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Learning Innovation



Microscope Imaging Station
Summative Evaluation

The Exploratorium

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Table of Contents

Introduction	2
Methods	4
Results and Discussion	7
Characteristics of the Visitor Sample	7
Key Exhibit Findings	9
Specimens	
Alive	
Size	
Microscope	
Sense of Wonder	
Connections to Life	
Connections to Basic Biological Research	
Connections to Human Health	
Tracking and Timing.....	26
Key Demonstration Findings.....	29
Conclusions	30
Acknowledgements.....	33
References	34
Appendix: Instruments	
Short Interview – Microscopes	
Short Interview – Media Pod	
In-Depth Interview	
Demonstration Survey – Giant Chromosomes	
Demonstration Survey – Germ Busters	

Introduction

In March of 2000, the Exploratorium submitted a National Institutes of Health (NIH) grant proposal to gain support for the development of Microscope Imaging Station. In the context of the NIH proposal, Microscope Imaging Station was described as:

“...a high-quality microscope imaging station...to display an unusually broad variety of living specimens fundamental to basic biology, human development, the human genome, and health related research...[providing] interactive access to breathtaking biological events at microscopic scales” (NIH Proposal, p.17).

The Exploratorium has since developed Microscope Imaging Station, a set of innovative, research-grade microscope equipment, supported by media and demonstrations. Microscope Imaging Station allows visitors to explore a broad variety of living specimens that are model organisms with particular relevance in the fields of biology and biomedicine. There are four components to Microscope Imaging Station: 1) a Zeiss Axiovert standalone microscope exhibit; 2) a Leica standalone microscope exhibit; 3) two Media Pod exhibits (with the same content); and 4) two demonstrations. Exploratorium staff purposefully planned the two microscope exhibits to allow visitors to explore basic biology. The two media exhibits build upon this basic biology with additional context and personally-relevant details in biomedical research.

The Exploratorium conducted extensive formative evaluation to gauge how well Microscope Imaging Station exhibits present interesting, engaging specimens that are well supported by labels, media, and demonstrations. The Institute for Learning Innovation (the Institute) was contracted to conduct a summative evaluation. The summative evaluation focused on the degree to which individual exhibit elements of Microscope Imaging Station collectively contributed to the project’s goals, as well as visitors’ interactions with and responses to individual elements of Microscope Imaging Station.

The overall goals of the Microscope Imaging Station project are to inspire an appreciation of the microscopic world and to empower visitors to see the personal significance in microscopic images of biological specimens. Each element makes distinct but overlapping contributions to reaching this overall goal. The Zeiss Axiovert microscope features zebrafish and amoeba and introduces visitors to the microscopic world and its relationship to basic biology. The Leica microscope features *C. elegans* (microscopic worms). The Leica exhibit, as in the Zeiss exhibit, was designed to introduce the microscopic world and convey its relationship to basic biology to Microscope Imaging Station visitors. The Media Pod elements provide a videographic explanation of how microscopic specimens are being used by scientists for biomedical research related specifically to human health. Finally, special demonstrations are conducted throughout the day, focusing on biological and biomedical research.

The details of the summative evaluation were finalized in consultation with the Microscope Imaging Station team. As part of that process, the project goals were refined and aligned with specific exhibit elements. (Alignment with exhibit elements is indicated below in parentheses.) The following project goals are based on the March 25, 2004 Debriefing Memo.

- 1) Visitors will successfully use a research-grade microscope to see a live, microscopic specimen. (Microscopes—both Zeiss and Leica)
- 2) Visitors will realize that they are using a microscope to see a very small specimen. (Microscopes—both Zeiss and Leica)
- 3) The experience will foster a sense of wonder about a microscopic world that they normally cannot see. (Microscopes—both Zeiss and Leica—Media Pod **and** Demonstrations¹)
- 4) The experience will encourage visitors to make personal connections between what they see and themselves. (Microscopes—both Zeiss and Leica—and Media Pod)
- 5) The experience will encourage visitors to make connections between what they see and basic biological research. (Microscopes²—both Zeiss and Leica—Media Pod and Demonstrations)
- 6) The experience will encourage visitors to make connections between what they see and biomedical research. (Media Pod)

The team agreed that visitors are not expected to focus on the microscopes except to realize that they are using a microscope to see the specimen. Nor are visitors expected to recognize that there are two different types of microscopes. Based on these premises, the specific project goals, and the extensive formative evaluation, Institute researchers developed a three-part summative evaluation. This report summarizes the results of the summative study.

¹ According to the 3/25/04 Debriefing Memo, goal #3 was originally connected to the microscopes, Zeiss and Leica, and the Media Pod, since then Microscope Imaging Station staff has also connected this goal with the demonstrations.

² According to the 3/25/04 Debriefing Memo, goal #5 was originally connected to the Media Pod, since then Microscope Imaging Station staff has also connected this goal with the microscopes, Zeiss and Leica, and the demonstrations.

Methods

The three components of the summative evaluation were designed to provide complementary information. Individually, each part of this study highlighted the strengths and weaknesses of different exhibit elements of Microscope Imaging Station, but also contributed to an overall understanding of the visitor experience. The components of the evaluation included yes-no, open-ended, and ranking questions. This design provided qualitative data on visitors' overall understanding and impressions of Microscope Imaging Station, while also gathering quantitative feedback on more specific issues. Each questionnaire was reviewed by a representative of the Microscope Imaging Station team and revisions were made accordingly. (See the Appendix for copies of each instrument.) A total of 411 visitors participated in the summative evaluation. The three components of the evaluation were:

- 1) **Self-Administered Demonstration Survey:** Exploratorium staff distributed a 12-question survey after each Microscope Imaging Station demonstration. Visitors filled out the survey themselves and returned it voluntarily. This data collection began in June and continued through July. A total of 126 surveys were collected; 77 from the Giant Chromosomes demonstration and 49 from the Germ Busters demonstration. In addition to answering the 12 questions about the demonstration, visitors were asked to answer three demographic questions (sex, age, and grouping).
- 2) **Short Interview:** Four data collectors from the Exploratorium were trained by Kirsten Ellenbogen and Cheryl Kessler. The data collectors interviewed a total of 244 visitors in July. Visitors were randomly recruited to participate in the interview after they were observed spending at least 30 seconds³ at one of the exhibit elements of Microscope Imaging Station (the Leica microscope, the Zeiss microscope, or one of the Media Pods). Therefore, the results do not provide information on "brief visitors," or visitors who spent less than 30 seconds at the exhibit element.
 - Interviews about the Leica exhibit element: 84
 - Interviews about the Zeiss exhibit element: 79
 - Interviews about the Media Pod exhibit element: 81

The short interview included 12 questions. The data collectors also filled in four demographic questions (sex, grouping, ESL, and estimated age). Short interviews were analyzed according to exhibit element (Zeiss, Leica, or Media Pod). Additionally, comparisons are made below between visitors who responded to the short interviews (those who visited only one exhibit element) and visitors who responded to the in-depth interviews described (those who had the opportunity to visit all Microscope Imaging Station exhibits).

- 3) **In-Depth Interview and Timing:** The in-depth interviews were conducted over a period of two days in July. Kirsten Ellenbogen, Cheryl Kessler, and one

³ This time was selected based on consultation with the Microscope Imaging Station team.

Exploratorium data collector randomly recruited 41 visitors as they approached one of the exhibit elements of the Microscope Imaging Station collection, asking them to participate in the study. The different components of Microscope Imaging Station were pointed out and the recruited visitors were asked to spend as little or as much time at Microscope Imaging Station exhibits as they wished before participating in an exit interview. These visitors were unique because, for the most part, they saw all of the elements of Microscope Imaging Station. A total of 39 visitors were tracked through Microscope Imaging Station (two timing and tracking data sheets were not sufficiently completed and therefore, could not be included in this portion of the results). The timing and tracking data collection included:

- Location of each stop (feet planted on the floor, head turned in the direction of the exhibit element for at least 3 seconds).
- Length (in minutes and seconds) of each stop.
- Interactions at each stop (read out loud, interacting with touch screen, call over, point, talk, interact with focus, interact with joystick, interact with UV light, interact with zoom).
- Specimens observed at each stop.
- Additional comments (e.g., overheard comments) at each stop.
- Total time in Microscope Imaging Station.

Note that visitors' conversations were not recorded, so there was no opportunity to analyze specific discourse trends, such as visitors' tendencies to make predictions or provide explanations. The post-visit interview was designed to build upon the short interview and had a total of 15 questions; 12 of the questions overlapped with the short interview. The data collectors also filled in four demographic questions (sex, grouping, ESL, and estimated age).

The extent of the timing and tracking for this summative evaluation was purposely limited. According to an extensive meta-analysis of tracking and timing studies (Serrell, 1998), an exhibition must fit certain criteria to qualify it for comparison among other timing and tracking studies. Specifically, an exhibition should be larger than 1,000 square feet and should contain at least ten exhibit elements. Therefore, comparing tracking results to national data is not possible due to a lack of data on exhibits of such small size. After discussions with Microscope Imaging Station staff, it was agreed that Microscope Imaging Station did not fit the criteria to be comprehensively evaluated as an exhibition with timing and tracking. Consequently, a minimal amount of timing and tracking data were collected.

