Background: Cold Seeps

Cold Seeps

- places where hydrogen sulfide, methane, and other hydrocarbon-rich fluids and/or gases escape from cracks in the ocean floor

Methane Cold Seep

- characterized by methane and hydrogen sulfide bubbles coming out of the seafloor
- chemicals provide energy for chemosynthetic ecosystems

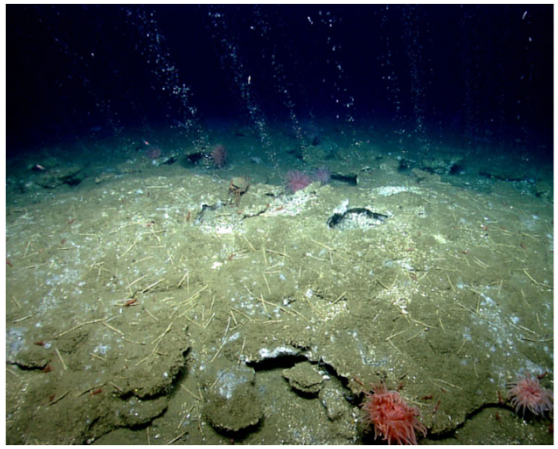

Image courtesy of NOAA Ocean Exploration. https://oceanexplorer.noaa.gov/okeanos/explorations/ex1903/background/seeps/welcome.html

Experience the Phenomenon: Cold Seeps and Methane Hydrate

Source: https://www.youtube.com/watch?v=ahmjHLyF9GM

Think about it!

- Have you ever seen an unfamiliar insect or other animal?
- Did you wonder where it lived, what it ate, or how it survived day to day?
- Scientists think about those same things when they come across new animals.

Methane Ice Worms of the Gulf: Optional

- In July 1997, eyeless worms were found living on **methane ice** >500m deep in the Gulf of America.
  - New organism AND a new niche, or a new ecosystem role
- Scientists had never seen an organism living on **methane hydrate**.
  - composed of methane gas locked into a water ice crystal structure
  - also may include significant amounts of hydrogen sulfide and oils
- Adult worms
  - 2 to 4 cm long, single adult worm in each depression
  - density of worms on hydrate surface ~2,500 individuals/square meter
  - related to earthworms - bristles protruding from appendages on each body segment
- Methane ice worms were the only organism visible on the hydrates, with no apparent predators or prey.

Big question:
How do methane ice worms obtain organic compounds and energy while living on methane hydrate?

Investigate: Think about it!

- What is the original source of energy for most food chains on Earth?
- Why can scientists not assume this to be the case for the methane ice worms?
- What are possible ways methane ice worms could obtain energy and organic compounds from the methane hydrate?

Investigate: Methane Ice Worm Hypotheses

2 potential sources of energy

Methane
1) The worms metabolize methane directly.
2) The worms consume bacteria that metabolize methane.
3) The worms rely on symbiotic bacteria that metabolize methane.

3 potential ways ice worms can obtain organic compounds and energy

Hydrogen sulfide
4) The worms metabolize hydrogen sulfide directly.
5) The worms consume bacteria that metabolize hydrogen sulfide.
6) The worms rely on symbiotic bacteria that metabolize hydrogen sulfide.

Investigate: Card Sort - Sample Match Below

2 Cards

UNDERSTANDING THE EVIDENCE *(for reference only)*

Some Evidence cards may need a brief explanation on **genetic** analyses. When you see this symbol, refer back to this card.

Lim and colleagues (2022) collected the most recent evidence on methane ice worms by analyzing **metagenomes**, *complete sequencing of the genetic material extracted directly* from the worms' gut and tissue samples.

- Scientists determined the sequences of **RNA fragments** associated with a subunit of the ribosome found in each sample and used a computer algorithm to **assemble sequence fragments** into **full sequences** that could be **compared** to the **sequences of known species**.
- Analyzing these RNA sequences allows scientists to investigate the **evolutionary relationships and classification of species** that may be only distantly related.
- The ability to construct full sequences from fragments allows scientists to **detect the presence of specific organisms** without directly isolating and culturing those organisms.

15 Cards

EVIDENCE

Lim and colleagues (2022) found that some bacteria identified in the gut of the methane ice worm have genes that would allow them to synthesize certain B vitamins and amino acids.

15 Cards

REASONING

Supplying B vitamins and amino acids that cannot be synthesized by the host is a common way that symbionts contribute to the nutrition of the host organism.

Sort/Match → **Select Best Evidence and Reasoning** → **Determine Best Hypothesis**

Put the Pieces Together: Reflection

- Are there any hypotheses that can be eliminated based on the class consensus?
- Did your group come to a consensus regarding any remaining hypotheses?
- Which pieces of evidence seem to be most important? Is there consensus within your group about this?
- What changes would you make to your initial argument after seeing the arguments from other group members?
- **Make sure your argument **directly** answers the question,
  "**How do methane ice worms obtain their energy and nutrients**?"

Assessment: Final Written Argument

- **Be sure to include the following:**
  - The **hypothesis** your group selected.
  - The specific **evidence** and **reasoning** selected.
  - Rationale **explaining** how the selected evidence and reasoning **supports** your selected hypothesis.