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MUSEUMS AND EVOLUTION

Yale Peabody Museum of Natural History's "Travels in the Great Tree of Life"

Museum Visitors Learn About Phylogenetic Relationships

Ellen Giusti

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Abstract The Yale Peabody Museum of Natural History developed a 1,000-square-foot exhibition to help the general public understand the concept of phylogenetic relationships and their depiction on scientific Trees, or cladograms. In addition, exhibition planners hoped visitors would understand that research on the Tree of Life is a massive, complex undertaking requiring powerful computers and that Tree research has many potential practical applications. Museum exhibits designed to convey scientific information must use "stealth" to accomplish their cognitive goals: Unlike students in formal science education classes, visitors are not obliged to learn—they do not learn because they must pass a final examination. Informal educators must engage visitors' interest so that they willingly take in new information and perhaps even learn new skills, change attitudes, and behaviors. "Travels in the Great Tree of Life" succeeded in engaging visitors who came away with awareness and understanding of scientific Trees, the immensity of the construct, and to a lesser extent, potential practical applications.

Keywords Yale Peabody Museum of Natural History · Tree of Life · Museum · Phylogenetic relationships · Cladogram · Lifelong learning · Surrounded by Science

I learned so much. I knew nothing about it [before]. Female 14–18

Background

"Travels in the Great Tree of Life," a 1,000-square-foot exhibition developed by the Yale Peabody Museum of Natural History in 2008, aimed to convey one principal concept and two subsidiary ideas:

- Visitors should come away understanding the concept of phylogenetic relationships, to wit, relationships among species are based on recency of common ancestry, not on observable similarity of physical characteristics.
- Visitors should understand that the Tree of Life (ToL) is huge—resolving the relationships within it is a complex undertaking, with current research producing some surprising findings.
- Understanding relationships in the ToL has a number of practical applications.

This paper is based on the summative evaluation of the exhibition conducted by Giusti in 2008. The purpose of the study was to find out the extent to which exhibition visitors grasped these ideas. In addition, the study examined how visitors used the exhibition. We were particularly interested in visitors' use of media, principally an interactive computer game designed to engage and instruct visitors—particularly children—about the exhibition's primary cognitive goal.

The "Discussion and Implications" section of this paper compares summative evaluation findings with findings from front-end audience research conducted during the exhibition's planning phase. This retrospective pre- and post-visit framework highlights the change in the public's perception of the main ideas and showcases the exhibition's cognitive impact on its visitors.

The exhibition received support from the National Science Foundation.

Methodology

A mixed-methods approach was used to gather data for the study. Structured exit interviews provided visitors' subjective

E. Giusti (✉)
Exhibition and Program Evaluation,
New York, NY, USA
e-mail: egiusti@nyc.rr.com

response to their exhibition experience and how engaged they were by the topic and its interpretation. Systematic observation of visitor behavior in the exhibition (timing and tracking) supplied objective data about what a random sample of the visitor population actually did in the exhibition and for how long—the exhibit components they attended to, the labels they read, and the interactive and media components they used.

Findings

The Visitors

The interview collected demographic characteristics; however, the only demographic data available for the tracked sample were those that data collectors could observe—gender and approximated age (by decade) (see Appendix). Interview and tracked samples included youngsters and adults. The majority of the sample was adults between 19 and 59 years. Twenty-three percent of interview respondents and 15% of tracked visitors were 18 years or younger. Interview data indicate that most visitors came from nearby—New Haven or other locations in Connecticut—and came to the museum with family or friends. Only 13% of interview subjects said they came to the museum particularly to see the exhibition; most of those who knew about it before arriving cited “personal communication” as their source.

Male and female visitors were equally likely to visit the exhibition. Half of the adult visitors were accompanied by children younger than 18 years old. Sixty percent of the exhibition’s adult visitors—as the interview sample revealed—had advanced academic degrees. Some 34% of the adults said they had special training in science and 87% felt “moderately well informed” to “very well informed about scientific discoveries and technology” (29% and 58%, respectively).

The next section discusses tracking and timing results because they will be referenced in subsequent findings to shed light on exit interview results. The relationship between observations of visitor behavior in exhibitions (tracking and timing) and responses to exit interviews can indicate which exhibit components convey content messages most effectively.