The Microscope Imaging Station team designated the target audience for the summative evaluation as visitors to Microscope Imaging Station aged eight and older (determined by a sight-based estimate)⁴. If target visitors appeared to be under the age of 16, the data collector obtained verbal consent for them to participate from parents or guardians. Any visitor who had participated in a previous evaluation that day (i.e., the visitor was

⁴ Refer to the March 25, 2004 Debriefing Memo.

wearing a black sticker) was ineligible for the study. At the request of the Microscope Imaging Station team, each interview was conducted with an individual (rather than a group). Thus, only single visitors or one member per group were included in the evaluation.

Open-ended questions were analyzed into qualitative coding categories. Qualitative coding categories emerged from visitor data. While researchers were cognizant of evaluation goals in creating coding categories, the frequency and similarities of visitors' responses determined resulting categories. Note that the coding categories for many questions were not mutually exclusive. Specifically, responses to some questions could be coded in more than one category, so the percentages could total more than 100%. Additionally, the n for every question was not always 411 because all questions were not asked in every evaluation component (for example, Media Pod visitors were not asked to identify the size of the specimen, therefore the n for any reference to size is only 204), and data collectors occasionally did not fill out demographic data or left out one of the introductory questions.

Data analysis utilized the statistical software program *SurveyPro* allowing chi square analysis, as appropriate. The significance level for all statistical analyses was set at .05. For example, data were analyzed for significant differences between the responses of female and male visitors as well as visitors' self-reported interest and knowledge levels. Data were also analyzed for overarching issues or themes that emerged from the interviews. These issues were brought up by many visitors over the course of the interviews and were not specifically related to any single interview question.

Results and Discussion

Characteristics of the Visitor Sample

A total of 411 visitors participated in the summative evaluation. Most of this sample participated in the short interviews (n = 244) or in-depth interviews (n = 41), which had a series of common questions that included more detailed demographic information than the demonstration surveys. The short interviews were used to gather data regarding three elements within Microscope Imaging Station. Of the 244 short interview participants, 79 participated at the Zeiss microscope station, 84 participated at the Leica microscope station, and 81 responded after visiting a Media Pod. A smaller number (126) of visitors participated in the self-administered demonstration survey. Demographic details below are from the visitors who participated in the short or in-depth interviews; data from the demonstration surveys are described later in the report.

Overall, most (57%) of the visitors that were interviewed were part of a group that included adults and children. Most of the interviewees were female (53%). Data collectors characterized only a small percentage (15%) of the visitors as non-native English speakers (ESL). The largest age group of visitors (21%) were estimated to be in their 30s. This was followed closely by visitors under 12. A median split for the age categories was calculated (on the entire interview data set—thus gaining a more representative age split) to use in cross tabulations; visitors aged 30 and older were above the median. The complete age ranges are detailed below in Table 1.

Table 1: Age Range of Interviewed Visitors

Age	Percent of Zeiss Visitors (n = 79)	Percent of Leica Visitors (n = 84)	Percent of Media Pod Visitors (n = 81)	Percent of In-Depth Visitors (n = 41)	Percent of Exhibit Sample (n = 279)
8-12	24%	21%	18%	14%	20%
13-17	15%	14%	17%	11%	15%
18-20s	9%	10%	20%	23%	14%
30s	28%	19%	17%	23%	21%
40s	18%	20%	16%	14%	18%
50s-60+	6%	16%	12%	14%	12%

More than half (58%) of the visitors who participated in the short or in-depth interview reported that this was their first visit to the Exploratorium. Visitors were also asked to rank their interest in and knowledge of biology. They were given a scale of 1 to 10 (1 was “I have absolutely no interest in biology” or “I know absolutely nothing” and 10 was “I am extremely interested in biology” or “I am a biomedical research scientist”).

The mean interest rating was 6.8. A median split for the interest rating was calculated to use in cross tabulations; visitors who ranked themselves at 7 or above were high interest. The mean knowledge rating was 4.5. Based on the median split calculation, visitors who ranked themselves at a 5 or above were high knowledge. Median split calculations were conducted on the entire sample, rather than breaking these data down by exhibit element

and then calculating median splits. It was expected that the overall median split would be more representative of typical Microscope Imaging Station visitors (who will most likely visit more than one element). Visitors' self-reported interest and knowledge levels did not significantly differ by age or sex. No significant differences were found between visitors with high or low levels of knowledge and sex or age for interview data (where short and in-depth were combined in an overall analysis), for each separate element, and for Microscope Imaging Station as a whole.

Short Interview Zeiss: Most (63%) of the visitors that were interviewed at the Zeiss station were part of a group that included adults and children. More than half of Zeiss visitors were female (56%). Data collectors characterized only a small percentage (15%) of the visitors as non-native English speakers (ESL). The largest age group of visitors (28%) were estimated to be in their 30s. This was followed closely by visitors under 12 (see Table 1).

Short Interview Leica: Most (58%) of the visitors that were interviewed at the Leica station were part of a group that included adults and children. More than half of Leica visitors were female (52%). Data collectors characterized only a small percentage (11%) of the visitors as non-native English speakers (ESL). The largest age group of visitors to the Leica microscope (21%) were estimated to be under 12. This was followed closely by visitors in their 40s (see Table 1).

Short Interview Media Pod: Most (51%) of the visitors that were interviewed at a Media Pod were part of a group that included adults and children. More than half of Media Pod visitors were female (61%). Data collectors characterized about a quarter (26%) of the visitors as non-native English speakers (ESL). Although this is a higher percentage of ESL participants, it is important to note that there are no significant differences among ESL and non-ESL participants across other concepts of interest (i.e., personal, biological, or biomedical connections). The largest age group of visitors (20%) were estimated to be between 18 to 29. This was followed closely by visitors under 12 (see Table 1).

In-Depth Interviews: Most (54%) Microscope Imaging Station visitors were part of a group that included adults and children. More than half of the visitors were female (56%). Data collectors characterized only a small percentage (6%) of the visitors as non-native English speakers (ESL). Finally, the two largest age groups of visitors (23%) were those who were estimated to be between 18 and 39 (see Table 1).

Key Exhibit Findings

Visitors who participated in the short and in-depth interviews were asked a range of 2-4 questions to solicit spontaneous descriptions of Microscope Imaging Station. This included “How would you describe this exhibit to another visitor at the Exploratorium?” and “What would you say is the main idea of the three exhibits you just saw?” These data were analyzed for the presence of statements related to the exhibit goals and supported by more directed questions asked later in the interview. Responses address the following issues: (1) Were the specimens an important and meaningful part of the experience?; (2) Did visitors appreciate that the specimens were alive?; (3) Did visitors understand the size of the specimens?; (4) Were the microscopes an important part of the exhibit experience?; (5) Did visitors experience a sense of wonder while at Microscope Imaging Station? Each issue is discussed in further detail below.

Microscope Imaging Station was designed to encourage visitors to connect what they saw to themselves, to biological research, and to human health. A variety of questions were posed to gauge visitors’ ability to make these connections, including open-ended questions asking them to describe Microscope Imaging Station. Responses address the following issues: (6) Did visitors make connections between the exhibit content and themselves?; (7) Did visitors make connections between the exhibit content and basic biological research?; and (8) Did visitors make connections between the exhibit content and human health? Overall, visitors were able to make strong connections to Microscope Imaging Station. Each issue is discussed in further detail below along with examples of visitors’ most common responses.

(1) Specimens: Microscope Imaging Station was designed to make microscopic specimens accessible and meaningful to visitors. The Microscope Imaging Station team worked to ensure that visitors could identify the specimens they were viewing under the microscopes by including text that provided both the common and technical specimen terminology.

When asked a series of general descriptive questions about Microscope Imaging Station (either as separate elements or as a whole), fully 84% (n = 202) of the visitors spontaneously mentioned specimens. The specimens were the most often mentioned element in Microscope Imaging Station descriptions. There were no significant differences between a visitors’ self-rated knowledge or interest in biology and their likelihood of spontaneously mentioning a specimen in their description. Nor was there any significant difference between ESL and non-ESL visitors and their likelihood of mentioning a specimen in their description.

Table 2: Specimens Named

Specimen (element where exhibited)	Percent of Zeiss Visitors (n = 79)	Percent of Leica Visitors (n = 83)	Percent of In-Depth Visitors (n = 40)	Percent of Exhibit Sample (n = 202)
Worms (specimen at Leica Microscope)	3%	92%	93%	57%
Zebrafish or Fish (specimen at Zeiss Microscope)	60%	0%	85%	40%
Amoeba (specimen at Zeiss Microscope)	29%	0%	28%	17%
Cells or Blood Cells (discussed in media at Zeiss Microscope)	23%	0%	10%	11%
Other	25%	10%	20%	8%
I Don't Know	9%	4%	0%	5%

Overall, when visitors were explicitly asked what specimens they had been looking at, only 5% could not name any specimens. Most visitors were able to name one or more specimens (see Table 2). The other specimens named by visitors included jellyfish, humans, algae, and bacteria. Note that one of the categories that emerged from this visitor data is cells or blood cells. Although this was not one of the specimens exhibited, blood cells and cells were mentioned in several places throughout the media accompanying the Zeiss microscope.

Short Interview Zeiss: When asked a series of general descriptive questions about the Zeiss microscope exhibit, 72% (n = 79) of the visitors spontaneously mentioned specimens. The specimens were the most often mentioned element in the Zeiss descriptions. There were no significant differences between visitors with high or low self-rated knowledge or interest in biology and their likelihood of spontaneously mentioning a specimen in their exhibit description. Nor was there any significant difference between ESL and non-ESL visitors and their likelihood of mentioning a specimen in their exhibit description.

