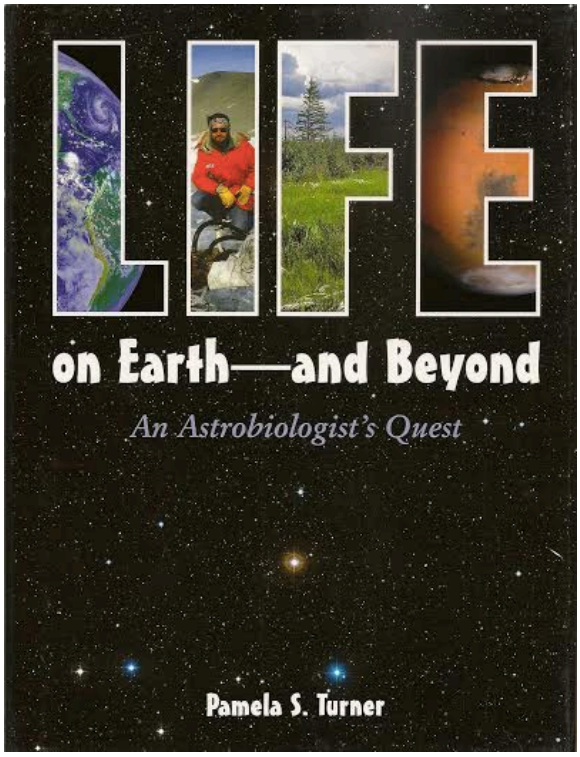
A Teacher's Guide for

LIFE on Earth – and Beyond:

An Astrobiologist's Quest



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About the Book:

Astrobiologists have searched Earth's most extreme environments in their quest to understand what factors are necessary to sustain life. Dr. Chris McKay's scientific journey has taken him from the freezing cold of Antarctica's Dry Valleys to the rocky wasteland of the Atacama Desert in Chile to the permafrost-covered tundra of Siberia. By studying environments on Earth that resemble those on Mars and elsewhere in the solar system, Dr. McKay hopes that his experiments will help answer the ultimate question: is there life beyond Earth?

About the Author:

Pamela Turner has written for kids and young adults, mostly about science and nature. She also has a strong interest in multicultural literature because she's lived in and worked in Kenya, South Africa, Japan, the Philippines, and the Marshall Islands.

Honors and Awards:

School Library Journal starred review, Booklist starred review, Bank Street College of Education Best Books List, AAAS/Subaru Science Writing Prize Prize finalist, Booklist Top Ten Sci-Tech Books for Youth, NSTA Outstanding Science Trade Book, Booklist Editors' Choice, CCBC Choice.

Booklist Starred Review:

"Astrobiologists look outward from the Earth seeking evidence of life elsewhere in the Universe. But, as this fascinating book shows, they also travel to places on Earth where extreme conditions may be similar to those on distant worlds... Turner's absorbing account gives enough detail to create vivid impressions of McKay's explorations and enough background information to show what his amazing findings imply. Occasional moments of amusement or amazement let readers share her evident enjoyment in McKay's quest...This beautifully designed volume offers an eye-opening look at an astrobiologist in action."

Pre-Reading Activities:

1. Take a poll with your class. Who thinks that there is life on other planets? What do your students think this life might look like? Create a bar graph to see which opinion has the most supporters. (W.7.1.A)
2. Have your students free write their own definitions of the word *life*. Ask them to consider what qualities something must have in order to be considered living.
3. Have a classroom debate. Divide students into two groups, one who must argue *for* sending an expedition of astronauts to Mars, while the other must argue *against* sending an expedition of astronauts to Mars. Revisit this debate post-read. (SL.7.1; W.7.1.A)

Reading Comprehension Questions:

Chapter 1: Between a Rock and a Cold Place: The Dry Valleys, Antarctica

1. What are seasons like in Antarctica's Dry Valleys? Why is this sort of climate fascinating to astrobiologist Chris McKay?
2. Can life exist in Antarctica's Dry Valleys? If so, where and what kind of life?
3. What factors must something have in order to be considered living?
4. How do viruses complicate a simple definition of life?
5. What challenges did Dr. McKay face when trying to find microbes in the Dry Valleys?
6. What type of life do scientists think would most likely be found on other planets? Why?

Chapter 2: Evolution of a Scientist: The Mars Underground

1. In the late 1800s, Percival Lowell claimed that Mars was covered with canals built by intelligent Martians. In the 1960s and 70s, space vehicles like the *Mariner 9* and *Viking 1* and *2* landed on Mars. What did they find? Did they prove Percival's claims?
2. When Chris wanted to host a conference about sending astronauts to Mars, his professor told him *no*. What did he do next?
3. List four surprising locations scientists have found microbes on Earth.
4. Where do scientists think life might exist on Mars? Why?
5. What is an extrasolar planet? Why might there be life on extrasolar planets?
6. After taking a job at NASA as a research scientist, Chris knew that water seemed to be the most important ingredient for life. Based on this, what did he want to study next?