Visitor Behavior in the Exhibition

The exhibition, encompassing just 1,000 square feet, was quite densely packed with information, media, and specimens. For purposes of observing visitor behavior, 19 exhibit elements were identified (Fig. 2). Visitors stopped at 33% of the exhibits on average. In terms of engagement, the elements in “Travels in the Great Tree of Life” are not equal: One of the displays, live elephant shrews (Fig. 1), attracted far more visitors than all the others (82%). Exit interview findings suggest (see below) that, rather than distract or detract from the main phylogenetic message, the elephant shrews and their close relative, a mounted aardvark, supported it.

Among other top attracters: The aardvark and relatives attracted 60% of visitors; the carnivorous plants drew more than half (54%); and *Rafflesia*, a giant plant, drew 49%. The computer game attracted 46% of visitors; however, only 31% were players while 23% watched others play.

Figure 2 suggests that a substantial percentage of visitors who stopped at the top attracting exhibit components also read about them (19% of visitors read about carnivorous plants, 34% about the elephant shrews, 38% about the aardvark specimen, and 28% read about *Rafflesia*). The exhibition’s phylogenetic message was well served by redundancy throughout.

Table 1 ranks the exhibits that attracted the highest percentage of visitors (at least 30%), from highest to lowest. Ten exhibit elements of a total of 19, more than half (55%), attracted more than 30% of the audience.

Beverly Serrell has conducted research comparing many exhibitions across museum type and size of exhibition (Serrell 1998). She defines what she calls the “diligent visitor” as one who attends to 50% or more of an exhibition and the “well-used exhibition” as one whose visitors attended to at least 50% of the exhibit elements. Serrell found very few exhibitions achieved that high standard. “Travels in the Great Tree of Life” falls within the norm of the many exhibitions Serrell studied and compared (Fig. 3).

Visitors’ time in the exhibition ranged from more than 20 minutes to less than two minutes, averaging ten minutes. Half the visitors stayed for less than ten minutes, but half stayed longer and some considerably longer. When compared with other exhibitions of similar size and content (see Serrell 1998), ten minutes average time in a 1,000 square foot exhibition is not unusual.

