name/date/period

This Old Tubeworm

(adapted from "This Old Tubeworm" @ oceanexplorer.noaa.gov)

Introduction

One of the major scientific discoveries of the last 100 years is the presence of extensive deep-sea communities that do not depend upon sunlight as their primary source of energy. Instead, these communities derive their energy from chemicals through a process called chemosynthesis (in contrast to photosynthesis in which sunlight is the basic energy source). Some chemosynthetic communities have been found near underwater volcanic hot springs called hydrothermal vents, which usually occur along ridges separating the Earth's tectonic plates. Hydrogen sulfide is abundant in the water erupting from hydrothermal vents, and is used by chemosynthetic bacteria that are the base of the vent community food web. These bacteria obtain energy by oxidizing hydrogen sulfide to sulfur: $CO_2 + 4H_2S + O_2 > CH_2O + 4S + 3H_2O$

Other deep sea chemosynthetic communities are found in areas where hydrocarbon gases (often methane and hydrogen sulfide) and oil seep out of sediments. These areas, known as cold seeps, are commonly found along continental margins, and (like hydrothermal vents) are home to many species of organisms that have not been found anywhere else on Earth. Typical features of communities that have been studied so far include mounds of frozen crystals of methane and water called methane hydrate ice, that are home to polychaete worms.

As is the case with hydrothermal vents, chemosynthetic bacteria are also the base of the food web in cold seep communities. Bacteria may form thick bacterial mats, or may live in close association with other organisms. One of the most conspicuous associations exists between chemosynthetic bacteria and large tubeworms that belong to the group Vestimentifera. Tentacles of vestimentiferans are bright red because they contain hemoglobin (like our own red blood cells). Vestimentiferans can grow to more than 10 feet long, sometimes in clusters of millions of individuals, and are believed to live for more than 100 years. They do not have a mouth, stomach, or gut. Instead, they have a large organ called a trophosome, that contains chemosynthetic bacteria. Hemoglobin in the tubeworm's blood transports hydrogen sulfide and oxygen to bacteria living in the trophosome. The bacteria produce organic molecules that provide nutrition to the tube-worm. Similar relationships are found in clams and mussels that have chemosynthetic bacteria living in their gills. A variety of other organisms are also found in cold seep communities, and probably use tubeworms, mussels, and bacterial mats as sources of food. These include snails, eels, sea stars, crabs, isopods, sea cucumbers, and fishes. Specific relationships between these organisms have not been well-studied.

While there are many similarities between biological communities associated with hydrothermal vents and cold-seeps, there are also some important differences. One of these is that the physical environment of vent communities can change dramatically over a short period of time. Highly acidic water as hot as 400°C may suddenly erupt, accompanied by large amounts of toxic hydrogen sulfide. Vent organisms adapted to this rapidly changing environment often have growth rates that are much higher than those seen among organisms living in other deep-sea communities.

Things are different in cold-seep communities, where the slow, steady release of methane and other hydrocarbon compounds provides a much more consistent environment. Yet, some species characteristic of cold-seep communities are quite similar to species found in vent communities. Tubeworms, for example, are abundant in both communities and have similar symbiotic relationships with chemosynthetic bacteria. Tubeworms in vent communities are among the fastest-growing invertebrates on the planet, and reach a large

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size in relatively few years. Do tubeworms in cold seep communities also have rapid growth rates? How old are the largest tubeworms in cold seep communities? These questions are the subject of this activity.

PreLab Questions

1. What is chemosynthesis?

2. What substances are used for energy during chemosynthesis?

3. Describe the tubeworms that live in these deep sea communities.

4. Name the type of symbiotic relationship described (not given here).

5. Do you think that tubeworms will have a greater growth rate at hydrothermal vents or methane seeps?

Procedure

a. Answer the prelab questions using the background information given.
b. The *Lamellibrachia* Growth Rate Data Sheet contains actual data from two cold-seep sites in the Gulf of Mexico. Using this data, plot growth rate (y-axis) as a function of length of the worm (x-axis). Be sure to use graph paper. Draw a best-fit curve once you have all the points plotted.
c. Use your graph to fill in the Growth Data Worksheet chart. Estimate the growth rate at the beginning and end of each interval by estimating the amount from your best-fit curve. Then calculate the average growth rate by adding the beginning and end rates then dividing by two. Finally, calculate the time to grow 10 cm by dividing 10 by the average growth rate.
d. Answer the analysis questions based on your graph and data chart.

Analysis Questions

6. Describe the basic relationship between growth rate and length in *Lamellibrachia* tubeworms at cold-seeps (methane seeps).

7. Based on your data, how old would a 200 cm tubeworm be? Does this surprise you?

8. What factors might contribute to this longevity in tubeworms?

9. Is it likely that other species in the same community would be this old? Why or why not?

10. Why is there a large difference in the growth rates of tubeworms at cold-seeps and hydrothermal vents?

Lamellibrachia Growth Rate Data	
Length of Tubeworm (cm)	**Growth Rate (cm/yr)**
5	4.75
10	4.25
10	4.75
10	3.75
20	4.25
20	3.60
20	3.00
30	3.20
30	2.80
40	2.75
40	3.00
50	2.00
50	2.75
50	2.40
60	2.00
70	2.25
70	1.25
80	1.50
90	1.75
90	0.75
100	1.25
110	1.00
120	0.75
130	0.75
130	1.00
130	0.50
150	0.75
150	0.25
150	0.50
170	0.10
170	0.70
180	0.50
180	0.10
200	0.05
200	0.45

Growth Data Worksheet				
Growth Interval (cm)	**A. Growth Rate at Beginning of Interval (cm/yr)**	**B. Growth Rate at End of Interval (cm/yr)**	**C. Average Growth Rate (cm/yr)** (C = A+B/2)	**D. Time to Grow 10 cm (yr)** (D =10/C)
0-10				
10-20				
20-30				
30-40				
40-50				
50-60				
60-70				
70-80				
80-90				
90-100				
100-110				
110-120				
120-130				
130-140				
140-150				
150-160				
160-170				
170-180				
180-190				
190-200				
			Total Time to Reach 200 cm =	