How Science Works...

Discovering Life Below the Sea Floor

Beth Orcutt is a marine microbial biogeochemist. She studies tiny bacteria that live in rocks and sediments deep in the ocean floor. She wants to understand how microbes thrive in deep sea environments and how their lives impact the cycling of elements on Earth.

"My inspiration is a love of chemistry and wanting to know what lives in the rocks at the bottom of the ocean."

EXPLORATION and DISCOVERY

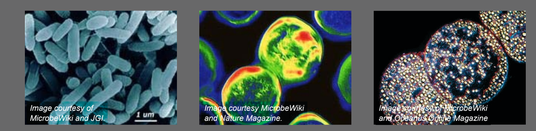


Image courtesy of MicrobeWiki and JGI.

Image courtesy MicrobeWiki and Nature Magazine.

Image courtesy MicrobeWiki and Oceanus Online Magazine

This particular scientific journey of Beth's began with a question that other researchers have also been asking…

What lives below the sea floor?

By reading scientific publications and sharing data and ideas with other scientists, Beth is excited to discover that there are LOTS of different types of bacteria living below the sea floor in some really extreme environments – places like hydrothermal vents and deep basalts. In these places the chemistry and temperatures vary greatly from conditions that we are used to on land. Beth is inspired to investigate some basic biological questions that she hopes will provide information for many more studies.

TESTING IDEAS

Beth's journey begins with the question:

What factors influence where certain microbes live?

Based on what she has already learned about these microbes, she comes up with several hypotheses that she could test. These include:

- The habitat (e.g. the environmental conditions) determines where a microbe can live.
- The region of the world (e.g. geography) determines where a microbe can live.
- Neither the habitat nor the geography determine where a microbe can live.

To test these hypotheses, Beth and her colleagues must collect samples from different habitats and regions of the ocean. They use the *JOIDES Resolution* research vessel to send special tools deep into the ocean floor to bring up the rocks and sediments that likely contain microbes. Once collected, they use microbiological techniques to isolate genetic material. This helps the researchers identify the particular microbes living in each of the samples. Then they can look for patterns in the data that help them evaluate each of the hypotheses.

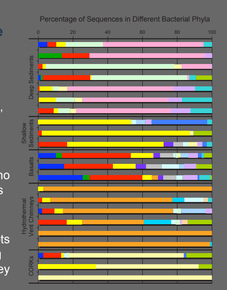
These researchers discover that no single hypothesis is completely supported by the data.

What did the data reveal?

Finding patterns in the data is complicated. There is some evidence that supports each of the hypotheses, and some evidence that contradicts the hypotheses.

For example, the researchers found that:

- Some microbes, such as members of Aquificea have only been found in hydrothermal vents and no where else in the ocean, suggesting that habitat is important for determining where they can live.
- Some microbes, such as the Gamma-proteobacteria are rather common and found in lots of different areas of the world's ocean, suggesting that neither habitat nor geography limits where they can live.



These data also inspire Beth to come up with some new hypotheses and ideas for new investigations.

What these researchers learned is that life in the sea floor is more complicated than expected. Some microbes are picky about their habitats and are only found in specialized environmental conditions. Others tend to stick to one region no matter what the conditions, and still others are cosmopolitan and can be found in a range of places and conditions!

COMMUNITY ANALYSIS and FEEDBACK

Like most science, this research is dynamic and involves lots of different steps and people.

How are the discoveries shared?

After gathering and evaluating more data, having more discussions, reading more literature, and talking to more scientists, Beth and her colleagues have enough information to write a research paper to report their findings. The paper is peer reviewed by a panel of experts to make sure the science was done well. Once reviewed, the paper gets published so other scientists can learn from what Beth and her team discovered.


Microbial Ecology of the Dark Ocean above, at, and below the Seafloor

BENEFITS and OUTCOMES

There are many ways in which Beth's research is important.

Beth's investigation provides some basic knowledge about what is living deep in the ocean floor, satisfying some curiosity and providing important information for other researchers pursuing their own related questions. Because working in such extreme environments with organisms that are so small and unknown is a huge challenge, researchers and engineers had to, and continue to invent new tools and technologies to collect and analyze the microbes. Most excitingly, because of Beth's research, there are now many new questions to explore!

What NEW questions can be pursued?

- How do microbes survive in such different habitats?
- What are the microbes doing down there?
- Why are certain kinds of microbes more abundant than others?
- How do the microbes affect our ocean ecosystem?

And there is a lot of potential for practical applications…

- Can technologies used for this investigation be used to search for the presence of bacteria on other planets?
- Do any of these bacteria have biomedical use?
- Can any of these bacteria be used as an energy source?

Beth and other scientists are working hard to answer these and many more questions about Earth's past, present, and future.

What scientific questions do YOU want to pursue?

Learn more at *www.joidesresolution.org*

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Figure modification and poster design by Jason Mallett, Consortium for Ocean Leadership www.oceanleadership.org