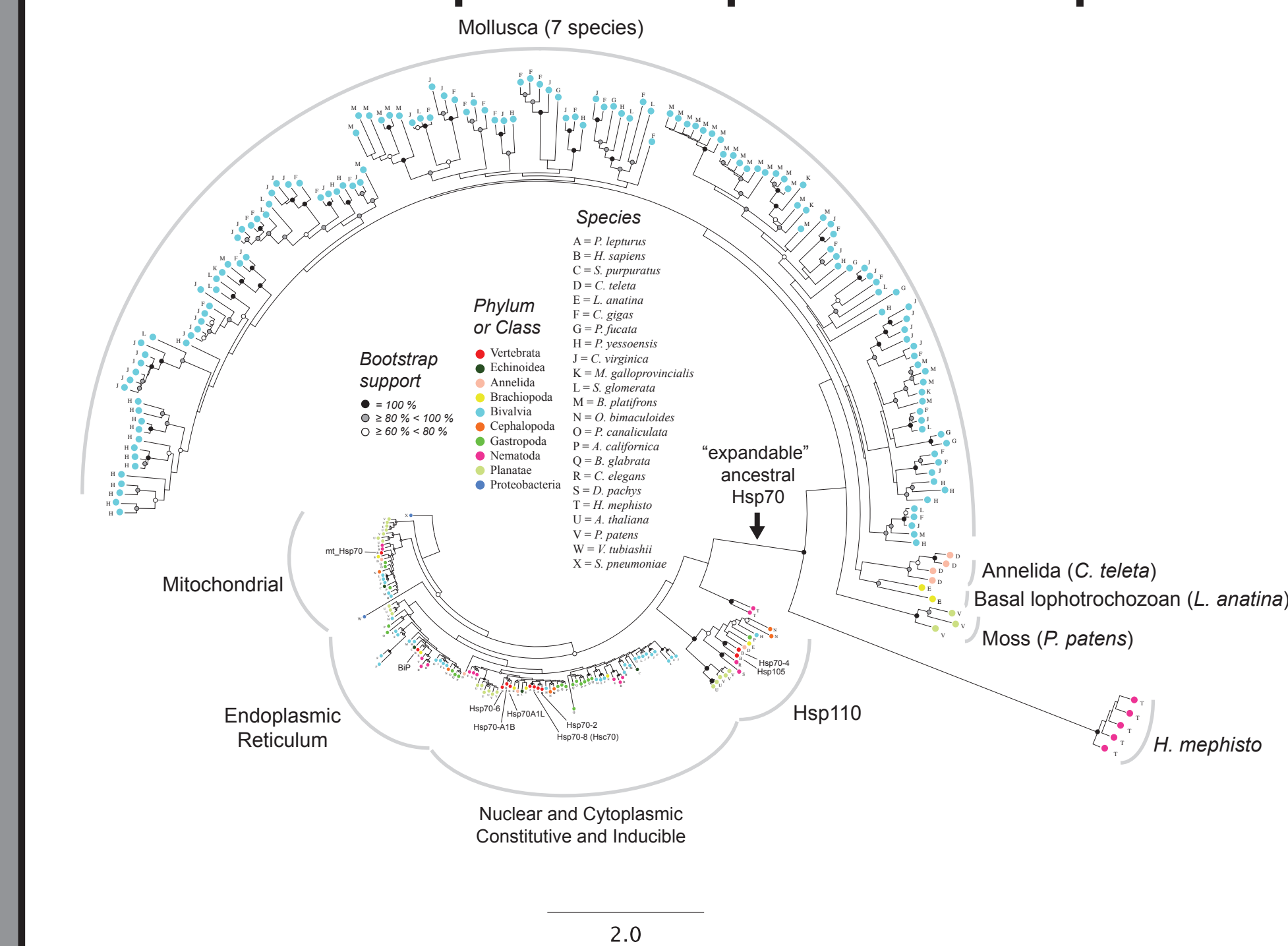
Test of feeding RNAi



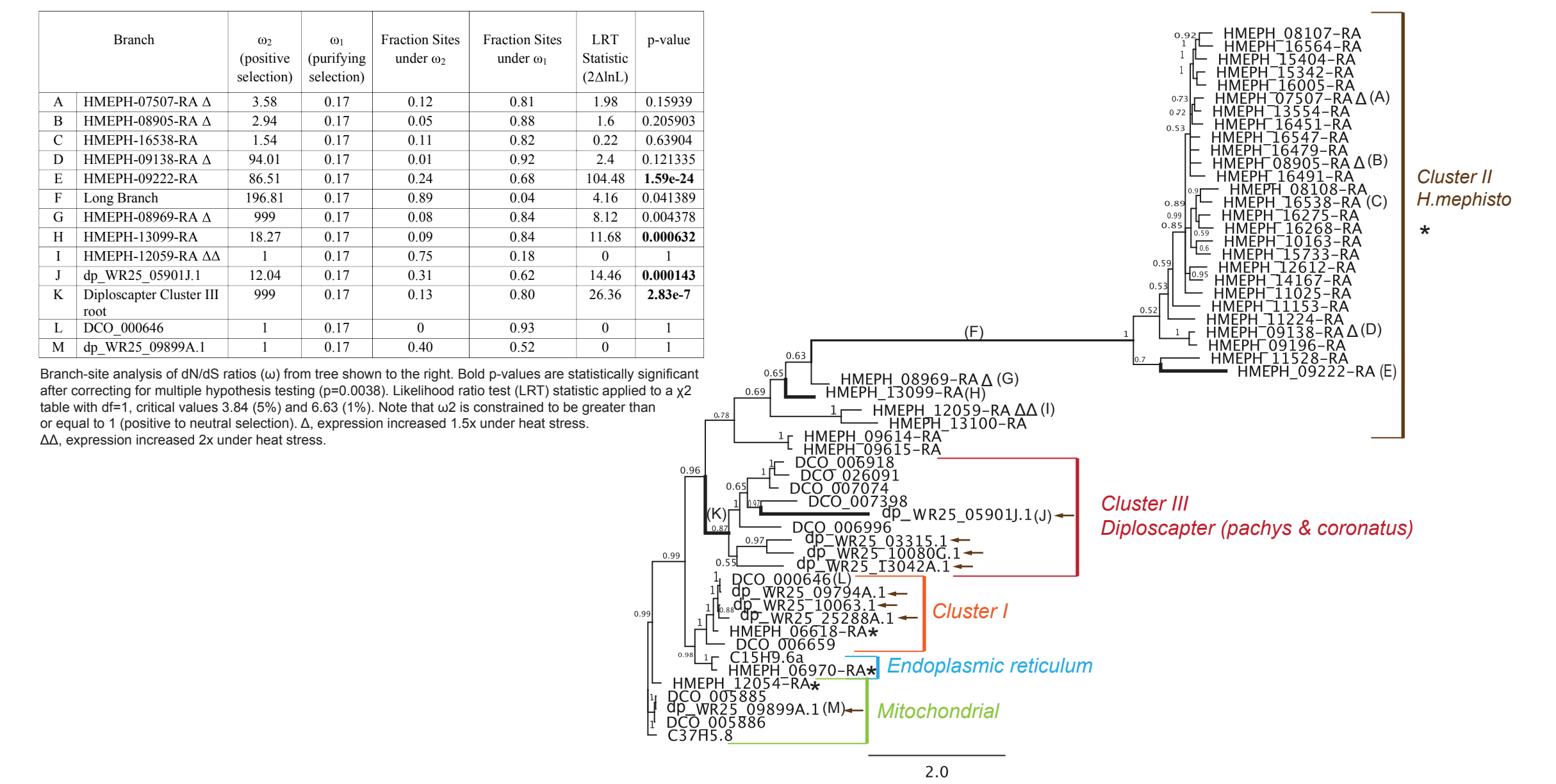
Genome-wide expression changes



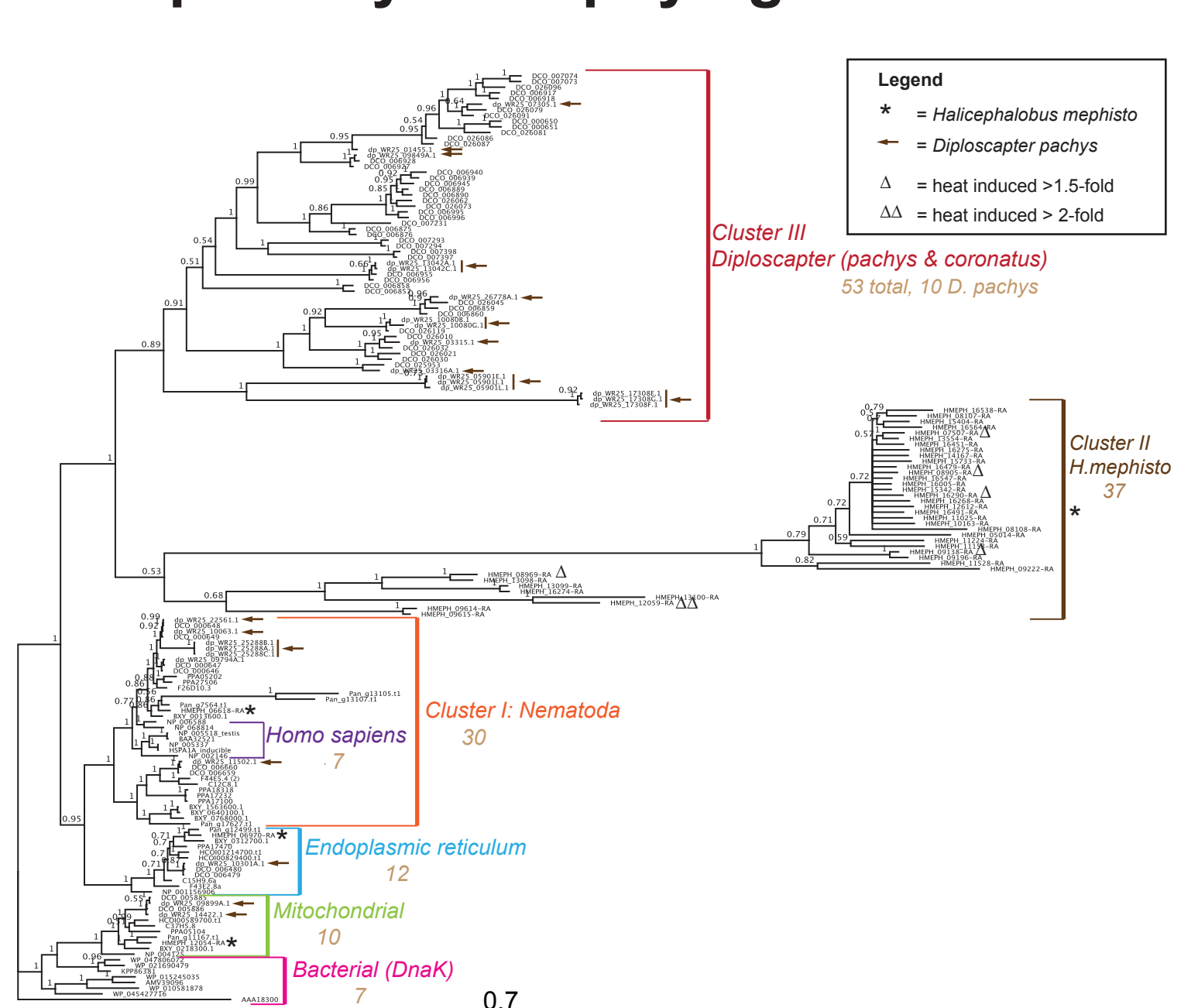