When Zeiss visitors were explicitly asked what specimens they had been looking at, only 9% could not name any specimens. Most visitors were able to name one or more specimens, and most mentioned the featured specimens; zebrafish and/or amoeba (see Table 2 above).

Short Interview Leica: When asked a series of general descriptive questions about the Leica microscope exhibit, 88% (n = 83) of the visitors spontaneously mentioned specimens. Again, the specimens were the most often mentioned element in the exhibit

descriptions. There were no significant differences between visitors with high or low self-rated knowledge or interest in biology and their likelihood of spontaneously mentioning a specimen in their exhibit description. Nor was there any significant difference between ESL and non-ESL visitors and their likelihood of mentioning a specimen in their exhibit description.

When Leica visitors were explicitly asked what specimens they had been looking at, only 4% could not name any specimens. Most visitors were able to name one or more specimens, and almost all visitors mentioned the featured specimen, worms (see Table 2).

Short Interview Media Pod: When asked a series of general descriptive questions about the Media Pod exhibits, 89% (n = 81) of the visitors spontaneously mentioned specimens. The specimens were the most often mentioned element in the exhibit descriptions. There were no significant differences between visitors with high or low self-rated knowledge or interest in biology and their likelihood of spontaneously mentioning a specimen in their exhibit description. Nor was there any statistically significant difference between ESL and non-ESL visitors and their likelihood of mentioning a specimen in their exhibit description. Media Pod visitors were not explicitly asked to name the specimens they saw. Zeiss, Leica, and in-depth interviewees were explicitly asked to name specimens in an effort to deal with issues unique to the microscopes (therefore, the question was inapplicable to Media Pod content).

In-Depth Interviews: As previously mentioned, in-depth respondents were given the opportunity to visit each element of Microscope Imaging Station prior to participating in the interview process. When asked a series of general descriptive questions about the exhibits, 88% (n = 40) of the visitors spontaneously mentioned specimens. The specimens were the most often mentioned element in the exhibit descriptions. There were no significant differences between visitors with high or low self-rated knowledge or interest in biology and their likelihood of spontaneously mentioning a specimen in their Microscope Imaging Station description. Nor was there any significant difference between ESL and non-ESL visitors and their likelihood of mentioning a specimen in their exhibit description.

When in-depth respondents were explicitly asked what specimens they had been looking at, none were unable to name a specimen. Most visitors were able to name more than one specimen (see Table 2).

In the in-depth interview, visitors were asked about the most memorable thing they saw at Microscope Imaging Station. In this instance, the beating heart of the zebrafish and the glowing of the worms were mentioned most frequently (see Table 3).

Table 3: Most Memorable Thing (n = 40)

Specimen	Percent
Beating or Pumping heart	33%
UV, Florescence, Glowing (of worms)	28%
Zebrafish (not heart)	18%
Worms (aging, not UV)	13%
Blood cells	5%
Amoeba	3%

When the specimen and its feature were combined (i.e., beating heart and zebrafish or UV and worms), just over half (51%) of the visitors thought the zebrafish was the most memorable thing they saw. Just under half (41%) of the visitors thought the worms were the most memorable thing they saw. These data suggest that visitors had a rather balanced attention to the two most popular specimens in Microscope Imaging Station (worms and zebrafish).

(2) Alive: Microscope Imaging Station was designed to allow visitors access to live specimens. The live aspect of the Microscope Imaging Station specimens greatly contributed to the unique and innovative quality of exhibit and therefore, it was important to identify whether visitors recognized that the specimens were alive.

When asked directly, almost all (91%; n = 202) visitors who participated in the Zeiss, Leica, or In-depth interviews recognized that they were looking at live specimens. When in-depth visitors were asked why the live aspect of Microscope Imaging Station was interesting, 85% gave positive feedback and felt that this was important to the overall message (see Table 4). The importance of live specimens was also apparent in the demonstration data (see Table 8).

Short Interview Zeiss: When asked directly, 85% (n = 79) of visitors to the Zeiss microscope recognized that they were viewing live specimens.

Short Interview Leica: When asked directly, 95% (n = 84) of visitors to the Leica microscope recognized that they were viewing live specimens.

In-Depth Interviews: When asked directly, 95% of in-depth visitors recognized that they were viewing live specimens while at the microscope exhibits. In the in-depth interviews, visitors were asked to elaborate on the live aspect of Microscope Imaging Station: “Why is the fact that the specimens were alive interesting?” Only 10% (n = 39) of these visitors felt that the fact that the specimens were alive was not important. A very small percentage (5%, i.e., 2 visitors) made a negative comment about the fact that Microscope Imaging Station included live specimens. There were five other common responses to this question (see Table 4), but more than half of the visitors’ responses included some sort of positive exclamation or commentary on the fact that the specimens were alive, such as “that’s cool,” “that’s the best part,” or “that’s what makes it interesting.”

Table 4: What Makes Alive Interesting? (n = 38)

Comment	Percent of Sample
Positive comment	55%
Movement	42%
Real science, Authenticity	21%
Better than	13%
Unique	11%
Not important	10%
Negative comment	5%

More than two-fifths (42%) of the visitors' responses included a comment about the movement of the specimens, or their ability to get the specimens to physically react to them. About a fifth (21%) of the responses pointed out that the live specimens made the experience authentic or real science. Smaller percentages of the responses included comments that the live specimens made the experience better than a book, or film (13%), or that the live specimens made the experience unique (11%).

Results from in-depth interviews and from the two different microscopes indicate that the Microscope Imaging Station team has successfully made exhibits that convey the live nature of the specimens involved. There is no statistically significant difference between Zeiss and Leica responses. In addition, results indicate that viewing live specimens contributed to visitors' sense of wonder (visitors' sense of wonder is further discussed below).

(3) Size of specimen: Microscope Imaging Station was designed to allow visitors to successfully use a research grade microscope to see a live microscopic specimen. The Microscope Imaging Station team wanted to know whether visitors understood that the specimens under the microscopes were microscopic. Visitors who participated in the short interview about the Zeiss or Leica exhibits or the in-depth interview were asked about the actual size of the specimens they saw. They were asked to choose between a series of familiar objects: a speck of dust, a dime, a tennis ball, or other. (See Table 5.)

Table 5: Size of Specimen

Size Descriptor	Percent of Zeiss Visitors (n = 79)	Percent of Leica Visitors (n = 84)	Percent of In-Depth Visitors (n = 40)	Percent of Exhibit Sample (n = 203)
Speck of Dust	70%	69%	45%	65%
Dime	15%	13%	13%	14%
Tennis Ball	4%	4%	5%	4%
Other – large	7%	7%	22%	11%
Other – smaller than a speck of dust	4%	7%	15%	6%

Overall, most visitors (65%; n = 203) appreciated the small size of the specimens. A small percentage of responses (6%) in the 'other' category suggested that visitors did not want to use the size comparisons provided in the interview, but they did understand the size of the specimen, e.g., tiny, not visible, microscopic, 3/4 mm, and a small dot. The responses that fell into the 'other – large' category included fingernail, pea, and small worm. Visitors' responses to the demonstration questionnaire also alluded to the importance of the microscopic size of the specimens in creating an interesting experience (see Table 8).

There was a significant difference between exhibit element type (i.e., Leica, Zeiss, Media Pod, or all for in-depth) and visitors' recognition of the microscopic size of the specimen. Follow up analyses revealed that visitors who participated in the in-depth interview were significantly less likely to describe the specimens as the size of a speck of dust. However, when combined with other responses that indicate an understanding of the small size (e.g., small dot) the percentages were comparable to the Zeiss and Leica visitors (no significant differences were found).

Short Interview Zeiss: The majority of Zeiss visitors recognized the microscopic size of the specimens they were viewing. Specifically, 70% (n = 79) recognized that the specimens were at least as small as a speck of dust. An additional 4% recognized the small size, but chose different words (e.g., a small dot and microscopic) as descriptors. Approximately one quarter (26%) of Zeiss visitors were not aware of the microscopic size of the specimens.

Short Interview Leica: The majority of Leica visitors recognized the microscopic size of the specimens they were viewing. Specifically, 69% (n = 84) recognized that the specimens were at least as small as a speck of dust. An additional 7% recognized the small size, but chose different words (e.g., a small dot and microscopic) as descriptors. Approximately one quarter (24%) of Leica visitors were not aware of the microscopic size of the specimens.

In-Depth Interviews: As previously mentioned, in-depth interviewees were asked to visit all of Microscope Imaging Station before responding to the interview questions. Less than half (45%; n = 40) of these respondents recognized the microscopic size of the specimens they were viewing. However, an additional 15% recognized the small size, but chose different words (e.g., small dot and microscopic) as descriptors. Two-fifths (40%) of visitors who had the opportunity to visit the entire Microscope Imaging Station were unaware of the actual microscopic size of the specimens.

(4) Microscope: One goal of Microscope Imaging Station was to engage visitors in a meaningful exploration of microscopic specimens, but the experience was not designed to emphasize the microscope itself. The Microscope Imaging Station team explicitly stated that the visitors were not expected to focus on the microscopes except to recognize that they were using a microscope to see a specimen.