Fig. 1 Elephant shrews

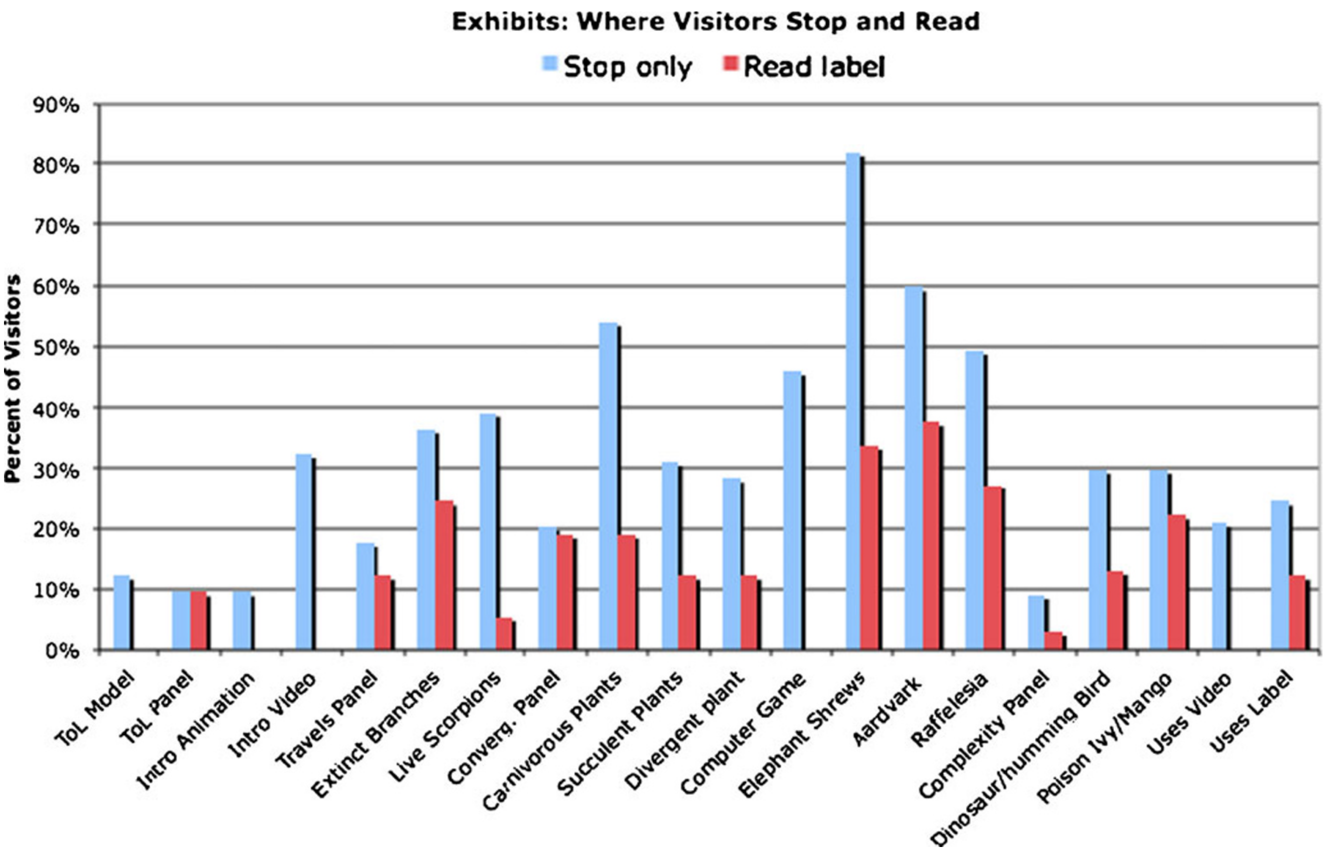

Fig. 2 Exhibits: where visitors stopped and read

Interview Findings

The Main Idea: Phylogenetic Relationships

We asked visitors to explain the ToL to a friend or family member, phrasing the question to avoid the appearance of a test. Among people's motivations for coming to informal science educational institutions is to learn (Hein 1998 p. 146; Csikszentmihalyi and Hermanson in Hooper-Greenhill 1994 pp. 147–153; Falk and Dierking 2000, pp. 16–22; Falk and Dierking 1992, pp. 14–15). But they don't come with the expectation of being tested on what they learned, as they might when studying science in a formal (classroom) educational setting. Exit interview questions were worded to avoid test pressure, which might result in visitors feeling they had "failed" or scored poorly. If visitors fail to "get" the exhibition's message, it is the museum that failed to make concepts appealing and understandable.

The majority of responses (57%) were coded as, "the ToL illustrates the relationships between organisms" or simply, "evolution" (Table 2).

Table 1 Well-used exhibits

Exhibit	Percent of visitors
Elephant shrews	82%
Aardvark	60%
Carnivorous plants	54%
Rafflesia	49%
Computer game	46%
Live scorpions	39%
Extinct branches	36%
Introductory film	32%
Succulent plants	31%
Poison ivy and mango	30%

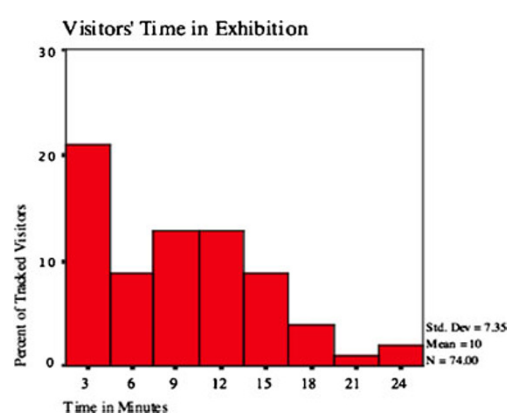

Fig. 3 Visitors' time in exhibition

Table 2 Visitors' perceptions of what ToL represents

Perception	Frequency	Percent
Relationships between/among organisms, connections	38	38
Evolution	19	19
Diversity	7	7
Other	14	14
Don't know, not sure	21	21
Wrong answer (conservation, preserve ecosystem, nature)	3	3
Total	102	102[a]

[a] Percents add up to >100% due to rounding

Responses in visitors' own words:

Relationships among organisms

[The ToL shows] how things are related to each other. I never would have suspected some of the relationships. (Female 19–39)

Building stones of life and evolution and relationship between species. (Male 60 and over)

Evolution

A graphic representation of evolution. (40–59)

The ToL is a system to record the ancestry of all types of life on the planet. (Female 14–18)

In addition, most of the responses categorized as "other" implied an understanding of phylogeny but were vague in articulating the concept. For example: The "[ToL represents] the basics of all life, all being" (Female 14–18) and "the development of animals."

