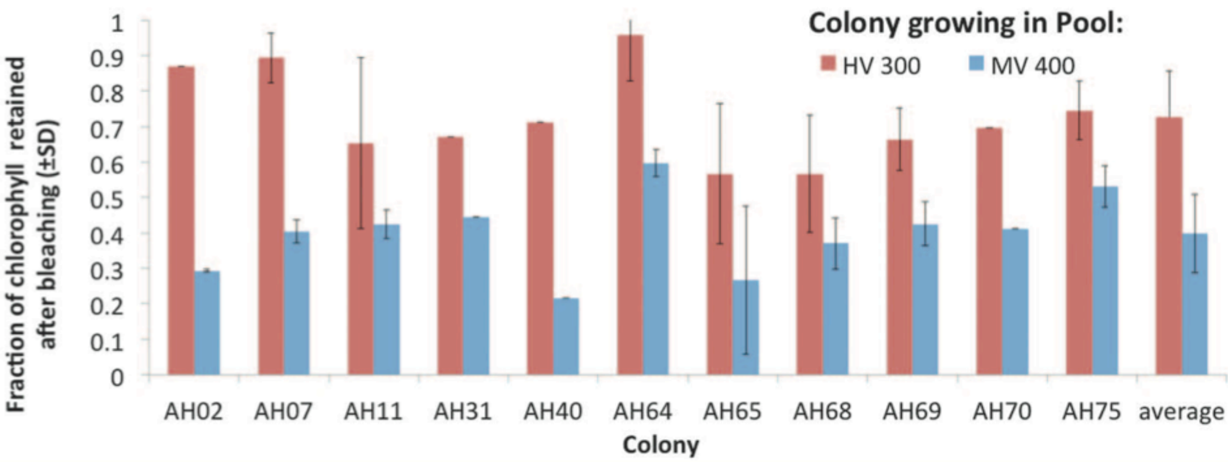
HOW TO USE THIS RESOURCE

Show the figure below to your students along with the caption and background information. The "Interpreting the Graph" and "Discussion Questions" sections provide additional information and suggested questions that you can use to guide a class discussion about the characteristics of the graph and what it shows.



Caption: Eleven samples of a coral species (*Acropora hyacinthus*) were reciprocally transplanted from their native pool to a moderately variable heat pool (MV, in blue) or a highly variable heat pool (HV, in red). After the corals spent a period of time in their new environments, they were exposed to heat stress. The degree of resistance to bleaching by a coral colony is measured by the ratio of chlorophyll that remains in the corals after heat stress compared to non-heat stressed controls.

BACKGROUND INFORMATION

Reef-building corals are sensitive to heat and can bleach when they experience temperatures above the normal range for their given location for a prolonged period of time. Bleaching occurs when the symbiotic algae and the chlorophyll they contain are ejected from coral cells. The algae give the corals their color, so when they are ejected, the coral turns white. Corals can survive short-term bleaching events, but become more at risk of disease and death.

To test whether corals can become more resistant to bleaching, Dr. Steve Palumbi and colleagues performed a series of experiments in the U.S. National Park of American Samoa off of Ofu Island. In these waters, corals tend to bleach around 30°C. The researchers first had to establish a baseline for bleaching. To do this they took coral samples from two different shallow pools: a highly variable pool (HV) that regularly experiences temperatures between 30 and 35°C, and a moderately variable (MV) pool where temperatures rarely exceed 32°C. They then exposed the samples to a heat stress protocol in a laboratory consisting of a steady increase in water temperature from 29°C to 34°C over 3 hours, followed by steady exposure to 34°C water for 3 hours, which mimicked conditions of a low tide cycle in an HV pool. They determined the baseline of bleaching by measuring the ratio of chlorophyll present before and after the heat stress. In this experiment, corals from the HV pool retained 80% of their chlorophyll, while corals from the MV pools retained 45%.

They next tested the ability of corals to acclimate to frequent heat stress. (*Acclimation* or *acclimatization* is the process by which an individual adjusts to changes in its environment.) The researchers took branches from 11 colonies (3 from the HV pool, 8 from the MV pool), split the samples, and grew one sample in each of the MV and HV pools. They let them grow in their new environment for 12, 19, or 27 months and then tested them for heat resistance using the heat stress protocol. In the graph above, the red bars represent data from each of the 11 colonies that grew in the HV pool and the blue bars represent data from each of the 11 colonies that grew in the MV pool. The graph shows average data from all heat exposure trials.

INTERPRETING THE GRAPH

The bars show the fraction of chlorophyll remaining after coral samples were exposed to heat stress in the laboratory relative to an unstressed control sample from the same colony. HV pools often exceeded the local bleaching threshold of 30°C, with temperatures ranging from 30°C to 35°C. MV pool temperatures rarely exceeded 32°C. Error bars show 1 standard deviation of colonies stressed on two to three different dates. The bars labeled “average” represent the average chlorophyll retained across all corals exposed to each temperature treatment. This graph shows that corals that were stressed after growing in HV pools retained a higher proportion of chlorophyll than corals that were growing in (or transplanted to) MV pools, inferring the ability to resist bleaching when exposed to high heat conditions. Irrespective of their origin (native to HV or MV pool), the transplanted corals all acquired similar heat sensitivity of the corals in the pool they were transplanted into. This suggests that the corals acclimated to the conditions in the new pools.

Not apparent in the graph, but included in the paper, were comparisons between native and transplanted corals acclimated to the same environment. Native HV corals were still more resistant to bleaching than transplanted native MV corals. Native HV corals retained 80% of their chlorophyll after heat stress, while MV corals acclimated to the HV pool retained 67.5%. There was no statistical difference, however, between native MV corals and HV corals transplanted to the MV pool. They retained 47% and 45% of their chlorophyll respectively.

Prompt your students to explain the following:

- <u>Graph Type</u>: Bar Graph

- X-Axis: Colony number
- Y-Axis: Fraction of chlorophyll retained after bleaching relative to an un-stressed control sample of the same coral
- Error Bars: Errors bars represent standard deviation (+/- 1) for colonies that were experimentally heat stressed on two to three separate dates.

DISCUSSION QUESTIONS

- Why are these experiments of acclimation and not adaptation? How could scientists research the ability of coral to adapt to sea temperature changes?
- Samples from the 11 pairs of transplants were taken to the lab and subjected to heat stress.
  - How does the fraction of chlorophyll retained after the heat stress was applied differ between the two coral groups, which grew in the two different pool conditions (HV and MV)?
  - Why might the coral from the MV pool show less retention of symbiont chlorophyll after the heat stress test?
- Using the graph, explain why it is important to show the average chlorophyll retained across all colony samples for each pool?
- Why is it important that each experimental result is standardized by comparing the chlorophyll retained by heat-stressed corals to a non-stressed sample of the same colony?
- How does the variation of the standard deviation in the 11 pairs of samples compare to that of the average? Why do you think there are changes in the standard deviation?

SOURCE

Figure 2 from:
Stephen R. Palumbi, et al. "Mechanisms of Reef Coral Resistance to Future Climate Change." *Science*. 2014. 344(6186): 895-898.

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