Overall, data analysis revealed that only 30% of the 204 visitors who participated in the short interview about the Zeiss or Leica exhibit elements or the in-depth interview mentioned microscopes in their initial descriptions of Microscope Imaging Station. The microscope was not the primary focus of the visitor experience. Visitors' descriptions of their Microscope Imaging Station experience (whether focused on single elements or the entire space) were more focused on other, more critical exhibit concepts, such as the specimens, or a sense of discovery. However, almost all (93%, n = 202) of these visitors recognized they were using a microscope to see the specimens when they were explicitly asked. Visitors' self-rated knowledge, interest in biology, and first language (ESL) had no significant impact on their likelihood of mentioning the microscope spontaneously in their exhibit descriptions or their tendency to say that they did know they were using a microscope when asked directly.

Visitors did show mastery over a range of microscope controls (see the in-depth interviews section below). Additionally, 16% (n = 284) of visitors' descriptions included language that indicated a feeling of control over the microscopes such as followed, zoomed, or focused and almost a quarter of the descriptions included a mention of the UV lights. These data suggest that visitors did not focus on the presence of the microscopes at Microscope Imaging Station, but instead focused on the use of the microscopes as tools. Finally, more than half (53%, n = 284) of the visitors' descriptions of Microscope Imaging Station included language about exploring, looking for something, showing, or comparing; this will be further discussed below in regard to the sense of wonder inspired at Microscope Imaging Station.

Short Interview Zeiss: About a quarter of Zeiss visitors (27%; n = 79) spontaneously mentioned microscopes in their initial descriptions of Microscope Imaging Station. However, when directly asked, the majority (94%) of visitors did know that they were using a microscope. The microscope was not the primary focus of the Zeiss visitor experience, yet the visitor did recognize they were using a microscope. Zeiss visitors' self-rated knowledge and first language (ESL) had no impact on their likelihood of mentioning the microscope spontaneously in their exhibit descriptions or their tendency to say that they did know they were using a microscope when asked directly. Zeiss visitors who rated themselves as having high interest in biology did spontaneously mention microscopes significantly more often than visitors with self-rated low interest. Familiarity and past experience tend to influence personal interest, but because interest was reported post-experience, it is possible that prior microscope use contributed to higher interest levels and more frequent mentions of the actual microscope.

Short Interview Leica: Less than two-fifths (38%; n = 84) of Leica visitors spontaneously mentioned microscopes in their initial descriptions of Microscope Imaging Station. However, when directly asked, the majority (89%) of visitors did know that they were using a microscope. The microscope was not the primary focus of the Leica visitor experience, yet the visitor did recognize that they were using a microscope. Leica visitors' self-rated knowledge, interest in biology, and first language (ESL) had no impact on their likelihood of mentioning the microscope spontaneously in their exhibit

descriptions or their tendency to say that they did know they were using a microscope when asked directly.

In-Depth Interviews: Less than one-fifth (18%; n = 40) of the in-depth interviewees who had the opportunity to visit the entire Microscope Imaging Station spontaneously mentioned microscopes in their initial descriptions of Microscope Imaging Station. However, when directly asked, almost all (98%; n = 39) visitors did know that they were using a microscope. The microscope was not the primary focus of the Microscope Imaging Station visitor experience, yet the visitor did recognize that they were using a microscope. For in-depth interviewees, self-rated knowledge, interest in biology, and first language (ESL) had no impact on the likelihood of mentioning the microscope spontaneously in descriptions of Microscope Imaging Station or on the tendency to say that they did know they were using a microscope when asked directly.

During the in-depth interview (n = 37), visitors were asked what they were able to do with the microscopes. Responses fell into four common categories: (a) zoom – 78%; (b) focus – 54%; (c) move specimen – 49%; and (d) use UV lights – 35%. These responses suggest that visitors were able to master a range of microscope controls. Less common in the visitors' responses however, was some indication of searching for or finding a specimen. Using the microscope to find a specimen was only mentioned in 8% of the responses. This may, however, simply be due to the visitors' focus on describing physical controls at the microscope rather than why they used those physical controls.

(5) Sense of Wonder: One goal of Microscope Imaging Station was to foster a sense of wonder about the microscopic world. Researchers have defined wonder in a museum as, "...the power of the displayed object to stop the viewer in his or her tracks, to convey an arresting sense of uniqueness, to evoke an exalting attention" (Greenblatt, 1991, p. 42). To understand the sense of wonder fostered by Microscope Imaging Station, researchers focused on responses to the fundamental descriptions of Microscope Imaging Station. The visitors' voices strongly suggest a sense of wonder, as demonstrated by two qualitative themes—discovery and positive exclamations. Words frequently mentioned in the discovery theme include: up-close, explore, show, and compare. Words repeated throughout the positive exclamation theme include claims that Microscope Imaging Station was fun, interesting, cool, and gross. For example: "[The] glowing stuff—that was cool! I wonder if we have that protein in our hearts?" (#185) and "It's a must-see; absolutely interesting. This could get me interested in biology! The ability to see something as small as that in such detail—it is mind-boggling" (#3).

Overall, over half (53%; n = 284) of the visitors' responses indicated a sense of discovery that was nurtured at Microscope Imaging Station. And more than a third (39%) spontaneously offered a positive exclamation about Microscope Imaging Station. In addition, these fundamental elements of discovery and positive comments were also seen in visitors' remarks about the size of the specimens and about the fact that the specimens were alive (see discussions above).

Short Interview Zeiss: When visitors were asked to describe the main idea of the exhibit, 44% (n = 78) of Zeiss microscope visitors spontaneously included words that indicated a sense of discovery, allowing them to get up-close, explore, and compare. Nearly half (47%) of Zeiss visitors spontaneously made a positive exclamation about what they saw at the microscope (fun, interesting, cool, or gross).

Short Interview Leica: In describing the main idea of the exhibit, 43% (n = 84) of Leica visitors spontaneously included words that fall into the discovery category. Positive exclamations were made by 39% of Leica visitors.

Short Interview Media Pod: Visitors to the Media Pods often referred to a sense of discovery. Specifically, 57% (n = 81) of visitors spontaneously included words indicative of a sense of discovery. Additionally, 33% of visitors made positive exclamations to say about the interesting, cool, gross or fun aspects of this portion of Microscope Imaging Station.

In-Depth Interviews: Visitors who had the opportunity to see the entire Microscope Imaging Station had a strong sense of discovery in their exhibit descriptions. Fully 88% (n = 41) of these visitors mentioned that Microscope Imaging Station allowed them to look at things up-close, to explore the specimens, to show others, or to compare what they were seeing. Almost a third (32%) made positive exclamations regarding Microscope Imaging Station.

(6) Connections to Life: One goal in the development of Microscope Imaging Station was to create a set of exhibits that helped visitors to connect the microscopic world to their own lives. There was a strong effort to make the microscopic specimens personally relevant to visitors.

More than two-thirds (68%; n = 285) of the visitors interviewed (in-depth, Leica, Zeiss, Media Pods) thought that what they saw was related to their lives in some way. When asked to elaborate, visitors' comments regarding personal relevance tended to fall into six categories: a) helping humans, b) basic biology, c) we are all alive, d) personal interest or work, e) exhibit-specific content, and f) located in the body or environment. Response categories that fell under 10% included: (1) direct personal connection where a specific person and a disease were named - 9%; and (2) school - 2%.

- a) **Helping Humans:** Approximately one-fifth (21%) of the visitors' responses described Microscope Imaging Station as relevant to their lives because it was about using animals to help prolong human life. Specifically, visitors mentioned finding cures, studying diseases, and the benefit of ongoing scientific research in the medical field. Some of these responses related Microscope Imaging Station very specifically to visitors' own aging and potential need for treatment in the future: "Well, because I'm getting up there and I'm hoping, really hoping, that studying those fish hearts is gonna help me out in the future" (#243).

- b) **Basic Biology:** One-fifth (20%) of visitors made a connection to their lives and Microscope Imaging Station through basic biological concepts. Concepts included cells and blood cells (visitors' own descriptions), genetics, DNA, and development or growth. (This topic will be further discussed in the connections to biology section below.)
- c) **We're All Alive:** Another fifth (20%) of the visitors' responses made a connection among all living beings. For example, "We undergo similar growth" (#86). Most of these responses, however, simply stated that we are all alive and all living things are connected.
- d) **Interest or Work:** Many visitors recognized the topics broached within Microscope Imaging Station as central to either their personal or professional interests. Again, approximately one-fifth (19%) of visitors' responses included some mention of personal or professional interests. For example: "Well, they are studying the heart and it relates to me - I work in a cardiac lab so I really found the heart stuff interesting" (#252) and "In my work I deal with living cells to produce medicine for people" (#1).
- e) **Exhibit-Specific Content:** Visitors made a strong connection between the topics of aging and Alzheimer's disease discussed at Microscope Imaging Station and themselves. Approximately 18% of visitors' responses included aging or Alzheimer's. Visitors often referenced personal stories or experiences, for example: "We think my grandma is showing signs of Alzheimer's. My grandma on my father's side" (#78). Visitors also made a strong connection to heart disease and other areas of cardiac research discussed in Microscope Imaging Station. Approximately 17% of visitors' responses included heart-related topics. Visitors reported: "It was interesting how the animals can help us to understand how our hearts work...it is good because, um, if we use them we don't have to use human hearts" (#251) and "My grandpa died of heart problems." (#214).
- f) **Body and Environment:** Finally, 12% of the visitors' responses included a connection between the specimens they saw and their body or their environment. These visitors thought that the specimens they saw in Microscope Imaging Station were physically present in their bodies or in their everyday environment. For example, "I don't know where these things really exist, but I'd imagine they're in the carpet, a moist area, a countertop, my food - anywhere in my world" (#3). This response is typical of a line of thinking that may have been the result of strong previous knowledge and misconceptions about the type of specimens they saw, microscopic organisms in general, or the use of microscopes to avoid contamination.

