Utilizing the Paleobiology Database to Provide Hands-On Research Opportunities for Undergraduates

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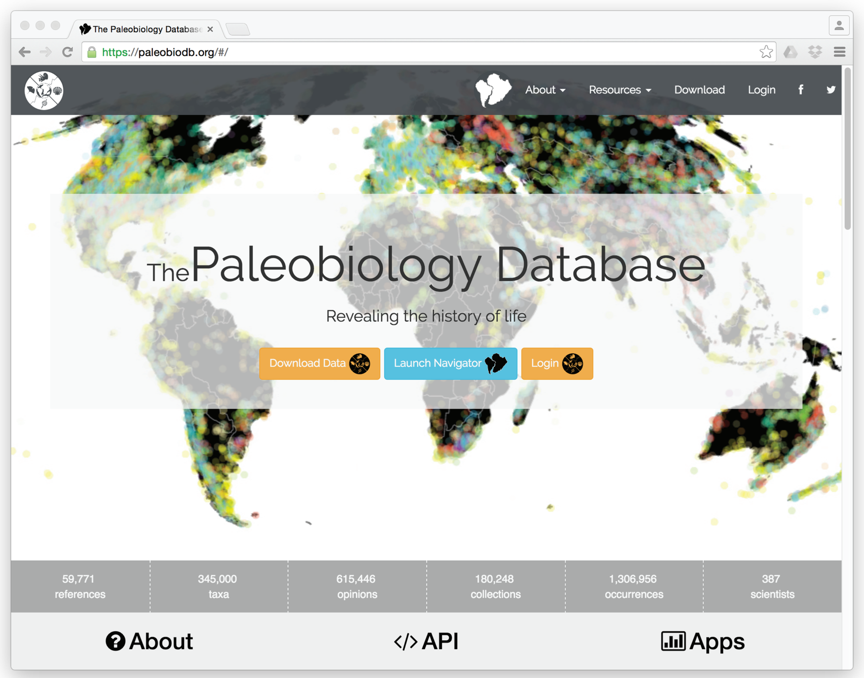

A. What is the Paleobiology Database?

The Paleobiology Database (PBDB, www.paleobiodb.org) is a public database of paleontological data that anyone can use, maintained by an international non-governmental group of paleontologists.

The contributing members, nearly 400 scientists from over 130 institutions in 24 countries, add fossil occurrences from scientific publications to the database (Figure 1).

The purpose of the database is to provide global, collection-based occurrence and taxonomic data for organisms of all geological ages, and data services to allow easy access to the data for independent development of analytical tools, visualization software, and educational resources.