Chapter 3: Is Life Liquid: Atacama Desert, Chile

1. Who are the *Spirit* and *Opportunity?* What were they sent to find?
2. What is the driest desert in the world? Why was Chris interested in doing research in such a dry place?
3. Chris used an air-sampling balloon while he was in the desert. What was he testing with this balloon? What did he learn from these tests?
4. What did the *Spirit* and *Opportunity* find during their mission to Mars? Was this what scientists had expected?
5. What did Chris learn about life and water during his research in Atacama?
6. In *Life on Earth and Beyond*, the author Pamela Turner writes, "In the party of life, water is the life of the party!" What does she mean by this statement?

Chapter 4: Rip Van Microbe: Siberia, North Russia

1. In what ways are Mars and Siberia different? In what ways are they similar?
2. Chris was studying permafrost in Siberia. What is permafrost? What was he looking for in the permafrost samples he drilled from the ground?
3. Why is it difficult for scientists to tell different types of microbes apart? What trick do scientists use to tell the difference between microbes?
4. What would it suggest if scientists found that Martian life and Earth life shared the same genetic code?
5. Does Chris hope that Martian life *is* Earth life or that it *isn't* Earth life? Why?
6. How do microbes help make Earth habitable for other life forms?

Chapter 5: Mother of All Deserts: The Sahara, North Africa

1. How is it possible that rock art could exist in the vast Saharan desert? When was this art created? What does it depict?
2. What did Chris want to learn about microbes in the Sahara?
3. What happened to Mars's atmosphere? Why hasn't this happened to Earth's atmosphere?
4. What happened to life on Earth when oxygen built up in its atmosphere? What happened to the microbes that used sunlight and water to receive energy and produced oxygen as waste?
5. Why do cyanobacteria live on the underside of rocks?
6. What is Chris hoping to learn about desert cyanobacteria?

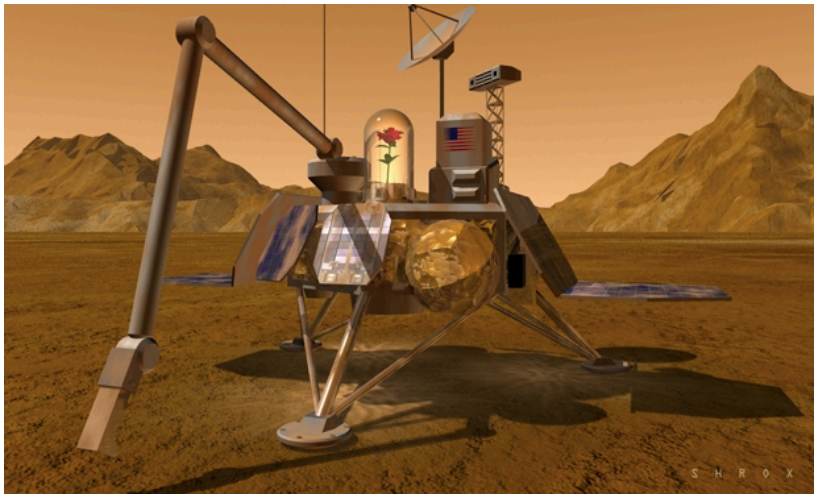
Chapter 6: Life Under Ice: Lake Hoare, Antarctica

1. A layer of ice covers Lake Hoare that is sixteen feet thick. How did Chris and other scientists reach the lake's water? How long did it take the scientists to reach the water?
2. What sort of gear did Chris put on before diving into the freezing-cold waters of Lake Hoare? How was this gear different than a typical wet suit?
3. What did Chris find when he dove to the bottom of Lake Hoare?
4. Chris installed sensors at the bottom of Lake Hoare. What did these sensors measure?
5. Why was Chris interested in studying Lake Hoare? How did it help him learn about Martian life?
6. What is a "cryobot"? What is a "hydrobot"? How might these devices help scientists learn about life on Europa?

Discussion Questions

1. Ask students to discuss how their opinions have changed about the possibility of Martian life since reading *Life on Earth*. Have their views changed? If so, how? (RST.6-8.8; W.7.1.B)
2. Form your class into small groups and have each group discuss the technology that Chris and other astrobiologists use to successfully collect samples for their research. What advancements in technology do your students think might make Chris's work easier? (SL.7.1)
3. Now that your students have read *Life on Earth*, ask them to revisit their previous definitions of *life*. Open up the conversation for them to share their previous definitions and to explain how their understanding has changed. (SL.7.4 ; RST.6-8.2; RST.6-8.8)