There were some significant differences among the types of visitors who were able to make a connection between Microscope Imaging Station and themselves. Visitors who rated themselves as having a high level of interest in biology were significantly more likely to say that Microscope Imaging Station was related to their lives. The same pattern

did not hold true for visitors' level of self-rated knowledge. This finding suggests that Microscope Imaging Station is capable of increasing personal connections for people with all levels of prior knowledge in biology, as long as visitors have some interest in the topic. Visitors' ability to make connections between Microscope Imaging Station and their lives did not significantly differ by age or sex.

Short Interview Zeiss: Over two-thirds (77%; n = 79) of Zeiss microscope visitors made personal connections between the exhibit content and their own lives.

- a) Helping Humans: Mentioned in 9% of visitors' responses.
- b) Basic Biology: Mentioned in 45% of visitors' responses.
- c) We're All Alive: Mentioned in 22% of visitors' responses.
- d) Interest or Work: Mentioned in 16% of visitors' responses.
- e) Exhibit-Specific Content: Mentioned in 7% of visitors' responses.
- f) Body and Environment: Mentioned in 7% of visitors' responses.

Zeiss visitors who rated themselves as having a high level of interest in biology were significantly more likely to say that the Zeiss content was related to their lives. Again, this pattern did not hold true for Zeiss visitors' level of self-rated knowledge. This finding suggests that the Zeiss exhibit experience is capable of increasing personal connections for people with all levels of prior knowledge in biology, as long as visitors are interested in the topic. Visitors' ability to make connections between Zeiss and their lives did not significantly differ by age or sex.

Short Interview Leica: Over half (62%; n = 84) of Leica microscope visitors made personal connections between the exhibit content and their own lives.

- a) Helping Humans: Mentioned in 30% of visitors' responses.
- b) Basic Biology: Mentioned in 12% of visitors' responses.
- c) We're All Alive: Mentioned in 7% of visitors' responses.
- d) Interest or Work: Mentioned in 23% of visitors' responses.
- e) Exhibit-Specific Content: Mentioned in 12% of visitors' responses.
- f) Body and Environment: Mentioned in 42% of visitors' responses.

Leica visitors who rated themselves as having a high level of interest in biology were significantly more likely to say that the Leica content was related to their lives. Again, the same pattern did not hold true for visitors' level of self-rated knowledge. This finding suggests that the Leica exhibit experience is capable of increasing personal connections for people with all levels of prior knowledge in biology, as long as visitors are interested in the topic. Visitors who made connections between Leica and their lives were significantly more likely to be adults over the age of 30 than young adults or children. One explanation for this is that older adults may find the information regarding aging in the exhibit more personally relevant than young adults and children. Visitors' ability to make a connection between Leica and their lives did not significantly differ by sex.

Short Interview Media Pod: Over half (65%; n = 81) of Media Pod visitors made personal connections between the exhibit content and their own lives.

- a) Helping Humans: Mentioned in 13% of visitors' responses.
- b) Basic Biology: Mentioned in 6% of visitors' responses.
- c) We're All Alive: Mentioned in 33% of visitors' responses.
- d) Interest or Work: Mentioned in 15% of visitors' responses.
- e) Exhibit-Specific Content: Mentioned in 67% of visitors' responses.
- f) Body and Environment: Mentioned in 0% of visitors' responses.

Unlike the Zeiss and Leica experiences, visitors' ability to make connections at the Media Pod did not significantly depend on their level of interest in biology. Additionally, the ability to make personal connections was not significantly related to visitors' self-rated knowledge about biology. Visitors' ability to make connections between the Media Pod exhibit and their lives did not significantly differ by age or sex.

In-Depth Interviews: Nearly two-thirds (71%; n = 41) of in-depth interviewees made personal connections between the content covered at the exhibits and their own lives.

- a) Helping Humans: Mentioned in 46% of visitors' responses.
- b) Basic Biology: Mentioned in 11% of visitors' responses.
- c) We're All Alive: Mentioned in 7% of visitors' responses.
- d) Interest or Work: Mentioned in 29% of visitors' responses.
- e) Exhibit-Specific Content: Mentioned in 61% of visitors' responses.
- f) Body and Environment: Mentioned in 0% of visitors' responses.

Unlike the Zeiss and Leica experiences, visitors' ability to make connections after having the opportunity to experience the whole of Microscope Imaging Station did not significantly depend on their level of interest in biology. Additionally, the ability to make personal connections was not significantly related to visitors' self-rated knowledge about biology. Visitors' ability to make connections between Microscope Imaging Station and their lives did not significantly differ by age or sex.

(7) Connections to Basic Biological Research: Microscope Imaging Station was specifically developed to encourage visitors to make connections between what they were experiencing and basic biological research. The survey question regarding connections to biological research was different in the short interview ("Does the exhibit element remind you of any previous experiences with biology?") than it was in the in-depth interview ("How does what you saw at these three exhibits relate to biology?"). This change was made in consultation with the Microscope Imaging Station team after researchers found that a large number of interviewees had difficulties understanding and answering the original question. However, responses to the short interview version of this question tended to center on school experiences and microscope use (48% and 20%, respectively). Therefore, responses to additional survey questions were probed to gain a better understanding of visitors' connections between Microscope Imaging Station content and basic biological research. Specifically, visitors' responses to the question regarding

connections to human health were analyzed for answers that related more to basic biological research than to biomedical research. Visitors' responses to biology and human health questions, where relevant to basic biological research, are reported below.

Almost two-thirds (62%; n = 282) of the visitors interviewed (Leica, Zeiss, Media Pods, in-depth) thought that what they saw was related to biology in some way (note: this question did not differentiate between basic biology and biological research). These results were also reflected in visitors' responses to the Microscope Imaging Station demonstrations, discussed in further detail below (see Table 8). Three response patterns that emerged reflected visitors' understanding of basic biological research: (a) basic biology in response to the connection to biology question; (b) basic biology in response to the connection to human health question; and (c) basic biological/scientific research in response to the connection to human health question.

- a) **Basic Biology (connection to biology):** Some visitors (15%) provided conceptual definitions of biology or development when making connections between Microscope Imaging Station and biology. These visitors focused on general biological concepts and definitions, such as DNA, genetics, cells and blood cells, and development and growth. Examples included: "I saw how the cell splits, then forms a layer of skin, then looks like a fish," (#212), "...the life-cycle occurs in front of your eyes" (#233), and "...they are talking about DNA sequences being similar among humans and animals—even more similar than we think" (#188).
- b) **Basic Biology (connection to human health):** A quarter of visitors (25%) provided definitions of biology or development when making connections between Microscope Imaging Station and human health. These visitors' responses focused on general biological concepts and definitions, such as DNA, genetics, cells and blood cells, and development and growth (as did those mentioned above). For example: "We all developed from embryos and I think it is good for kids to be able to see that development" (#268), and "they found the gene for aging in the worms! How cool is that?" (#185).
- c) **Biological Research:** A small number of visitors (9%) mentioned the connection between what they were seeing and scientific research unrelated to human health. Examples included: "...it could be helpful to use for research" (#44), and "Well, single cellular organisms can be used for research on lots of things. It is pretty broad. It's good to have it" (#87).

There were significant differences between visitors who were able to make a connection to biology and those who could not. As previously mentioned, this question did not differentiate between basic biology and biological research. Visitors with a high level of interest in biology were significantly more likely to make a connection between Microscope Imaging Station and biology. This finding is not surprising given that people often show more interest in familiar topics. There was no relationship between visitors' self-reported knowledge of biology and their tendency to make a connection between Microscope Imaging Station and biology. Visitors who made a connection between

Microscope Imaging Station and biology tended to be over 30 years of age. Visitors' ability to make connections between the exhibits and biology did not differ by sex.

Short Interview Zeiss: The majority (66%; n = 79) of Zeiss microscope visitors felt that what they saw was related to a previous experience with biology.

- a) Basic Biology (connection to biology): Mentioned in 10% of visitors' responses.
- b) Basic Biology (connection to human health): Mentioned in 31% of visitors' responses.
- c) Biological Research: Mentioned in 14% of visitors' responses.

Visitors who rated themselves as having a high level of interest in biology were significantly more likely to say that the Zeiss content was related to biology. This pattern did not hold true for Zeiss visitors' level of self-rated knowledge. This finding suggests that Zeiss exhibit experience is capable of portraying biological connections for people with all levels of prior knowledge in biology, as long as visitors are interested in the topic. Adults over 30 tended to make connections between the microscope and biology more often than young adults and children. Visitors' ability to make connections between Microscope Imaging Station and biology did not significantly differ by sex.

Short Interview Leica: Over half (60%; n = 83) of Leica visitors were able to make a connection between the exhibit and their previous experiences with biology.