Cognitive Impact: New Learning

Interviewees were asked to describe one thing they had learned in the exhibition that they hadn't known before. Nine in ten (88%) were able to articulate something specific. The most frequent response categories were organisms' relationships/evolution (41% of the responses). The second most frequent responses were interesting facts about specific species (30%). Somewhat fewer respondents said they had learned about current research in the ToL (18%), and just a few noted learning about practical uses of ToL research (6%). Table 3 illustrates the frequency tabulation.

Redundancy in delivering the exhibition's number 1 message, phylogenetic relationships, helped ensure that visitors got it. Aspects of the message were repeated in all the exhibit elements, starting with the three-dimensional Tree model (Fig. 4) at the exhibition entrance. ToL information was included in the introductory film, the Travels text panel, Extinct Branches, information about carnivorous and succulent plants, the computer game, the elephant shrews, the mounted specimens, and information about practical uses.

Table 3 Visitors learned new information

New information learned	Frequency	Percent[a]
About organisms' relationships (you wouldn't expect) and evolution	37	41
Facts about animals and plants	27	30
About current research and the ToL	16	18
Practical uses of the ToL	5	6
Other	5	6
Total	90	100

[a] Percents add up to >100 due to rounding

Visitors' own words best express what they learned.

Learning about phylogenetic relationships: I learned that …

… the cat is closer to a mushroom than flower. (Male 10–13)
… the aardvark is related to elephants. Male 19–39
… lots of those relationships are bizarre. I suppose the huge distance of time has let a lot of weird things happen. (Female 40–59)

About current research

Research: *I didn't know so many people were doing research. (Male 19–39)*
I didn't know how much there was still to categorize (regarding life on our planet). (Female 60)

Facts about animals and plants

Pitcher plants evolved separately on different continents. (Female 19–39)
That elephant shrews were neither elephant nor shrew. (Female 19–39)

"Other" learning

I'm a scientist, but I didn't know all the applications of biodiversity. I didn't know how it was being used. (Male 19–39)

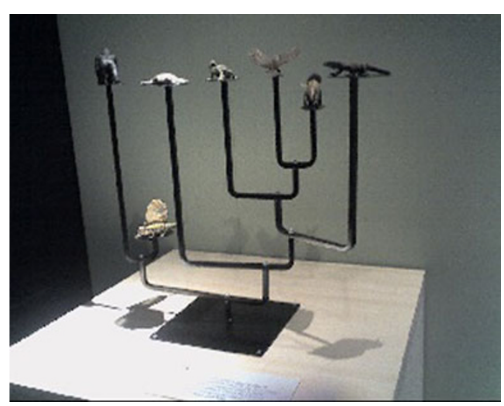

Fig. 4 Tree model at exhibition entrance

Snake—its genes show how to make a bite antivenin from a snake that is related. (Female 19–39)

How to Read the ToL

Interview subjects were shown a small bit of the ToL (Fig. 5) and asked which species was more closely related to the human—the mushroom or the flower.

Unlike front-end study participants, a large majority of respondents correctly answered (78%) "the mushroom." Half of them reasoned, "the mushroom is closer or on the same branch."

Practical Applications of the ToL

Visitors came away from "Travels in the Great Tree of Life" with limited awareness of the variety of practical applications stemming from ToL research. When asked specifically if they could think of any practical uses for the ToL, the top-of-mind response was "basic knowledge" or "education." Almost one in three interviewees (29%) recognized the ToL's practical uses in "health and medicine"—a few visitors mentioned seeing information about the ToL's use in research on the HIV virus. Just 5% mentioned the ToL's value to food and agriculture (Table 4).

