Environmental Science Institute
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Get Chilly: Life in Frozen Seas

Lesson plan for grades 9-12
Length of lesson: 45 minutes over 3-5 days
Authored by: Louisa Torrance, Environmental Science Institute, 06/26/12

SOURCES AND RESOURCES:

- Introduction to Europa and its frozen oceans
  http://news.discovery.com/space/europa-ocean-ice-life-111116.html
- Psychrophile adaptations
  http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1456908/

POTENTIAL CONCEPTS TEKS ADDRESSED THROUGH THIS LESSON:
§112.34. Biology: 4(b), 5(a), 9(a), 9(c)

PERFORMANCE OBJECTIVES (in order of increasing difficulty to permit tailoring to various age groups):
Students will be able to:

- Connect adaptations of cells and organisms to how life exists in extreme climates
- Present researched projects

MATERIALS (per group)):

- Computer and internet access
- Student Project packet

CONCEPTS:
Psychrophiles are organisms that can thrive in freezing conditions. They have special adaptations, including specialized enzymes, genomics, and membrane fluidity. In this lesson, students will connect ideas about important functions within cells and their environment. Psychrophiles are important to study on Earth because similar cold environments have been documented to exist in space, which leads some scientists to hypothesize that these extraterrestrial habitats could support comparable life forms.

BACKGROUND:
Membrane fluidity is essential for maintaining proper membrane functionality in freezing temperatures. Cells can facilitate membrane fluidity by having higher unsaturated, polyunsaturated, and methyl-branched fatty acids and a shorter fatty acid chain within cell walls. There is also evidence of increased large lipid head groups and proteins in these structures. For transcription and translation, psychrophiles have evolved processes that have activity optimums at low temperatures, such as protein folding and enzyme activity. They often have proteins that act like “antifreeze” and cold-adapted enzymes.

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PREPARATION:
Review adaptations of psychrophiles and the terrestrial locations they are found in. Have packets made and student pairs chosen for assignment.

ENGAGE:
Teacher asks: [Target Student Answers]
What do we know about cell processes? How do cells signal each other and organelles within the cell? [Proteins are vital, proteins need to be in proper configuration to function, have chaperones to help misfolded proteins]
How do cells adapt to different situations, such as high salinity? High temperature? Low temperature?
In space, what kinds of environments do we find? [high radiation, low temperature, very high temperature, varying gravity, etc.]

1. Show a photo of Europa's surface and ask what kind of environment is apparent. Give visual of Europa in relation to the rest of the solar system. Explain how Europa potentially has an ocean underneath its icy shell. Discovery Channel video: http://www.youtube.com/watch?v=CP_1MgyPtB8

2. *Teacher asks:* What do we define as "freezing"? [Freezing point of water, 0^0 C]
Is this anthropomorphically biased (that is, conceived solely from the perspective of human life) or does it apply to all conceivable life forms? [Unbiased according to the hypothesis that liquid water is an essential ingredient/nutrient for any life form to exist]

EXPLORE:
1. Hand out Get Chilly: Life in the Frozen Seas packet to each student and explain expectations and components.
2. Assign pairs and give representative organism to research:
    a. *Methanococcoides burtonii,*
    b. *Aeromonas hydrophila,*
    c. *Arthrobacter globiformis,*
    d. *Moritella profunda,*
    e. *Marinomonas primoryensis,*
    f. *Pseudomonas putida,*
    g. *Pseudoalteromonas haloplanktis,*
    h. *Desulfotalea psychrophila,*
    i. *Colwellia psychrerythraea,*
    j. *Methanogenium frigidum*

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3. Allow work time.

EXPLAIN :

Discuss the following factors if students encounter a roadblock during their projects:

- The relationship between freezing temperatures
- How increased viscosity changes cell membranes
- How proteins are specialized for particular functions and also for particular environments
- What conditions increase or decrease enzyme activity
- Which kingdoms or phylums are able to live in extreme environments and their physiology

A summative Power Point can be made with explanations of adaptations after presentations.

ELABORATE:

- Ask about the probability of life existing on Europa based on psychrophiles. Discuss further:
- What other needs must be met for life to exist?
- If life does exist on Europa, does it only come in psychrophilic form?
- If psychrophiles exist in freezing environments, what other environments might hold life?
- What would happen if life could only exist in a particular temperature range?

EVALUATE:

Grade projects according to Student Packet (see Materials).

Get Chilly: Life in the Frozen Seas

Project Purpose: Students will be able to explain and illustrate how cells adapt and organisms thrive in freezing conditions, both on Earth and potentially in space.

	Illustration (as pairs)	**Class Presentation (as pairs)**	**Report (as individuals)**
Project Components:	• Organism(s) in environment (overall phenotype) • Close up of single cell including parts (organelles, membranes) • All adaptations highlighted and explained in writing	• Describe all of illustrations and why your organism(s) will survive	Reports should include peer reviewed citations and describe the why and how of adaptions in psychrophiles.
Helpful Reminders:	1. Each group will be responsible for at least two adaptations per organism, or one adaptation in two organisms 2. The class will vote on your organism's survival as part of your grade!	1. Your presentation may include videos, PowerPoints, movies, posters, computer links and guest speakers. 2. All oral region presentations should be a minimum of 10 minutes long and no more than 15 minutes.	1. Each individual will write a 5-10 page report that includes a thesis, introduction, and thorough discussion that includes at least 5 credible citations.

Procedure: Groups will be assigned to use the Internet to research specific areas of the universe and find model organisms that may survive there, based on organisms that survive in similar (or analogous conditions) on Earth. Students will compare cell structure and adaptive processes that differ and why these allow organisms to survive in freezing environments. This information will then be illustrated and presented to peers.

Illustration Rubric

Students Names: **Total Points earned_____/100**

Criteria	Incomplete	Poor	Below Average	Average	Good	Excellent

Presentation Rubric

Students Names: **Total Points earned_____/100**

Criteria	Incomplete	Poor	Below Average	Average	Good	Excellent

Report Rubric

Students Names: **Total Points earned_____/100**

Criteria	Incomplete	Poor	Below Average	Average	Good	Excellent

Peer Evaluation

Name of Evaluator: _____

Think hard about what you and your partner contributed to the project and decide how much effort they put into the project. Complete each section and write a total for each person. Please keep this form private and turn it in to your teacher when it has been completed.

Names	Cooperation	Preparation for Class	Work in Class	Total Points
	1 2 3 4 5	2 4 6 8 10	2 4 6 8 10	
	1 2 3 4 5	2 4 6 8 10	2 4 6 8 10	