- a) Basic Biology (connection to biology): Mentioned in 4% of visitors' responses.
- b) Basic Biology (connection to human health): Mentioned in 18% of visitors' responses.
- c) Biological Research: Mentioned in 13% of visitors' responses.

There were no significant differences by interest or knowledge level and visitors' ability to make a connection between the Leica microscope and biology. Adults over 30 were significantly more likely than young adults and children to make connections between the exhibit and biology. Visitors' ability to make connections between Leica and biology did not significantly differ by sex.

Short Interview Media Pod: Just over half (51%; n = 80) of Media Pod visitors reported that the exhibit reminded them of previous experience with biology.

- a) Basic Biology (connection to biology): Mentioned in 6% of visitors' responses.
- b) Basic Biology (connection to human health): Mentioned in 27% of visitors' responses.
- c) Biological Research: Mentioned in 6% of visitors' responses.

The only significant difference between the types of visitors who were able to make a connection between the Media Pods and biology was between adults over 30 and young adults or children. Visitors' ability to make connections between Media Post and biology did not significantly differ by interest level, knowledge level, or sex.

In-Depth Interviews: Nearly all (93%; n = 40) of the in-depth interviewees felt that the exhibits related to biology. As previously mentioned, in-depth interviewees were asked how the elements of Microscope Imaging Station related to biology. These responses are different from short interview responses, in that they more strongly focus on biology in general.

- a) Basic Biology (connection to biology): Mentioned in 48% of visitors' responses.
- b) Basic Biology (connection to human health): Mentioned in 33% of visitors' responses.
- c) Biological Research: Mentioned in 3% of visitors' responses.

Again, there were no significant differences among the types of visitors who were able to make a connection between Microscope Imaging Station experience and biology. Visitors' ability to make connections between Microscope Imaging Station and biology did not significantly differ by interest level, knowledge level, age, or sex.

(8) Connections to Human Health: Microscope Imaging Station was designed to help visitors make connections between the microscopic specimens and biomedicine or biomedical research.

After consultation with the Microscope Imaging Station the term human health was used in the interviews in order to avoid difficulties with vocabulary and to insure the most accurate responses.

More than three-quarters (76%; n = 278) of the visitors interviewed (in-depth, Leica, Zeiss, Media Pods) thought that what they saw was related to human health in some way (see also Table 8 for further support of visitor connections to human health). When asked to elaborate, visitors' comments tended to fall into three categories: a) helps humans, b) basic biology, and c) exhibit-related content. Response categories that fell at 10% or under included: (1) presence of particular specimens in the body or environment –10%; and (2) related to personal or professional interests – 2%.

- a) **Helps Humans:** Visitors' responses in this category typically referred to the use of the worms (*C. elegans*) or zebrafish to aid in finding cures and studying diseases related to human conditions. Approximately 43% of visitors' responses connected what they saw in Microscope Imaging Station to advancing medical research on human health. Visitors commented that the things they saw: "...show how you can create a mutation, change things genetically. If you can mutate things so specifically it might really help in medicine" (#35), "...worm genes are similar to genes that humans have so they study the worms" (#178), and "... [help] to make people's lives better through science—curing [diseases] and such" (#187).
- b) **Basic Biology:** As discussed above, some visitors still referred back to the basic biological component of Microscope Imaging Station when discussing biomedicine. A quarter (25%) of visitors made reference to DNA, genetics, cells or blood cells, and/or growth and development. For example: "[the exhibit

provides] a better understanding of how we [humans] work at an embryonic level” (#86).

- c) Exhibit-Related Content: Visitors often made a connection between human health and aging or dementia such as Alzheimer’s. Approximately 21% of visitors’ responses connected what they had seen to human health via aging and Alzheimer’s. For example: “It could potentially prolong the human aging process” (#255), and “...the thing about aging (indicates her 70 year-old mom) and proteins, Alzheimer’s, the clumping of proteins - more and more people are affected” (#203). About a fifth (17%) of visitors’ made a connection between human health and heart issues. Typical responses included: “The heart of a fish can tell us how to heal our hearts” (#174), and “...because it is similar to a human heart, they can watch it and learn from it” (#165).

Visitors who had higher levels of interest in biology were significantly more likely to describe a connection between Microscope Imaging Station and human health. Visitors who made a connection between Microscope Imaging Station and human health did not significantly differ on their reported level of knowledge of biology. This suggests that Microscope Imaging Station is capable of increasing health-related connections for people with all levels of prior knowledge in biology, as long as visitors are interested in the topic. Visitors who made a connection between Microscope Imaging Station and human health were significantly more likely to be adults over 30 than young adults or children. Visitors’ ability to make connections between Microscope Imaging Station and human health did not significantly differ by sex.

Short Interview Zeiss: Almost three-quarters (74%; n = 77) of Zeiss microscope visitors recognized a connection between the exhibit and human health.

- a) Helps Humans: Mentioned in 29% of visitors’ responses.
- b) Basic Biology: Mentioned in 31% of visitors’ responses.
- c) Exhibit-Related Content: Mentioned in 9% of visitors’ responses.

Visitors who had higher levels of interest in biology were significantly more likely to describe a connection between the Zeiss microscope and human health. Visitor’s who made a connection between Zeiss and human health did not significantly differ on their reported level of knowledge of biology. This suggests that the Zeiss exhibit is capable of increasing health-related connections for people with all levels of prior knowledge in biology, as long as visitors are interested in the topic. Visitors’ ability to make connections between Zeiss and human health did not significantly differ by age or sex.

Short Interview Leica: Two-thirds (66%; n = 84) of the visitors to the Leica microscope reported a connection between the exhibit and human health.

- a) Helps Humans: Mentioned in 38% of visitors’ responses.
- b) Basic Biology: Mentioned in 18% of visitors’ responses.
- c) Exhibit-Related Content: Mentioned in 18% of visitors’ responses.

Unlike Zeiss visitors, Leica visitors, ability to make connections between the exhibit and human health did not significantly differ by interest level, knowledge level, or sex. Adults over 30 were significantly more likely than young adults and children to recognize connections between the exhibit and human health.

Short Interview Media Pod: Two-thirds (66% ; n = 76) of Media Pod visitors recognized the connection between the exhibit and human health.

- a) Helps Humans: Mentioned in 46% of visitors' responses.
- b) Basic Biology: Mentioned in 27% of visitors' responses.
- c) Exhibit-Related Content: Mentioned in 59% of visitors' responses.

Media Pod visitors' connections to human health did not significantly by interest level, knowledge level, age, or sex.

In-Depth Interviews: Of the in-depth visitors, almost all (98% ; n = 41) were able to make a connection between the exhibits and human health.

- a) Helps Humans: Mentioned in 70% of visitors' responses.
- b) Basic Biology: Mentioned in 33% of visitors' responses.
- c) Exhibit-Related Content: Mentioned in 75% of visitors' responses.

Visitors' ability to make connections between Microscope Imaging Station and human health did not significantly differ by interest level, knowledge level, age, or sex.

Tracking and Timing

Tracking and timing data was collected as part of a cued interview in which visitors were specifically directed to the exhibit elements in Microscope Imaging Station. A Meta-analysis study on the impact of cuing visitors on tracking and timing revealed conflicting and inconclusive results. For example, the summative study of the Memory exhibition (Serrell, 1999) at the Exploratorium found that there was no significant difference between the amount of time that cued and uncued visitors spent in the exhibition. In contrast, the Traits of Life Final Summary Evaluation Report (Hein, 2003) reported that cued visitors spent significantly more time in the exhibition than uncued visitors. The study did find that cuing visitors had no significant impact on other measures.

Time spent at Microscope Imaging Station was fairly evenly divided among the three main elements, Zeiss, Leica, and Media Pod(s) (2:21; 2:22; and 2:27, respectively). See Table 7 below for a demographic breakdown of holding times. Visitors spent an average of 2:25 per stop (123 stops were observed). Half of the visitors spent 1:51 or less at each stop. Almost all of the visitors observed stopped at the Zeiss microscope (90%), and the Leica microscope (95%), and fully 100% stopped at a Media Pod. Even though visitors were told there were three different exhibit elements to visit, these data indicate that visitors recognized the Zeiss and Leica microscopes and the Media Pod exhibit as unique and engaging enough that they stopped and spent a sufficient amount of time at each element (see Table 6).

Table 6: Summary of Tracking and Timing Data (n = 39)

Exhibit Element	% of visitors who stopped	Average time per stop (in minutes)	Minimum time (in minutes)	Maximum time (in minutes)	Average time per visitor	Interaction differences
Zeiss	90 %	2:29	0:11	5:57	2:21	
Leica	95%	2:44	0:14	5:17	2:22	> I* ; > IF**
Media Pod	100%	2:45	0:11	5:46	2:27	> I*
TOTAL		2:25	1:04	14:52	7:06	

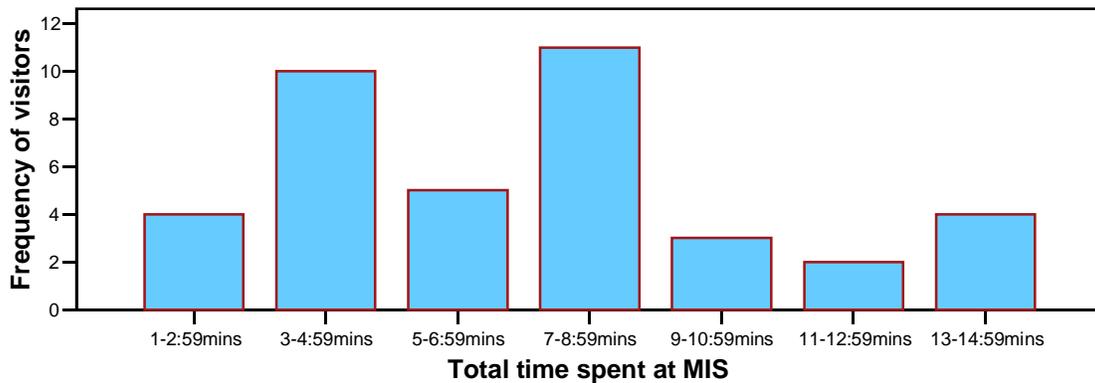
* I = interactions with the touch screen.