Tracking results correlate and shed light on this finding. Just 24% stopped at the text panel (see Fig. 2: uses label) that discusses practical uses and only half of them appeared to read it. All of the visitors who stopped were adults. About one in five (21%) of tracked visitors stopped to watch the video about practical applications (all adults), but the average viewing time was only 1.5 of the film's four minutes.

A few visitors cited a practical benefit of the ToL that is closer to anthropology than biology, saying that understanding that we are all related should make us more tolerant of each other as human beings, for example:

Every student in the U.S. should come here. Maybe they wouldn't judge each other because they would know we're all related. (Female 10–13)

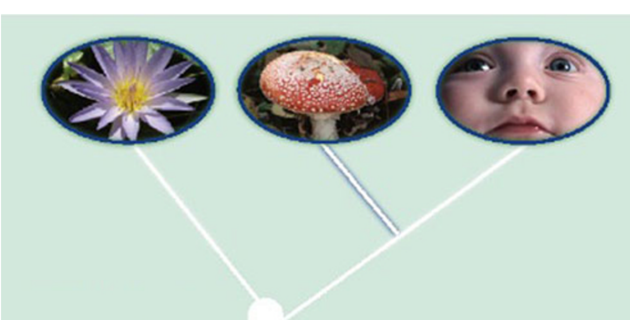

Fig. 5 ToL branch

Table 4 Visitors' ideas of ToL's practical applications

Application	Frequency N=76	Percent
Basic knowledge, education	36	47
Health, medicine, antivenin	22	29
Save the environment, endangered species	12	15
Food, agriculture	4	5
Cultural considerations (e.g., we're all the same so let's get along)	3	4
Other	4	5

Great for racial relations and cultures; as the world gets smaller we find more alikeness. (Female 40–59)

Discussion and Implications

Primary Learning Goal: Phylogenetic Relationships

In preparation for this exhibition, front-end analysis of visitors' preconceptions[1] revealed that many people interpret the expression, "Tree of Life," as a vague ethical or environmental concept relating to the Bible, biodiversity, the ecosystem, conservation, or the Tree of Life in Disney World. Findings showed that very few people thought of the Tree of Life as a cladogram, a scientific construct. Only 29% of front-end interview respondents' top-of-mind association with the ToL had to do with evolution or the interrelationships of species. The exhibition succeeded admirably in redressing the general public's misconceptions. After seeing the exhibition, almost six in ten visitors were able to articulate a reasonably accurate explanation: 39% said the Tree represents relationships between or among organisms; 19% said it represents the evolution of species, and others mentioned nonspecific connections to "all life" and "where animals come from." This represents a substantial advance over front-end findings, doubling the percent of people who understood the Tree as a scientific construct.

"Travels in the Great Tree of Life" appeared to resolve other common misconceptions found in front-end study: Cladograms were no longer perceived as timelines or examples of evolutionary "progress" from simple to complex life forms.

The evolutionary time span was confusing for front-end research participants: Those who tried to interpret a cladogram as a timeline could not grasp that both a dinosaur and a human could be at the top of a branch, seeming to exist contemporaneously. This was not an issue for summative exit interview respondents. Even though they did not articulate the preferred

[1] Giusti, E. and Scott, M. (2006) "Yale Peabody Museum of Natural History: Tree of Life Visitor Study." Unpublished report.

nomenclature, "recency of common ancestry," their reading of the Tree could be deemed to imply this concept.

Participants in the front-end study expressed confusion about the placement of humans on the Tree—several tried to understand how the Tree could be interpreted to illustrate human superiority, or why humans were placed on the same level as a "lower species." The exhibition appears to render moot the notion of human superiority: None of the interview respondents alluded to this when asked which organism on the Tree was closer to the human.

Secondary Learning Goal: ToL Research Is Complex and Ongoing

The vast majority of exit interview respondents knew that the ToL is current research. Ninety-nine percent said the ToL is still growing as opposed to basically complete, and 94% of respondents agreed ("The exhibition showed me that new scientific discoveries are being made that change the ToL."). Visitors took away ideas about surprising results in the research findings: Many of them remarked that they were surprised to learn of the close relationships between cat and fungus or poison ivy and mangoes.