Writing and Research



1. In her conclusion, Turner writes about upcoming NASA projects, including the *Phoenix Lander* and *Mars Science Laboratory* (the name of the *Mars Science Laboratory's* rover is *Curiosity)*. Have students research these projects, or other projects by Chris or NASA, and have them write five paragraph essays on their findings. Students can work individually or in groups. (W.7.7; W.7.8)
2. Ask students to pick a topic of interest from *A Life on Earth* as a jumping off point for their own interests (maybe they will choose art in the Sahara, the Dry Valleys in Antarctica, or the possibility of life on Europa. Let them be creative, conduct research, and then craft presentations for their peers. As part of their projects, encourage that they evaluate the best resources for their research and to use proper citations. (W.7.7; W.7.8)
3. Have your students write persuasive essays about Martian life. They can choose to argue that they believe there *is* Martian life, or that there *is not* Martian life. Make sure your students conduct thorough research to support their claims and properly cite their sources. When their essays are complete, have them publish their work to your class website and link to sources for further reading. (6-8.1; RI.7.4; W.7.6)

Interdisciplinary Activities

1. Connect with your local college's science department and see if you and your class take a field trip to campus. Maybe a physics professor can give an exciting lecture to students about their work, or maybe your students could tour a lab and talk to graduate students. If a field trip isn't an option, they could come to you: ask if anyone in the department might be interested traveling to your school to present a fun hands-on activity. (R1.6.7)
2. Take your class outside and have them look under rocks. What do they find? Have your students keep note of *what* they find and *how much* of each item they find (living or otherwise). When you get back to your class, have your students take a look at their data and create bar graphs to see what were the most, and least, common findings. (RST.6-8.7)
3. Go on a hike with your class. Is there desert nearby? Wetlands? A path behind your school? A walk around the block? Take your students outside and encourage them to observe the wildlife they see, both *big* and *small*. Are they surprised by how much they find when they really take the time to look?

Resources for Further Learning

Further Reading

Breidahl, Harry. *Extraterrestrial Life: Life Beyond Earth? (*Life in Strange Places). Broomall, PA: Chelsea House, 2001.

Grady, Monica. *Astrobiology*. Washington, DC: Smithsonian Institution Press, 2001.

Skurzynski, Gloria. *Are We Alone? Scientists Search for Life in Space.* Washington DC: National Geographic Society, 2004.

Multimedia

Jenkins, Mark and Dale Anderson. *Life on Ice: Antarctica and Mars.* Carl Sagan Center, 2006. QuickTime movie, **http:// daleanderson.seti.org/**

Butler, George, *Roving Mars*. IMAX movie. Burbank, CA: Walt Disney Pictures, 2006.

Internet Resources

Astrobiology Magazine
http://www.astrobio.net

The Astrobiology Web
http://www.astrobiology.com/

Google Mars
www.google.com/mars

NASA's Mars Exploration Program: Fun Zone
http://mars.jpl.nasa.gov/funzone_flash.html
Play games and download paper models on this website about NASA's Mars missions.

Mars Exploration Rover Mission
http://marsrovers.jpl.nasa.gov/home/index.html
Watch multimedia shows on the Mars rovers and view the images beamed back to Earth from Mars.

NASA Astrobiology Institute
http://www.marstoday.com/
Look here for news and reference information on the Red Planet.

Mars Science Laboratory:
Curiosity: **http://www.nasa.gov/mission_pages/msl/#.U-fbRPIdWSp**
Phoenix: **http://phoenix.lpl.arizona.edu/index.php**

Of Special Interest to Educators

Mars Student Imaging Project
http://msip.asu.edu
Learn about a program that allows students to do real imaging work with scientists from NASA and Arizona State University.

NASA Astrobiology Institute
http://nai.arc.nasa.gov/
Dive into the "For Teachers" section for materials and classroom activities on the search for life beyond Earth.

NASA's Mars Exploration Program
http://mars.jpl.nasa.gov/classroom
Find workshops, resources, and educational program and astrobiology and space science.

Roving Mars Movie
http://disney.go.com/disneypictures/rovingmars/
Click on "Educator's Guide" for a downloadable educator guide to the movie.

Common Core State Standards

CCSS.ELA-LITERACY.W.7.1.A Introduce claim(s), acknowledge alternate or opposing claims, and organize the reasons and evidence logically.

CCSS.ELA-LITERACY.W.7.1.B Support claim(s) with logical reasoning and relevant evidence, using accurate, credible sources and demonstrating an understanding of the topic or text.

CCSS.ELA-LITERACY.W.7.6 Use technology, including the Internet, to produce and publish writing and link to and cite sources as well as to interact and collaborate with others, including linking to and citing sources.

CCSS.ELA-LITERACY.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCSS.ELA-LITERACY.RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-LITERACY.SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

CCSS.ELA-Literacy.W.7.7 Conduct short research projects to answer a question, drawing on several sources and generating additional related, focused questions for further research and investigation.

CCSS.ELA-Literacy.W.7.8 Gather relevant information from multiple print and digital resources, using search terms effectively; assess and credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

CCSS.ELA-Literacy.RST.6-8.2 Determine the central ideas or conclusions of a text; provide accurate summary of the text distinct from prior knowledge or opinions.

CCSS.ELA-Literacy.R1.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

CCSS.ELA.RST-.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-LITERACY.RI.7.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of a specific word choice on meaning and tone.