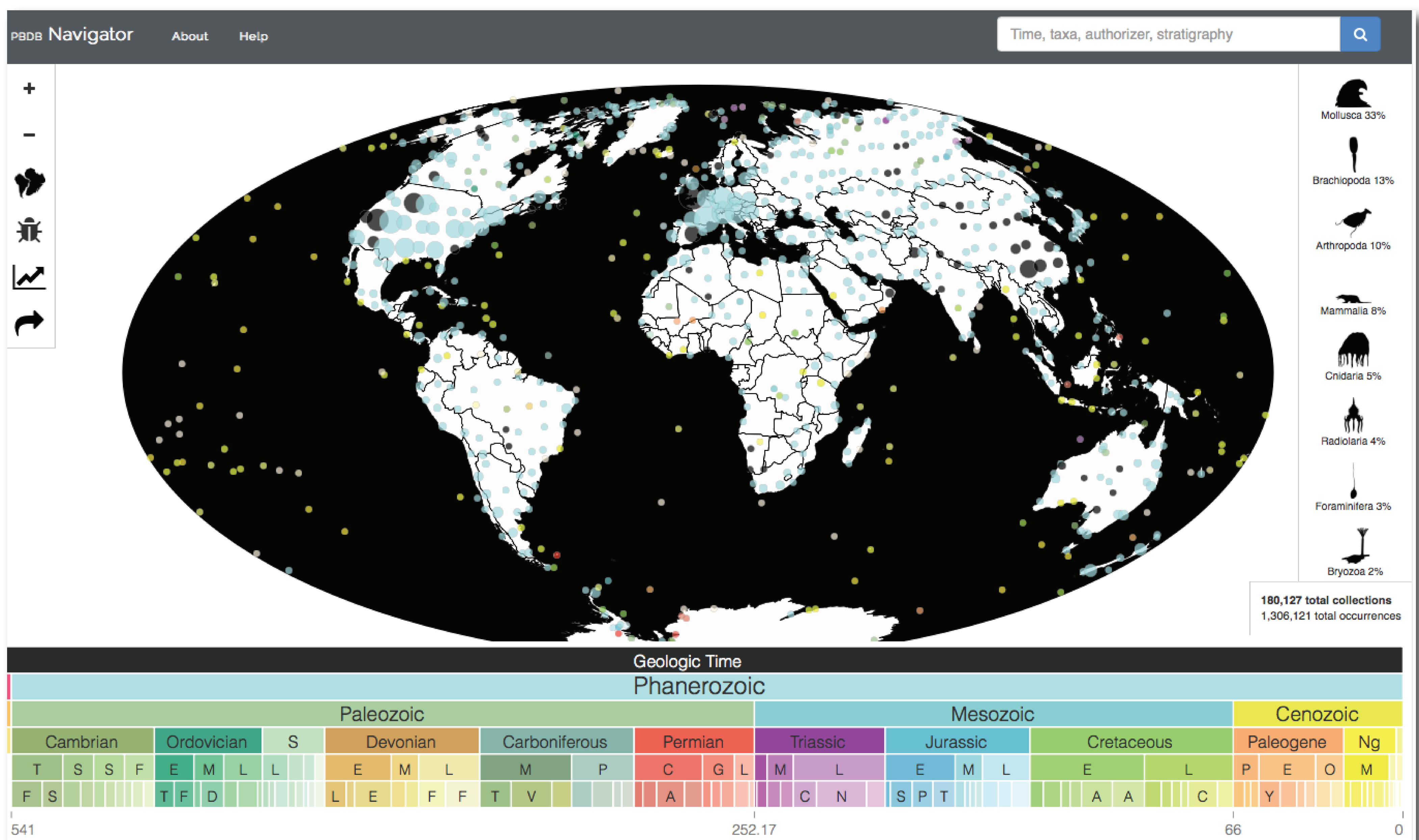

Figure 1: Navigator view
This view shows the site localities for fossils entered into the database. Navigator is a web application that queries the PBDB in real-time and displays the results for any taxa, time interval, or stratigraphic layer in the database.

B. Paleobiology Database as an Educational Tool

We investigating how students' attitudes towards scientific research change after engaging in inquiry experiences using the PBDB. Many undergraduates' only exposure to science comes through an introductory science class where research experiences are limited or absent. However, the availability of high quality professional research databases, such as the PBDB, may provide excellent, easily accessible research experiences.

The PBDB is an ideal database for this study, given the wealth of key concepts and skill-building it incorporates, including information on geologic time, climate change, evolution, mass extinction, geospatial data, and quantitative/statistical skills.

The research questions we will address include:

1. How do student attitudes and interest toward scientific research change after such an experience? How do these changes (if present) compare to previous research on the effectiveness of field or lab-based research experiences?
2. How can a large online database such as the PBDB be leveraged as a tool to provide effective research experiences for undergraduate students at 2YC and 4YC?
3. How can databases be leveraged as tools to teach STEM principles to non-majors, majors, and pre-service teachers to help create a STEM literate population?

As we examine how a large database like PBDB can be leveraged to provide research experiences to undergraduates, we are also developing a set of data-focused lessons that can be incorporated into introductory and advanced undergraduate classes.

The lessons will be modular so that they can be utilized in class assignments, laboratory exercises, field investigations, or as homework, and feature essential skills for scientifically literate citizens, including critical thinking and data analysis.

Goals for lessons

1. Developing a balance between guidance and inquiry that is appropriate for the students and the learning objectives.
2. Creating opportunities for students to work with data and tools outside of class or lab.
3. Designing exercises with student background in mind — will incorporate a safety net to support students through the challenges of research.

