LIFE ON EARTH
ALL LIFE ON EARTH IS RELATED

Executive Summary

Life on Earth seeks to improve visitor understanding of evolution by combining innovative information visualizations with a multi-user interactive tabletop technology. Building on research in the learning sciences and human-computer interaction, our project offers visitors the opportunity not only to see but also to *touch, and explore* over seventy thousand species in a phylogenetic Tree of Life. Our goal is to help visitors understand evolution through common ancestry while bridging macro-evolutionary patterns of change with micro-evolutionary processes.

Life on Earth includes three types of evolution experiences

DeepTree is an interactive visualization based on data from the Tree of Life Web Project (tolweb.org), the Encyclopedia of Life (eol.org), National Center for Biotechnology Information (www.**ncbi**.nlm.nih.gov*)* and the TimeTree knowledge base (timetree.org). This tree of life represents the evolutionary relationship of species from the beginning of life to the present. The DeepTree provides a deep zoom interface, allowing visitors to "fly through" the vast array of diverse living species. The exhibit emphasizes the idea that all life on earth is related through shared derived traits, and includes major times of divergence.

FloTree is a multi-user simulation illustrating the dynamic processes underlying evolution. FloTree links population-level processes to speciation and biodiversity. By placing hands or arms on the surface of the multi-touch table, visitors discover how a population of organisms changes from one generation to the next. As the visitors add environmental barriers, they see the effects of interrupting the gene flow between populations and how this results in the formation of new species. After each run, visitors can visualize the result of the population simulation in the form of a phylogenetic tree. The free-form hand and body touch gestures invite creative input from users, encouraging active participation and opportunities for social engagement.

Build-A-Tree Is a multi-level puzzle that invites visitors to construct trees that show evolutionary relationships among organisms. Black silhouettes of organisms are superimposed on colored circles that visitors drag around the table. Touching any two circles together joins them into a tree or joins two sub-trees together. The reverse action, dragging circles apart, removes an organism from an existing tree. This mechanism supports collaborative problem solving as multiple players work together.

FloTree and DeepTree can be experienced in a seamless application, allowing visitors to grasp the relationship between evolutionary processes and phylogenetic patterns of change. Build-A-Tree offers visitors the opportunity to experiment with their tree-building skills in a novel puzzle-like environment. All of these experiences are collaborative, eliciting social engagement from families and friends and groups of varying sizes.

Project Background

Immense knowledge and data from the life sciences, resulting from over two centuries of scientific endeavor, are compiled into online repositories available to anyone with an Internet connection. Two important datasets of this type are the Tree of Life web project (www.tolweb.org) representing current knowledge of the evolutionary relationships among organisms, and the Encyclopedia of Life project (www.eol.org). These biological data sets are rich and varied, combining scientific data, and textual descriptions with sounds, images, videos, and geographical data that enable a complete view of life on earth and the relationships among species. We believe that these repositories are valuable resources for public understanding because they reveal the nature of evolution and the pressing challenges of preserving biodiversity. However, in their current form, large biological datasets can be difficult for the public to understand and appreciate, especially in informal learning settings. It is difficult for people to use such tools to explore visually the diversity and evolutionary relationships of life on Earth.
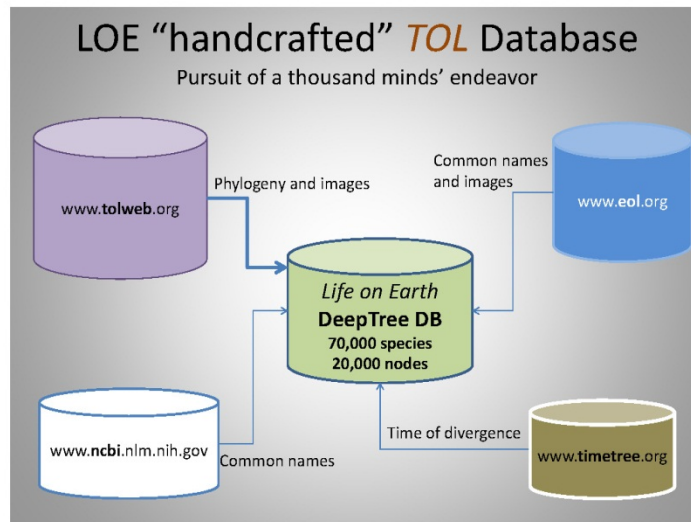
Life on Earth is designed for use by a wide range of visitors, through a developmentally tested range of activities that allow visitors to choose their own difficulty level, engage with family members and peers, and share the exhibit experiences. Life on Earth helps advance informal STEM learning by incorporating many of the skills required by the National Science Education Standards (National Academy of Sciences, 2012). Learning researchers and evaluators will use complementary methodologies to study how visitors learn about evolutionary relationships and processes and how this exhibit engages museum visitors in exploring this interactive visualization of data from the Tree of Life.

PROJECT TEAM and PARTNER MUSEUMS

Harvard University in partnership with Northwestern University, University of Michigan, and the University of Nebraska State Museum developed Life on Earth. The project team includes computer scientists, biologists, and learning researchers. Biologists from several of our partner institutions advise this project. Our partner museums include the California Academy of Sciences, the Field Museum of Natural History, the Harvard Museum of Natural History, and the University of Nebraska State Museum.

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