Stress-responsive expansion of Hsp70



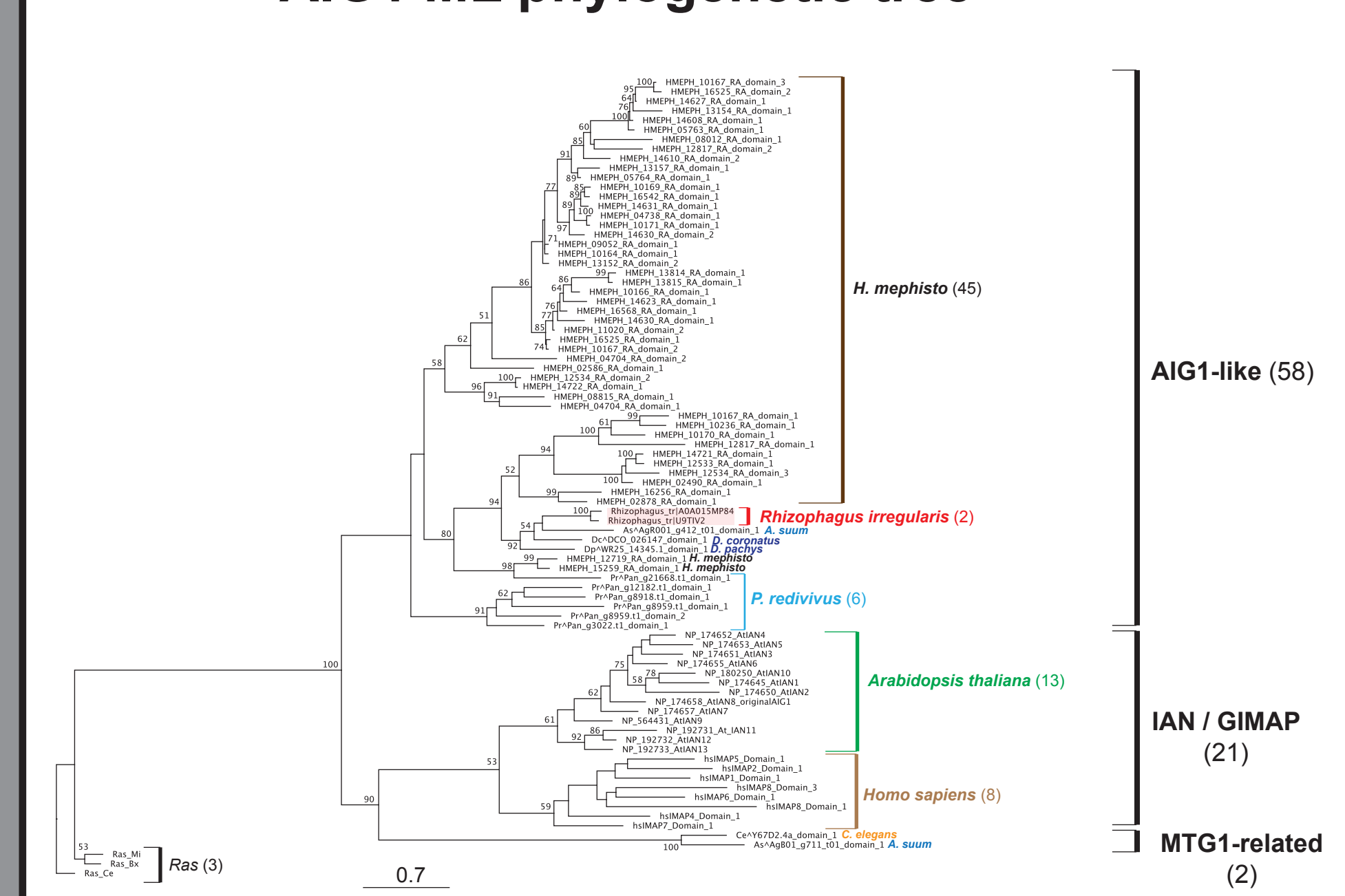
Positive Selection of Hsp70 Genes



Hsp70 Bayesian phylogenetic tree

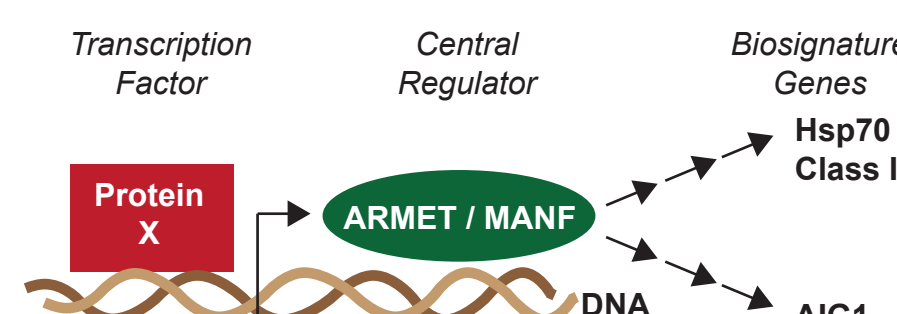


AIG1 ML phylogenetic tree



Future directions

- Test effect of knockdown of Hsp70, AIG1, and ARMET on survival at 37°C
- Test microinjection and transgenic array formation
- Add *H. mephisto* genes to *C. elegans*
- Test different stresses: hypoxia, methane
- A new model system for stress adaptation and Hsp70 research



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