C. Examples of Inquiry Activities Using PBDB

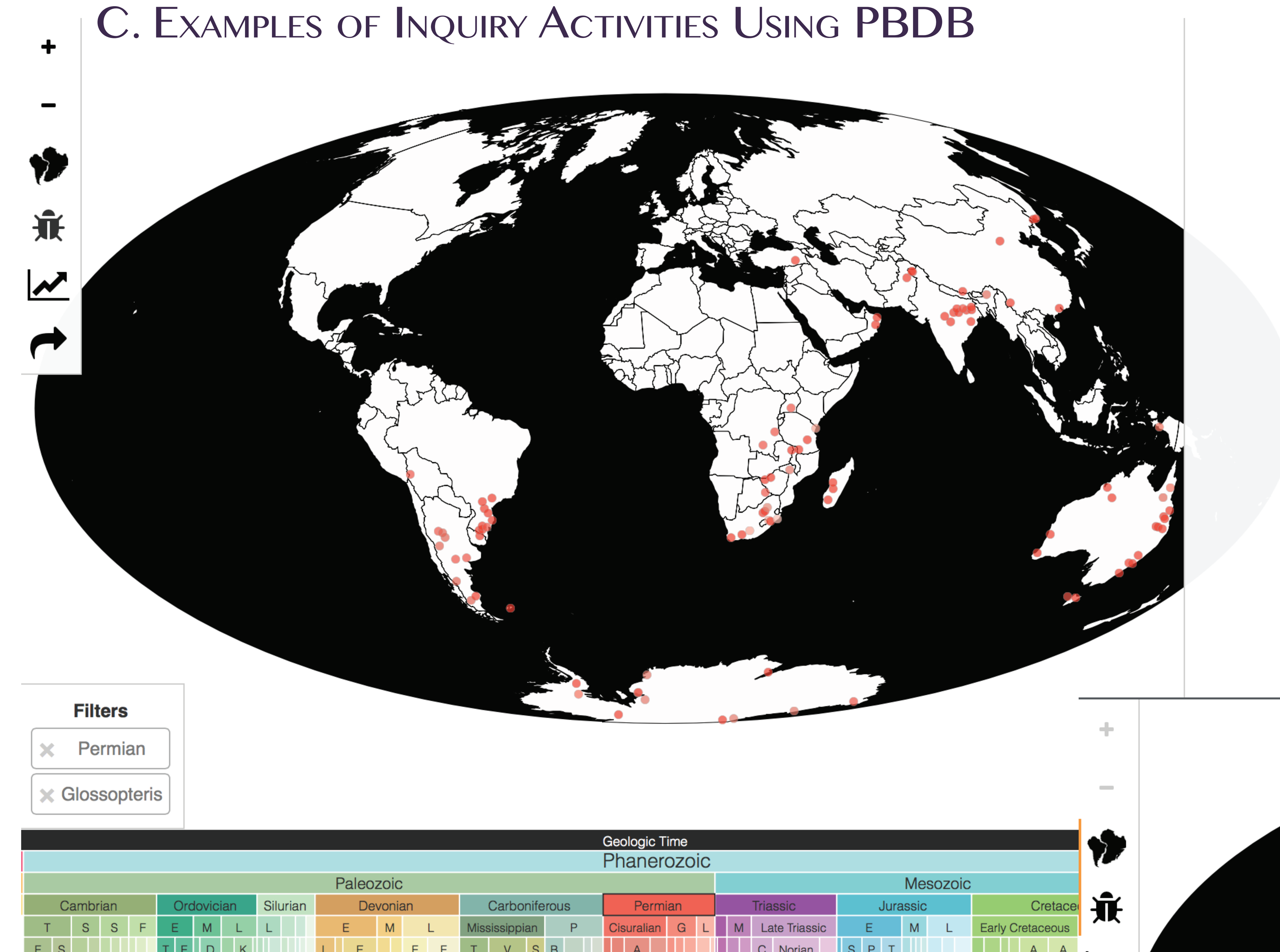

Figure 2 (above): *Glossopteris* localities
Students should be able to quickly see that the fossils are primarily distributed across the southern continents

Example 1: Discovering Pangaea (this excerpt is from a lesson for an introductory-level geology class)

Learning objective:
Learn how the biogeographic distributions of fossil organisms was distorted by plate motions since the time of their deposition as fossils.

Example Procedure and Questions:
1. Predict the distribution you would expect for a plant fossil. Type *Glossopteris* in the search field and click enter.
2. How does this compare to your prediction? What do the fossil localities have in common? How could you explain this distribution? (Figure 2)
3. Now enter *Mesosaurus*. It was a small reptile incapable of swimming across an ocean basin. How could it be found in both South America and Africa?
4. *Mesosaurus* lived during the Permian, so click the Permian in the time scale and then select the paleogeography button. What can you infer from this difference on your map? (Figure 3)

