

Museum exhibit developed at Harvard SEAS puts evolution at visitors' fingertips

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The multitouch surface and programming of a new museum exhibit allow museum visitors to zoom and scroll through the Tree of Life, the immense tree diagram biologists use to represent the evolutionary history of millions of related species. Credit: Michael S. Horn

With a quick swipe of the finger, the Tree of Life became a blur of branches flying past, zooming away from the root through deep history until finally, at the end of a twig, the human species *Homo sapiens* appeared. Engaging with an exhibit at the California Academy of

Sciences last fall, a young visitor could hardly contain his awe at how far he had traveled: "Whoa, 3.5 billion years ago—that's a long time." The boy's mother then pointed to a pair of connecting lines and told him gleefully, "You're related to a banana!"

Now, visitors to the Harvard Museum of Natural History (HMNH) in Cambridge, Mass., can experience and interact with the same computerized tabletop exhibit, while learning about evolution and the history of life on Earth.

The result of a three-year project funded by the National Science Foundation and based at the Harvard School of Engineering and Applied Sciences (SEAS), the Life on Earth exhibit represents the cutting edge of tabletop computing technology. Its multitouch surface and programming allow museum visitors to zoom and scroll through the Tree of Life, the immense tree diagram biologists use to represent the [evolutionary history](#) of millions of related species.

The educational feat of illustrating the accumulation of subtle changes over the course of billions of years—something biologists and museums alike have struggled to show in the past—is as notable as the underlying technology.

"We animate the whole process of opening up the tree, showing so many interactions, so many diversifications, and giving a real sense of the magnitude of biodiversity," explains Chia Shen, Senior Research Fellow in Computer Science at SEAS, who led the project from its conception to this culmination in the Evolution hall of the Museum.

Shen, director of the Scientists' Discovery Room Lab at SEAS, is the principal investigator of the multi-institutional Life on Earth project, the goal of which was to develop learning activities to advance the public's understanding of the history of life on Earth and biodiversity, in both

formal and informal educational settings.

HMNH has been a longtime partner to the Life on Earth project, accommodating and assisting with the research, observation, and evaluation stages of the activities' development.

The exhibit, which opened at HMNH on March 5 showcases one of the multitouch tables and two activities.

The DeepTree software (video: <http://youtu.be/dpo9iK26el8>) allows users to fly through the evolutionary relationships of over 70,000 named species and learn how they are related through shared derived traits. The FloTree program (video: <http://youtu.be/cb279wqU9QA>) is a simulation of evolution in action. Branching lineages of organisms progress up the screen, until some environmental change—your hand, placed on the tabletop—prevents them from interbreeding. These lineages continue to multiply around and above your hand, propagating genetic variations and diverging into new species over many generations. DeepTree and FloTree run on the same exhibit table, highlighting the relationship between life's evolutionary history and the speciation process that underlies this diversity.

As Shen explains, "These are very abstract concepts: divergence, ongoing evolution, shared ancestry. Our main goal is to use visualization to present that information and knowledge correctly to people who are not familiar with these concepts."

In addition to the software programs that run on the table, the user interface itself is crucial to the learning experience. In the chaos of a museum setting, where multiple participants constantly arrive and leave the table, it's important that the interface be able to handle conflicting input—the clicks and swipes of excited fingers—in a meaningful manner.

"One of the advantages of a multitouch table is that everyone can touch it at once—but that's also a disadvantage if you don't build it into your design. When one person taps something on the screen, we don't want the whole tree to change," explains Shen. "We've designed the interface very carefully to work with the way people really use it."

The FlowBlocks interface (named after Florian Block, a postdoctoral fellow at SEAS who was lead author for this portion of the research) is the product of hundreds of hours of user observation. Presented at the ACM Symposium on User Interface Software and Technology and IEEE Information Visualization conferences last fall, the FlowBlocks interface works on the premise that most touches on the screen should have a start point and an end point.

User operations that change the entire tree display are therefore only enacted with a deliberate drag-and-drop movement. Such an exaggerated motion is also visible to other participants around the table, allowing for a collaborative learning process.

"If you see my arm moving to make a change in the Build-A-Tree game, you can stop me halfway if you don't agree with me," says Shen. "We did that very intentionally."

The team also constantly works on making the table simple to use for all generations of visitors. Noticing that older visitors tend to prefer tapping motions, while younger visitors who are accustomed to touch-screen technology often incorporate swiping motions, the team designed the interface so that both approaches result in intuitive interactions.

Perched at the interface between evolutionary biology, human-computer interaction, cognitive psychology, and learning sciences, the Life on Earth exhibit results from the collaboration of many sharp minds at Harvard SEAS (Shen, Block, and Brenda Phillips), the University of

Nebraska, Lincoln (Judy Diamond), the University of Michigan (Margaret Evans), and Northwestern University (Michael Horn, previously a postdoctoral researcher at SEAS). The idea to use the Tree of Life as the focal learning activity for the exhibits and activities originated with James Hanken (Alexander Agassiz Professor of Biology at Harvard and now a science adviser for Life on Earth), who described the challenges involved in visualizing the principles and processes of evolution during an auspicious visit to Shen's lab in 2008.

The Harvard Museum of Natural History is one of only four museums in the country to have the Life on Earth exhibit. Other touch tables are on display at the University of Nebraska State Museum and at the California Academy of Sciences in San Francisco. The Field Museum of Chicago will open their Life on Earth touch table in April.

Jane Pickering, Executive Director of the Harvard Museums of Science and Culture, greeted some 60 scientists and museum members at the exhibit opening on March 5.

"The Tree of Life is the central organizing principle for biology, but it is not easy for the general public to understand," Pickering said. "This exhibit gives users the opportunity to interact playfully with new technology first hand to explore the Tree of Life and to visualize instantly how all [life on Earth](#) is related."

Provided by Harvard University

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