

EART101: Spatial and environmental patterns

The latitudinal diversity gradient (high tropical diversity, decreasing toward the poles) is a prominent pattern in many extant marine and terrestrial clades. This exercise evaluates potential causes of that diversity gradient.

First, are today's latitudinal diversity gradients similar to those from the geological past?

Open RStudio and read the function

```
source("https://people.ucsc.edu/~mclapham/eart101/exercises/lat_gradient.R")
```

The function will read data for a specified taxonomic group from the Paleobiology Database and plot a latitudinal diversity profile. It will take a few seconds to request and download all of the data for common taxonomic groups, so be patient and wait for the graph to appear. Try a few different taxonomic groups and time intervals. For example:

```
lat.gradient("Trilobita", "Ordovician")
```

For each analysis, also go to <https://paleobiodb.org/navigator/> to view the distribution of fossil localities on a paleogeographic map. Type the group name in the search bar (upper right), click on the time interval (the timescale at the bottom), and select the paleogeographic map option (continent symbol on the left menu). When you are ready to input the next taxonomic group, exit the paleogeographic map by clicking on the continent symbol again and then remove the taxon and time filters by clicking on the "x" beside their names.

Synthesize your findings to answer the following two questions:

- 1.** Describe the latitudinal diversity gradients from the plots and compare them to the present-day bivalve gradient. Has a gradient of decreasing diversity from the tropics to the poles generally been a consistent feature through the Phanerozoic?
- 2.** How did the latitudinal diversity gradients compare to the distribution of landmasses and of fossil localities? (Although the organisms are marine, they lived in shallow-water environments that are preserved on the present-day continents). Given that, what is one way the distribution of landmasses may contribute to the latitudinal diversity gradient? What is one argument for the diversity gradient being an artifact (i.e., not a true biological pattern)?

Next, look at the pdf file "Bivalve latitudes" (at Canvas). In the file, each row contains data on a single northern hemisphere genus, including the geological time period of its first appearance (name and age), the paleolatitude of that first record, and the present-day latitudinal range of the genus. All data are hypothetical, for illustration purposes only.

- 3.** Are origination rates higher in the tropics (between 0 and 25 degrees) or in the extratropics (greater than 25 degrees)? What evidence from the bivalve latitude data file supports your conclusion?

4. How will the recorded latitudinal range of a species in the fossil record compare to the true range of that species? Why does that relationship exist? (Hint: it's analogous to recorded/true first appearances; also, think about why species may have latitudinal ranges at all).

5. For genera that first originated in the tropics, how does their latitudinal distribution typically change from their first appearance to their modern distribution? What does that mean for the latitudinal diversity gradient?

6. Compare the present-day latitudinal distributions of originally-tropical genera from different time intervals (i.e., how does the present-day distribution of genera that first appeared in the Tortonian differ from that of Messinian genera, etc.). What does that tell you about the process of range shifts?

7. Any range expansions of tropical taxa to higher latitudes could result from a bounded random walk (since they already originate near the equator they cannot expand to be any more tropical). What evidence supports the argument that range expansions are real trends and not a random walk? (Hint: look at shifts in taxa that originated in extratropical regions).

Finally, open the data file "Bivalve ages" (from Canvas). This file contains the geological duration (time in millions of years since its origination) for extant bivalve genera. The geographic distribution (tropical, extratropical, or both) is also indicated for each genus. All data are hypothetical, for illustration purposes only.

8. What does the distribution of taxon ages tell you about extinction rates in the tropics vs. the extratropics? Support your answer with reference to the data. How could that contribute to the formation of the latitudinal diversity gradient?

9. Some of the longest-lived genera are found in both tropical and extratropical regions. How do you think they maintain a presence in the extratropics given the extinction rate in that region?