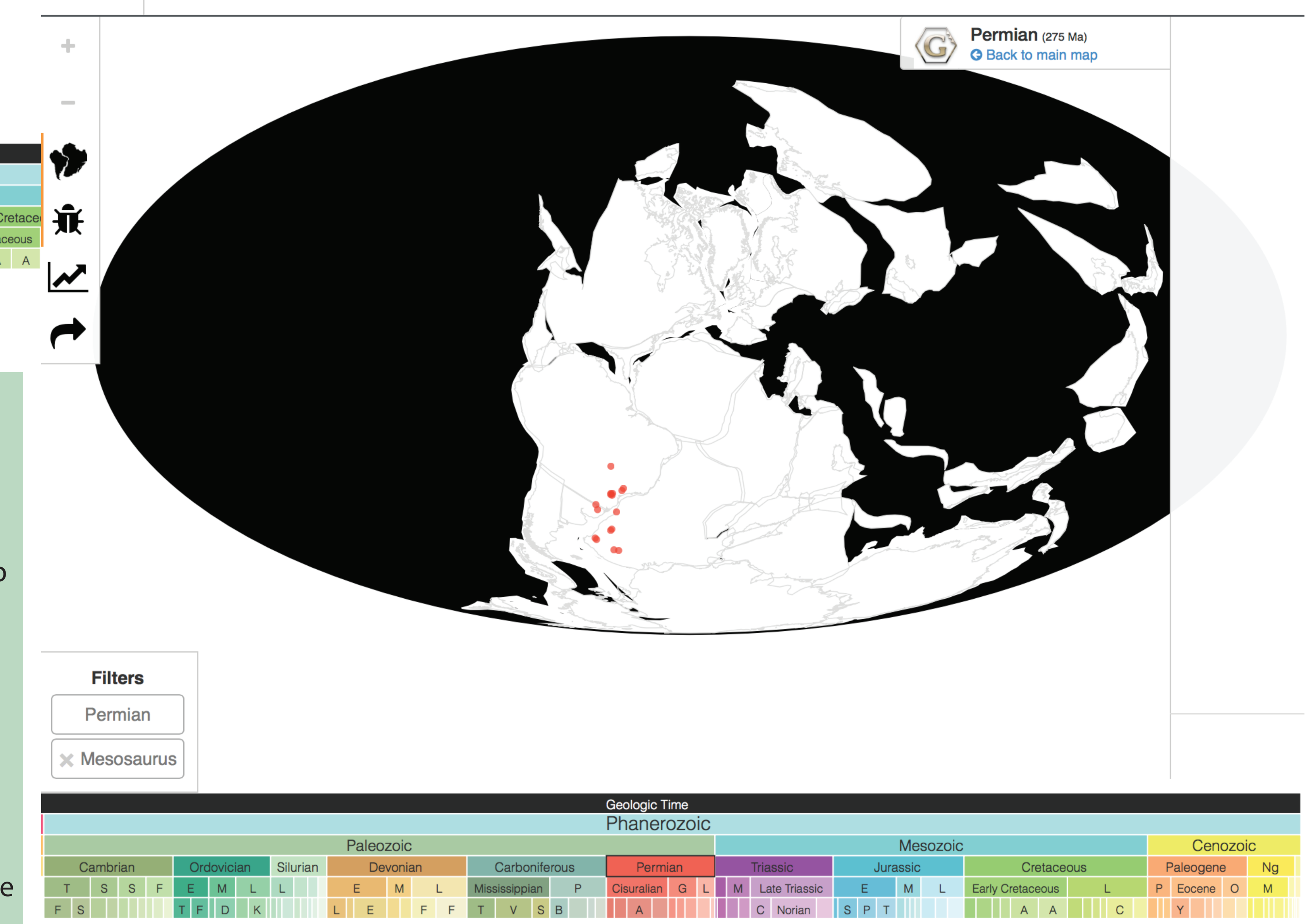

Figure 3 (right): *Mesosaurus* localities
By enabling the paleogeography, the distribution of *Mesosaurus* should become clear to students.

Example 2: Counting Critters: Using the Paleobiology Database to track fossil diversity through geologic time (this excerpt is from a lesson for an upper-level paleontology class)

Learning objectives:
Construct a diversity curve using data and tools from PBDB Navigator and develop hypotheses to explain changes in diversity through time.

Example Procedure and Questions:
1. Select the Toggle Stats button to generate a diversity curve. (Figure 4)
2. Given what you know about the early history of life on Earth, predict how the number of genera (i.e., genus-level diversity) would change over the past 500 million years.
3. Given what you know about fossil preservation, does this curve fully represent the diversity of life through time? Identify at least two groups of organisms that are likely to be overrepresented in these data (more likely to be preserved) and two that are likely under represented. Explain why they are more likely to be over or under represented.

