Application of Environmental DNA in a middle school classroom

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Abstract

The use of DNA in forensics has been glamorized by television and movies, and students of all levels are excited and engaged when asked to solve crimes using forensic evidence. Recently scientists have been able to use environmental DNA (eDNA) to monitor for the genetic presence of aquatic organisms (Henley et al., 2006). eDNA can be used to indicate the presence of local species, invasive, endangered, and/or species that are not accessible through visual surveys. Students in the middle school setting will use eDNA as a medium to increase STEM (Science, Technology, Engineering and Mathematics) education in a Life Science classroom. The purpose of the activity is to analyze real scientific data and illustrate how advances in technology increase our understanding of an ecosystem. The students will analyze pictures of a gel to identify invasive, endangered and local species in a waterway. It is hopeful that the activity will engage young learners, so they may be more apt to participate in STEM related subjects in future years (Hayden et al., 2011). Application and assessment of the activity will be conducted at Conestoga Valley Middle School and Stroud Water Research Center.

Conestoga Valley Middle School Profile

Conestoga Valley School District encompasses 56 square miles in Lancaster County, Pennsylvania. The middle school is comprised of approximately 680 seventh and eighth grade students. The student body is made up of 33% economically disadvantaged, 3.4 % English Language Learners, and 12.4% students with learning disabilities.

MH teaches 7th grade Life Science at Conestoga Valley Middle School. The classroom consists of an average of 28 heterogeneously grouped students. Each class period is approximately 43 minutes long and the students attend the class five days per week. The Life Science curriculum in seventh grade consists of basic biochemistry, genetics, cells, ecology, and the 6 kingdoms.

eDNA information

Environmental DNA surveillance is the process we use to identify DNA particles in aquatic ecosystems. eDNA does not require visual surveys of the organism, which potentially makes it more accurate and time efficient than traditional surveys. The process involves taking a 1L water sample, and through filtration, extraction, and PCR using DNA primers specific to the species of interest. Amplification of a product indicates the presence of the DNA from the species of interest..

Next Generation Science Standards

MS-LS2-1 Analyze and interpret data to provide evidence for the effect of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Pennsylvania State Standards

3.1.7B5 Compare and Contrast observable patterns in the physical characteristics across families, strains, and species.

3.1.7B6 Use appropriate tools and technologies to gather, analyze, and interpret data and understand that it enhances accuracy and allows scientists to analyze and quantify results of investigations.

4.1.7.D: Explain how biological diversity relates to the viability of ecosystems.

Learning Objectives

- Students will discuss the effect resource availability has on freshwater mussel population distributions
- Students will use appropriate scientific tools to analyze and interpret data.
- Students will collaborate and use evidence from their investigation to support their conclusion
- Students will present their final conclusions to the class

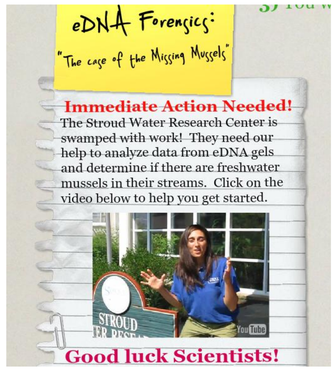
Background Information for Students

The following activity will take place after students have had the opportunity to:

- Identify the 4 basic classes of macromolecules needed for life
- Understand that streams are comprised of more than H_2O molecules
- Demonstrate their knowledge of DNA by designing a model
- Apply the basic principles of heredity (Mendelian Genetics)
- Describe why mutations may affect proteins by kinesthetically acting out the building of a protein

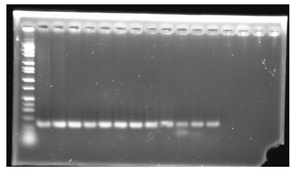
Activity details

Students will be in groups of 4 and their task will be to use eDNA surveillance to determine if Stroud Water Research Center has freshwater mussels in their local streams. Students will log on to a classroom wiki to access an introductory video which illustrates a plea for help to analyze all of the data that Stroud has collected.



After watching the introductory video, students will be given one of 4 Scientist jobs and will watch a video to learn what he/she does. The group of students will then collaborate to understand the terms endangered species and eDNA, understand the importance of mussels in an ecosystem and how changes to the ecosystem affect the biodiversity, and be able to analyze data from a gel.

Students will load their own practice gel, and then analyze gels created with mussel eDNA (at Stroud), and present their findings to the class.



All activities can be found at http://hess.wiki.conestogavalley.org/eDNA+forensics

Curriculum inspiration

During the summer of 2014, we conducted investigations to determine how far eDNA particles are transported downstream from the source of DNA.

Searching for freshwater mussels in a local pond.

We were investigating the DNA from several species of freshwater mussels including *Margaritifera margaritifera, Elliptio complanata,* and *Pyganodon cataracta.*

Pyganodon cataracta

1L water sample taken at stream.

Literature Cited

Hayden, K., Ouyang, Y., Scinski, L., Olszewski, B., & Bielefeldt, T. (2011). Increasing student interest and attitudes in STEM: Professional development and activities to engage and inspire learners. *Contemporary Issues in Technology and Teacher Education*, *11*(1), 47-69.

Henley, W. F., Grobler, P. J., & Neves, R. J. (2006). NON-INVASIVE METHOD TO OBTAIN DNA FROM FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE).*Journal of Shellfish Research*, *25*(3), 975–977. doi:10.2983/0730-8000(2006)25[975:NMTODF]2.0.CO;2

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