Somewhat fewer visitors expressed understanding of the huge size of the Tree of Life and its complexity that requires a very powerful computer to work on it. Six in ten interviewees agreed, "The exhibition made me realize that it takes a very powerful computer to work on the ToL," but open-ended remarks suggested that this topic was not very interesting to visitors. Information about the complexity of ToL research was displayed in text and graphics on a panel, Tree of Life: A Monumental Scientific Challenge. Tracking indicated that only 9% of the audience stopped to look at the panel, and only 3% read it (see Fig. 2). The panel was text-heavy and may have appeared dauntingly technical to visitors.

The ToL is itself an abstract idea, and abstract ideas typically are difficult to turn into museum exhibitions. The museum succeeded on the whole in rendering this abstract concept concrete through its use of objects, models, and mounted specimens. Conveying the enormity and incredible complexity of the ToL may be beyond the scope of a museum exhibition.

Tertiary Learning Goal: Practical Applications

The exhibition did not convey a strong sense of how the ToL can be used by science and society. When asked to name something new they learned in the exhibition, just 6% of respondents cited some of the ToL's practical applications. When asked if they could name any practical uses for the ToL, advances in health and medicine were the most frequently cited benefits (29%), followed by helping the environment and conservation (15%), and food and agriculture (5%). A few people mentioned an interesting social application for phylogenetic research: The ToL could help with race relations because it shows that we are all related.

Somewhat disappointingly, almost half (47%) respondents' top-of-mind ideas were similar to front-end findings: People still believed that the primary purpose of Trees is to advance scientific knowledge and education.

Outcomes-Based Evaluation

In order to standardize evaluation of science exhibitions so that we can compare apples to apples, the National Science Foundation recommends the recently published Framework for Assessing the Impact of Informal Science Educational Programs (Friedman 2008). The framework represents a systematic way to plan a program so that its science, technology, education and medicine (STEM) goals are measurable. The "broad categories of potential project impacts" to measure are increased awareness knowledge and understanding, engagement and interest, attitudes, and beliefs toward STEM-related topics, behavior, and acquisition of skills.

"Travels on the Great Tree of Life" effectively raised awareness, knowledge, and understanding of its primary learning goal, that the evolutionary relationships of all organisms, living and extinct, can be understood by their placement on a scientific construct, a cladogram, or Tree of Life. A comparison of responses to similar questions from a group of the general public before seeing the exhibition and one after confirms this finding.

Systematic observation and open-ended interview responses indicate that museum visitors were engaged by and interested in the exhibit elements and content. Comparing results from front-end study of the exhibition's potential audience with those of the actual audience, findings indicate that the exhibition increased the lay public's ability to interpret scientific Trees.

"Surrounded by Science," published by the National Academies of Science, points out that for everyone with the exception of professionals, formal schooling represents but a fraction of the lifelong opportunities for learning science. Although people may not realize it, they are occupied in scientific pursuits when bird watching, gardening, and taking care of animals, and various "hobbies" are some of the general public's pursuits that involve learning science. "Surrounded by Science" identifies six strands of informal learning mirroring the framework that effective informal science programs incorporate (Fenichel and Schweingruber 2010).

Museums can be the premiere purveyors of out-of-school science because they typically include one or more of the above referenced Strands, as defined in the following. Strand 1: Sparking interest excitement and motivation to learn about phenomena in the natural and physical world; Strand 2: Understanding scientific content and knowledge, generating, remembering, and using concepts, explanations, arguments, models, and facts related to science; Strand 3: Engaging in scientific reasoning, manipulating, testing, exploring, predicting, questioning, observing, and making sense of the natural and physical world; Strand 4: Reflecting on science as a way of knowing, including the processes, concepts, and institutions of science. It also involves reflection on the learner's own process of understanding natural phenomena and the scientific explanations for them; Strand 5: Using the Tools and Language of Science, participation in scientific activities and learning practices with others, using scientific language and tool; Strand 6: Identifying with the scientific enterprise, coming to think of oneself as a science learner and developing an identity as someone who knows about, uses, and sometimes contributes to science (Fenichel and Schweingruber 2010).

Conclusions and Implications

The framework and the strands represent the formal science establishment's recognition of the value of non-formal modalities to educate the public about science. To be responsible members of society, it is crucial that citizens be able to participate knowledgably in the political decision-making process on issues of nuclear energy, climate change, nanotechnology, digital technology, and aerospace programs.