** IF = focusing.

Visitors who participated in the in-depth interview spent an average of 7 minutes and 6 seconds at Microscope Imaging Station. Time spent at Microscope Imaging Station ranged between 1:04 and 14:52 (see Table 6). Time spent at Microscope Imaging Station by the number of visitors was distributed throughout this range (see Graph 1).

Graph 1

Frequency of Visitors by Time Spent at MIS



Visitors' typical interactions were recorded at each stop in Microscope Imaging Station (read out loud, interacting with touch screen, call over, point, talk, interact with focus, interact with joystick, interact with UV light, interact with zoom). Both microscope exhibit elements encouraged interactions with the touch screen, focusing, joystick and UV light, as well as pointing and talking among visitors. Much of the interactions at these exhibits were directed toward controlling the microscopes to find specimens, typified by the visitor exchange: "Dude, what is that? Zebrafish, is that what we are looking at? Oh my god I just zoomed in on it!" Visitors did tend to interact with the touch screen and focus the microscope more often at the Leica microscope than at the Zeiss microscope.

Per Microscope Imaging Station team member requests, tracking and timing results were compared between the Traits of Life exhibit (Hein, 2003) and the Microscope Imaging Station. These are two different exhibit experiences (e.g., there are 50 components at the Traits of Life exhibit and only 3 components at the Microscope Imaging Station). Due to this difference and based on a large meta-analysis of tracking and timing data (Serrell, 1998), we would not recommend drawing strong conclusions based on the following comparisons. The component with the strongest attracting power in the Traits of Life exhibit was "Goldfish Evolution"—58% of visitors stopped at this exhibit element. Comparatively, the element with the strongest attracting power at the Microscope Imaging Station was "Media Pod"—100% of visitors stopped at this component. The component with the highest holding time at the Traits of Life exhibit was "Genetic Inheritance"—visitors, on average, spent 1:49 at this exhibit element. The component with the highest holding time at the Microscope Imaging Station was "Media Pod"—visitors, on average, spent 2:45 at this element. Visitors stopped more often and spent more time at Microscope Imaging Station elements than at Traits of Life elements, yet this is not indicative of stronger attracting or holding power given the vast differences between the two.

Table 7: Average Holding Times at Each Exhibit by Demographics

	<u>Sex</u>		<u>Group</u>		<u>ESL</u>		<u>Age**</u>		
	Male mean/median (n*)	Female mean/median (n*)	Adult mean/median (n*)	Adult +kids mean/median (n*)	No mean/median (n*)	Yes mean/median (n*)	< 20s mean/median (n*)	30s – 40s mean/median (n*)	> 50 mean/median (n*)
Zeiss	2:49/2:23 (16)	2:13/1:48 (12)	2:40/1:51 (11)	2:31/2:14 (16)	2:28/1:49 (26)	3:49/3:49 (2)	2:32/1:47 (15)	3:18/2:56 (9)	1:02/0:54 (5)
Leica	2:32/2:28 (16)	2:12/1:50 (13)	2:20/2:08 (14)	2:21/1:52 (14)	2:18/1:53 (27)	3:34/3:34 (2)	2:26/1:53 (13)	2:10/1:51 (12)	2:37/2:54 (5)
Media Pod	2:17/2:17 (18)	2:34/2:35 (14)	3:03/2:57 (14)	1:51/2:00 (17)	2:17/2:14 (30)	4:17/4:17 (2)	2:32/2:25 (16)	2:28/2:30 (12)	2:25/2:54 (5)
Total time	7:39/7:31 (18)	6:51/6:20 (14)	8:15/7:47 (14)	6:30/6:03 (17)	6:56/6:51 (30)	12:55/12:55 (2)	7:13/6:51 (16)	7:51/7:56 (12)	6:21/7:25 (5)

*The sample sizes reported in this table are lower than the total sample sizes due to missing data (and visitors who did not stop at certain exhibits).

**In an effort to achieve parsimony, age groups were combine for the analyses in this table.

Key Demonstration Findings

Visitors who filled out the surveys about Microscope Imaging Station demonstrations were generally very positive about the experience (See Table 8). Visitors' responses indicated a high interest level. There were no significant differences between visitors' responses to the two types of demonstrations (Giant Chromosomes and Germ Busters).

Table 8: Demonstration Surveys (n=126)

Interest Ranking 1=Strongly Disagree 5=Strongly Agree	Mean Score
This demonstration was interesting.	4.6
This was interesting because it allowed me to see the microscopic world.	4.6
This was interesting because I could see life processes happen live, right in front of me.	4.5
This was interesting because it demonstrated how things work.	4.3
This was interesting because it showed the importance of scientific research.	4.1
This was not interesting because I have seen or done this before.	1.5
This was not interesting because I didn't understand what I was seeing.	1.4
This was not interesting because it was not relevant to human life.	1.3
I wanted more information.	2.5

The high scores on the demonstration survey are in many instances analogous to visitors' comments in the short and in-depth interviews. Visitors were most positive about being able to see the microscopic world, live. The interesting and unique aspects of the experience, in combination with the live, microscopic qualities, lend further support to project goal number three; the Microscope Imaging Station helped to foster a sense of wonder in the visitors. Visitors' high response levels to questions regarding demonstrations of how things work and their importance to scientific research provide further support for project goal number five; the Microscope Imaging Station encouraged connections to basic biological research. Finally, visitors' responses reflected connections between what they saw and human health, which provides further support for project goal number six; the Microscope Imaging Station encouraged connections to biomedical research. Visitors' did not write comments alongside their response to the survey question about wanting more information, but the low mean score for this suggests that visitors did not feel strongly about it in general.

Conclusions

Project Goal #1: Visitors will successfully use a research-grade microscope to see a live, microscopic specimen.

Data indicate Microscope Imaging Station visitors were able to use the research-grade microscopes to see a live specimen. Visitors were successfully able to do this regardless of whether they went to only the Zeiss exhibit, only the Leica exhibit, or if they had the opportunity to visit the entire Microscope Imaging Station. Visitors spontaneously mentioned the specimens they had been viewing when asked to describe Microscope Imaging Station and were able to name one or more of the specimens when asked directly. In addition, visitors recognized the specimens they saw under the microscopes were alive.

Project Goal #2: Visitors will realize that they are using a microscope to see a very small specimen.

Almost all of the Microscope Imaging Station visitors who had visited a microscope exhibit recognized that they had used a microscope. The microscopes, however, were not the primary focus of visitors' descriptions of their exhibit experience. Instead, visitors focused on more fundamental issues, such as the specimens. More than two-thirds of the visitors were able to accurately describe the size of these specimens as comparable to a speck of dust or by using their own words.

Project Goal #3: The experience will foster a sense of wonder about a microscopic world that they normally cannot see.

Visitor responses strongly suggest that they felt a sense of wonder about the microscopic world they saw in Microscope Imaging Station. Although it is difficult to strictly define wonder in museum experiences, there were multiple points of evidence in the visitor data. Visitors' sense of wonder was apparent in their overall descriptions of their Microscope Imaging Station experience, as well as their responses to questions about the size and live aspects of the specimens.

Project Goal #4: The experience will encourage visitors to make personal connections between what they see and themselves.

Two-thirds of the visitors were able to describe personal connections to their Microscope Imaging Station experience. Results suggest that overall, (and specifically at the Zeiss and Leica exhibits) visitors with a high level of interest in biology were significantly more likely to be able to make a personal connection. In addition, visitors to the Leica exhibit were significantly more likely to make a personal connection if they were over the age of 30. The content of the Leica exhibit—aging and Alzheimer's—is arguably less personally relevant to children and young adults. The topic of aging and Alzheimer's, however, was frequently mentioned by Leica visitors throughout the interviews. The data

indicate that aging and Alzheimer's were a powerful context for the Leica exhibit visitor, despite the age difference in visitors' ability to make personal connections to the exhibit.

Project Goal #5: The experience will encourage visitors to make connections between what they see and basic biological research.

Nearly two-thirds of Microscope Imaging Station visitors were able to describe a connection between what they saw in Microscope Imaging Station and biology. An examination of visitors' comments throughout the interviews revealed a presence of key terms such as DNA, genetics, development, and cells. These terms were present in almost half of the responses from in-depth interviewees when they were asked more specifically to describe how Microscope Imaging Station related to basic biology. These terms were also mentioned (more often) in response to questions regarding human health. Additionally, visitors mentioned basic biological research (with no human connection) in response to the question regarding human health. These data suggest that visitors were making connections to both basic biology and biological research. Finally, visitors were significantly more likely to connect their experiences to basic biology if they had a high level of interest in biology (overall and Zeiss) or if they were over the age of 30 (overall, Zeiss, and Leica).

