Use Your Knowledge Activity - Extraterrestrial Life - Chapter 18: Prokaryotic diversity

Task:

You are part of a team planning a mission to search for extraterrestrial life on other planets. Use your knowledge of the origin of life on Earth to plan where to collect samples, predict characteristics, and classify the new life forms.

Is Earth the only planet on which life has evolved? A recent astronomical study discovered 603 new planets and 10 of these planets are similar to Earth in size and the amount of sunlight that they receive (Petigura et al. 2013). The closest of these Earth-like planets may only be 12 light-years away. Imagine that we are able to send probes to areas where life may have evolved to study the areas and collect samples. What might we find? How might this change how we think about and classify life forms? ***Team up*** with another student to answer the questions below.

1) Scientists currently think that water is essential for life to evolve. How could you use this information to narrow your search for extraterrestrial life?

2) You discover a new planet that is covered in extremely hot, oxygen-poor, highly toxic water. Despite these inhospitable conditions, you find evidence of life. Based on your knowledge of the conditions that prokaryotic organisms tolerate, what Earth life form might the new life most closely resemble?

3) A mission to get samples of these new life forms finds evidence that these new organisms are single-celled, lack structures that resemble organelles, and have cell walls that are not made of peptidoglycan. Based on these characteristics, how would you classify your new life forms?

4) Further analyses on your new life forms show that they contain genetic material similar to DNA. However, when you analyze the genetic sequence, they are very different from anything we find on Earth.
   a) Draw a sketch of the evolutionary tree showing the three domains of life (→).
   b) Based on your new genetic analysis results, how would you incorporate extraterrestrial life forms into an evolutionary tree? Explain.

Instructor notes: This activity addresses Driving Questions # 1 (what are the prokaryotic domains of life), #2 (what are the features of bacteria and archaea), and #3 (what are challenges faced by prokaryotes living in extreme conditions similar to Lost City).

Students should work in pairs to make inferences and predictions about extraterrestrial life.

Total time budget = 8–11 min

- 1–2 min for activity introduction and to allow students to pair up
- 5–7 min for students to work together to answer the questions
- 2 min optional follow-up class discussion of activity

RUBRIC: 5 points total (1 point each for Questions 1–3; 2 points for Question 4)

References:

Petigura, E. A., A. W. Howard, and G. W. Marcy. 2013. Prevalence of Earth-size planets orbiting Sun-like stars. Proceedings of the National Academy of Sciences, published online November 2013 at http://www.pnas.org/content/early/2013/10/31/1319909110.full.pdf+html.

KEY:

1) Scientists currently think that water is essential for life to evolve. How could you use this information to narrow your search for extraterrestrial life?

If life cannot exist without water, then it only makes sense to search for life on planets or moons where there is evidence of water.

2) You discover a new planet that is covered in extremely hot, oxygen-poor, highly toxic water. Despite these inhospitable conditions, you find evidence of life. Based on your knowledge of the conditions that prokaryotic organisms tolerate, what Earth life form might the new life most closely resemble?

Probably the extremophile archaea because they can tolerate these conditions on Earth

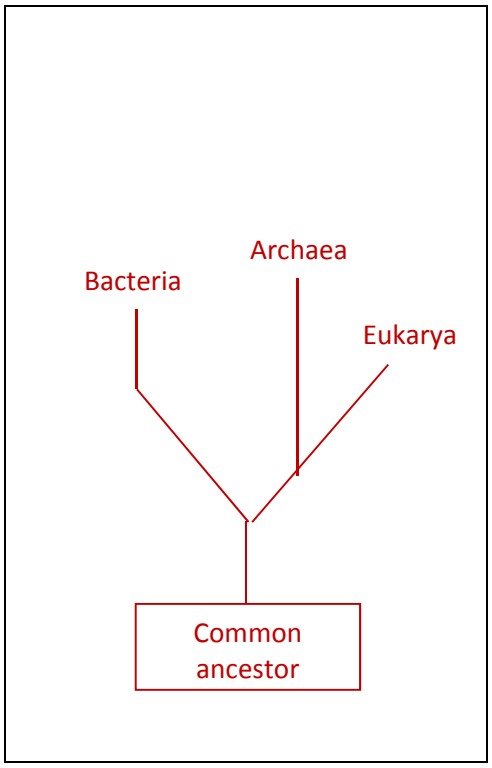
3) A mission to get samples of these new life forms find evidence that these new organisms are single-celled, lack structures that resemble organelles, and have cell walls that are not made of peptidoglycan. Based on these characteristics, how would you classify your new life forms?

Bacteria-like organisms (archaea have cell walls made of molecules other than peptidoglycan)

4) Further analyses on your new life forms show that they contain genetic material similar to DNA. However, when you analyze the genetic sequence, they are very different from anything we find on Earth.

   a) Draw a sketch of the evolutionary tree showing the three domains of life (→).

   b) Based on your new genetic analysis results, how would you incorporate extraterrestrial life forms into an evolutionary tree? Explain.



There are several ways this question could be answered. The key point is that life on separate very distant planets probably evolved independently and do not share a common ancestor.

1) Students could draw another separate tree with a separate common ancestor (depicting two separate evolutionary histories that do not share a common ancestor).

2) Students could re-envision the system we use to categorize life forms, so that all life forms can be categorized with a single tree, but the tree would not rely on being rooted at a common ancestor.