Outside Resources

What can we learn from worms? How the nematode* C. elegans *maintains balance in a changing environment

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Resource Justification:

Synopsis:

This 5-lesson curriculum module helps students build an understanding of how genes and environment interact to determine traits, by learning how the nematode *C. elegans* maintains homeostasis in an unfavorable environment caused by high osmotic stress. Intended for high school biology classes, students learn the importance of *C. elegans* as a model organism and perform an experiment in which they compare the activity of two nematode strains at high and low salt concentrations over a three-day period. Using their own observations, data from the scientific literature, a dialysis tubing model, and knowledge of how a mutation involving a single nucleotide can drive behavior change, students develop their own explanations based on evidence, and experience first-hand how an environmental factor affects the expression of a trait. Each lesson integrates the three dimensions of the Next Generation Science Standards (NGSS).

Introduction:

The soil nematode Caenorhabditis elegans is a useful model organism for studying gene-environment interactions because it is a multicellular eukaryote that can be easily grown in the classroom on agar plates. Like all living organisms, C. elegans needs to be able to respond to environmental changes, such as high osmotic stress. Scientists utilize osmotic regulation mutants to understand the mechanisms that enable nematodes to survive in certain harsh environments. *What can we learn from worms?* brings a manageable, much-studied organism into the high school classroom and synthesizes a number of important biological concepts for students. With many states in the process of adopting the NGSS, this resource provides a ready-made experience that highlights important NGSS Disciplinary Core Ideas such as: how feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range (HSLS1.A), how environmental factors affect expression of traits (HSLS3.B) and how trait variation leads to differences in performance among individuals (HSLS4.B). Student also participate in science and engineering practices and are exposed to crosscutting concepts throughout the lab.

Approach/Method:

This curriculum module consists of five lessons plus an assessment. In this lab experience, students observe behavioral changes of *C. elegans* worms when wild type and mutant worms are moved from a low salt environment to a high salt environment. Students will see some worms thrive and some worms be challenged in response to the environmental change, and will collect and analyze behavioral data such as worm movement, signs of eating, evidence of reproduction and general vigor.

What happens to the worms? At the 15-minute observation time, students should see the worms continue to move and behave normally when transferred to low-salt plates. When transferred to high salt plates, however, most wild type worms will stop moving, change shape, and appear to be dead. The

mutant worms will continue to move on the high salt plates and may have migrated to the food source and begun to eat after 15 minutes. At this point, students can see the behavioral effects of the mutation in an obvious way. But that is not the end of the story! After 24 - 48 hours on the high salt plates, the wild type worms have rebounded and are now moving, eating, and reproducing, thanks to increased glycerol production in response to the environmental challenge.

The module is designed around the 5E Learning Cycle Model developed by the Biological Sciences Curriculum Study. The 5E model provides a scaffold for guiding and assessing student inquiry and learning through the following stages: Engage; Explore; Explain; Elaborate; and Evaluate. Instructional components include *Teacher Pages* which contain background and procedural information for the teacher, and *Student Resource* pages which are for students to look at but not write on, so they may be re-used. *Student Sheets* are a lab sheets or worksheets that require student answers and should be photocopied for each student.

Instructions for pouring, seeding and maintaining worm plates in included in the Appendix. Teachers may also order a companion worm kit from Carolina Biological Supply.

Justification:

Students often learn genetic concepts through the study of discrete (yes/no) traits that illustrate Mendelian inheritance, such as Huntington's disease, cystic fibrosis, or Tay-Sachs disease. While this can be powerful and instructive, genetics education in the high school classroom often ends before delving into the complexities of gene-environment interactions that play a large role in the development of heart disease, cancer, type 2 diabetes and other common conditions. This hands-on lab experience provides a context for learning how an environmental factor can affect the expression of a trait. By using a model organism common in research labs to observe gene-environment interactions in real time, students learn foundational concepts and competencies in genetics that that have been underscored by both the Genetics Society of America and the NGSS Lead States.