Research on the complexity of the Tree of Life will potentially have great impact on human life—in areas of health and medicine, the environment and conservation, agriculture and the production of food.

"Travels in the Great Tree of Life" advanced the visiting public's understanding of scientific Trees. Visitors gained awareness and understanding of phylogenetic relationships and how they are arrayed on a scientific Tree. The exhibition sparked interest and excitement through its use of unusual live animals and juxtapositions of mounted specimens and models. Interactive components allowed visitors to simulate participation in the scientific process. Being able to decode the interpretive material allowed visitors to believe that they are capable of understanding complex scientific concepts and constructs. The only area where "Travels" did not fully succeed in its goals was conveying the many practical applications of research on Trees.

Appendix. Demographic Data

Interview Respondents

Table 5 Demographic data of interview respondents: gender

Gender	Frequency	Percent
Female	49	48
Male	45	44
Missing data	8	8
Total	102	100

Table 6 Demographic data of interview respondents: age

Age, years	Frequency	Percent
10–13 years	18	18
14–18 years	5	5
19–39 years	40	39
40–59 years	28	29
60 plus years	9	9
Missing data	1	1
Total	102	101[a]

[a]Percents add up to >100 due to rounding

Table 7 Demographic data of interview respondents: residence

Place of residence	Frequency	Percent
New Haven area	41	40
Other Connecticut	39	38
Other USA	18	18
International	3	3
Missing data	1	1
Total	102	100

Table 8 Demographic data of interview respondents: visiting

Visiting	Frequency	Percent
Alone	10	10
With family	79	78
With friends	13	13
Total	102	101[a]

[a]Percents add up to >100 due to rounding

How well informed are you about scientific discoveries and technology?

Table 9 Demographic data of interview respondents: how informed do visitors feel about scientific discoveries and technology

How informed visitors feel	Frequency	Percent
Very well informed	30	29
Moderately well informed	59	58
Poorly informed	10	10
Missing data	3	3
Total	102	100

Table 10 Demographic data of interview respondents: special training in science

Special training	Frequency	Percent
No	66	65
Yes	35	34
Missing data	1	1
Total	102	100

Table 11 Demographic data of interview respondents: highest level of education completed

Highest level of education	Frequency	Percent
Middle school	9	9
High school	6	6
Some college	13	13
Bachelor degree	27	27
MA/PhD/professional degree	34	33
Missing data	13	13
Total	102	101

Percents add up to >100 due to rounding

Table 12 Demographic data of interview respondents: grade just completed (students)

Grade just completed	Frequency	Percent
Third to sixth grade	14	74
Seventh to 11th grade	5	26
Total	19	100

Tracked Sample

Table 13 Demographic data of tracked sample: gender

	Frequency	Percent
Female	33	45
Male	39	53
Missing data	2	3
Total	74	101[a]

[a]Percents add up to >100 due to rounding

Table 14 Demographic data of tracked sample: age

Age, years	Frequency	Percent
10–13 years	6	8
14–18 years	3	4
19–39 years	19	26
40–59 years	37	50
60 plus years	8	11
Missing data	1	1
Total	74	100

References

Csikszentmihalyi M, Hermanson K. Intrinsic motivation in museums: why does one want to learn? In: Hooper-Greenhill E, editor. The educational role of the museum. New York: Routledge; 1994.

Falk J, Dierking L. Learning from museums: visitor experiences and the making of meaning. Walnut Creek: Altamira Press; 2000.

Falk J, Dierking L. The museum experience. Washington, DC: Whalesback Books; 1992.

Fenichel M, Schweingruber H. Surrounded by science: learning science in informal environments. Board of Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press; 2010.

Friedman A, editor. Framework for evaluating impacts of informal science education projects [online]. 2008. (Available at: http://insci.org/resources/Eval_Framework.pdf).

Giusti E. Travels in the great tree of life: a summative evaluation. Yale Peabody Museum of Natural History. Unpublished report. 2008.

Giusti E and Scott M. Yale Peabody Museum of Natural History: tree of life visitor study. Unpublished report. 2006.

Hein G. Learning in the museum. New York: Routledge; 1998.

Serrell B. Paying attention: visitors and museum exhibitions. Washington, DC: American Association of Museums; 1998.