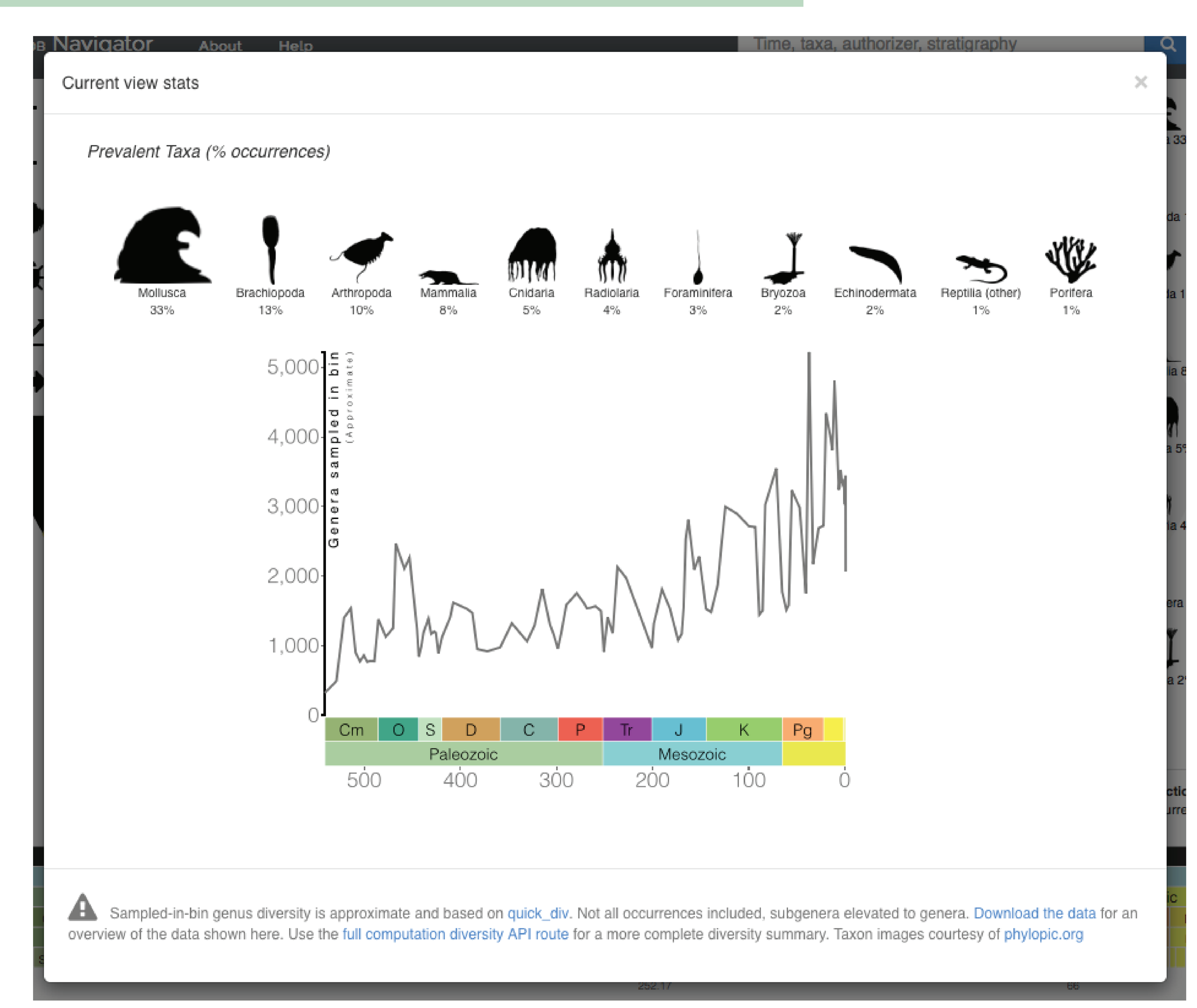

Figure 4: Diversity curve
Genus-level diversity curves can be quickly generated directly from searches within Navigator.

D. Project Goals

This coming academic year we will begin testing our lessons in classrooms at our home institutions, which include 2 and 4-year institutions, as well as in 100% online learning environments. Online courses typically lack research experiences, and our lessons will directly address this deficiency.

Research skills, such as critical thinking, statistics, and computing, will be emphasized in the lessons, and are essential to scientifically literate citizens.

This project will help guide other large scientific databases in crafting research experiences for undergraduate students. Guided inquiry into the PBDB will form the foundation for students to ask an essentially unlimited number of research questions, giving them the opportunity to explore data on their own and creating authentic research experiences.

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