Project Goal #6: The experience will encourage visitors to make connections between what they see and biomedical research.

More than three-quarters of the visitors were able to make a connection between what they saw and biomedical research. Specifically, visitors were able to articulate relationships between the specimens they saw, the research that was described, and human health issues. Visitors were significantly more likely to make this connection if they had a high level of interest in biology (overall and Zeiss) or if they were over the age of 30 (overall and Leica).

Overall the Microscope Imaging Station messages did reach visitors. In fact, there was strong evidence that Microscope Imaging Station was exceeding its goals by reaching the full diversity of the Exploratorium audience. For example, most of the project goals were met regardless of visitors' self-reported knowledge of biology. Likewise, visitors who speak English as an additional language were as likely as native English speakers to make the connections outlined in the project goals. Finally, visitors' experiences met the project goals regardless of their sex.

There are, however, a few instances where visitors' self-reported interest level in biology or age had a statistically significant impact on their exhibit experience. Two instances in particular beg further examination:

- Zeiss visitors who had a low level of interest in biology were significantly less likely to make a personal, biological, or biomedical connection to their exhibit experience.

- Leica visitors under the age of 30 were significantly less likely to make a personal, biological, or biomedical connection to their exhibit experience.

It is worth exploring how exhibit content or specific text could be changed to reverse these exceptions. It is difficult to change visitors' level of interest in a general topic such as biology during a brief exhibit experience. However, adjustments to the Zeiss content or text could provide alternative "entry points" to the content that draw upon other visitor interests (such as current events, or non-science-related subjects). Another possible solution is to make the personal, biological, or biomedical connections more explicit in the Zeiss exhibit.

The content of the Leica exhibit is arguably less relevant for children and young adults. However, the overall success engaging visitors in the topic of aging and Alzheimer's suggests that it would be prudent to leave that content intact. Alternatively, text that makes the content more immediately relevant to young people (such as references to grandparents) could be added to the exhibit.

The exceptions outlined here were a minor element of the overall data that strongly demonstrated the Exploratorium's success in meeting the Microscope Imaging Station goals. In fact, the qualitative data provides evidence that the project has exceeded its goals. In particular, visitors' comments revealed a clear understanding of the importance of using animal-based research to improve human health. The strong contextual elements and the presence of live specimens in Microscope Imaging Station proved to be a potent combination. In fact, human health issues were raised in all of the qualitative visitor responses across the exhibit elements. Microscope Imaging Station has proven to be a powerful visitor experience for exploring the connection between the microscopic world and human health.

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Appendix: Instruments

Microscope Imaging Station Short Interview *Final* – MICROSCOPES

Zeiss/Zebrafish/Amoeba or Leica/Worms

Survey Number: _____

Date: _____ Data Collector Name: _____

I am working with the museum to find out people's thoughts about the exhibit you have just visited. [Point to exhibit.] Would you mind talking with me briefly about it? It should take about five minutes. (Secure parental permission if under 16 and confirm that s/he is at least 8 if necessary.)

1) Is this your first visit to the Exploratorium? (*circle one*) Yes No

2) How would you rate your interest in biology on a scale on 1 to 10 if 1 is "I have absolutely no interest in biology" and 10 is "I am extremely interested in biology"? (*circle one*)

1 2 3 4 5 6 7 8 9 10

3) How would you rate your knowledge of biology on a scale on 1 to 10 if 1 is "I know absolutely nothing" and 10 is "I am a biomedical research scientist"? (*circle one*)

1 2 3 4 5 6 7 8 9 10

4) How would you describe this exhibit [*point to exhibit*] to another visitor at the Exploratorium? (Probe: What would you tell them it was about? What is interesting? What about [*use their words*]?)

5) Tell me a bit about what you saw.

5a) What specimens were you looking at?

5b) Did you know that you were looking at those specimens through a microscope? (*circle one*) Yes No

Microscope Imaging Station Short Interview *Final* – MICROSCOPES

Zeiss/Zebrafish/Amoeba or Leica/Worms

Survey Number:

Date: _____ Data Collector Name: _____

5c) Would you say that the specimens you saw through the microscope were alive?
(circle one) Yes No

Microscope Imaging Station Short Interview *Final* – MICROSCOPES

Zeiss/Zebrafish/Amoeba or **Leica/Worms**

Survey Number: _____

Date: _____ Data Collector Name: _____

5d) What is the size of the actual specimens under the microscope -- would you say they were the size of a tennis ball, a dime, a speck of dust, or something else?

6) Is what you saw related to your life in any way? (*circle one*) Yes No
(*If yes, in what ways?*)

7) Does this exhibit remind you of any previous experiences with biology? (*circle one*)
Yes No (*If yes, in what ways?*)

8) How does what you saw relate to human health?

Thank you! Your feedback really helps us improve the museum.

Here is a sticker for you to wear. There are other surveys being done in the museum today, so if you wear this you won't be asked to participate in any others.

-----OBSERVED DATA-----

Sex (*Circle one*): Male Female

Group (*Circle one*): Adult only Adult with kids

ESL (*Circle one*): Yes No

Age (*Circle one*): 8-12 13-17 18-20s 30s 40s 50s 60s+

Microscope Imaging Station Short Interview *Final* – MEDIA POD

Survey Number: _____

Date: _____ Data Collector Name: _____

I am working with the museum to find out people’s thoughts about the exhibit you have just visited. [*Point to exhibit.*] Would you mind talking with me briefly about it? It should take about five minutes. (Secure parental permission if under 16 and confirm that s/he is at least 8 if necessary.)

1) Is this your first visit to the Exploratorium? (*circle one*) Yes No

2) How would you rate your interest in biology on a scale on 1 to 10 if 1 is “I have absolutely no interest in biology” and 10 is “I am extremely interested in biology”? (*circle one*)

1 2 3 4 5 6 7 8 9 10

3) How would you rate your knowledge of biology on a scale on 1 to 10 if 1 is “I know absolutely nothing” and 10 is “I am a biomedical research scientist”? (*circle one*)

1 2 3 4 5 6 7 8 9 10

4) How would you describe this exhibit [*point to exhibit*] to another visitor at the Exploratorium? (Probe: What would you tell them it was about? What is interesting? What about [*use their words*]?)

5) Tell me a bit about what you saw.

Microscope Imaging Station Short Interview *Final* – MEDIA POD

Survey Number: _____

Date: _____ Data Collector Name: _____

6) Is what you saw related to your life in any way? (*circle one*) Yes No
(*If yes, in what ways?*)

7) Does this exhibit remind you of any previous experiences with biology? (*circle one*)
Yes No (*If yes, in what ways?*)

8) How does what you saw relate to human health?

Thank you! Your feedback really helps us improve the museum.

Here is a sticker for you to wear. There are other surveys being done in the museum today, so if you wear this you won't be asked to participate in any others.

-----OBSERVED DATA-----

Sex (*Circle one*): Male Female

Group (*Circle one*): Adult only Adult with kids

ESL (*Circle one*): Yes No

Age (*Circle one*): 8-12 13-17 18-20s 30s 40s 50s 60s+

Microscope Imaging Station In-Depth Interview

Survey Number: _____

Date: _____ Data Collector Name: _____

I am working with the museum to find out people's thoughts about three new exhibits. Would you be willing to take a look at these exhibits for as long or as short a time as you wish and then answer some questions afterwards?

(Secure parental permission if under 16 and confirm age if necessary.)

1) Is this your first visit to the Exploratorium? *(circle one)* Yes No

2) How would you rate your interest in biology on a scale on 1 to 10 if 1 is "I have absolutely no interest in biology" and 10 is "I am extremely interested in biology"?

(circle one)

1 2 3 4 5 6 7 8 9 10

3) How would you rate your knowledge of biology on a scale on 1 to 10 if 1 is "I know absolutely nothing" and 10 is "I am a biomedical research scientist"? *(circle one)*

1 2 3 4 5 6 7 8 9 10

4) What would you say is the main idea of the three exhibits you just saw?

5) What was the most memorable thing you saw?

6) Tell me a bit about what you saw at each exhibit. *[prompt to include all three]*

6a) What specimens were you looking at?

Zebrafish

Amoeba

Worms

Microscope Imaging Station In-Depth Interview

Survey Number: _____

Date: _____ Data Collector Name: _____

7) Did you know that at two of the exhibits you were looking at those specimens through a microscope? (*circle one*) Yes No

7a) [*If yes*] Tell me a bit about what you were able to do with the microscope.

8) Thinking about all of the specimens you saw through the microscopes, would you say that they were alive? (*circle one*) Yes No

8a) [*If yes*] How interesting is it that those specimens were alive? Why?

7b) What is the size of the actual specimens under the microscope? Would you say it was the size of a tennis ball, a dime, a speck of dust, or something else?

11) Is what you saw related to your life in any way? (*circle one*) Yes No
(*If yes, in what ways?*)

12) How does what you saw at these three exhibits relate to biology?

13) How does what you saw at these three exhibits relate to human health?

Thank you! Your feedback really helps us improve the museum.

Here is a sticker for you to wear. There are other surveys being done in the museum today and if you wear this you won't be asked to participate in another survey.

-----OBSERVED DATA-----

Sex (*Circle one*): M F **Group** (*Circle one*): A A+k **ESL**(*Circle one*): Yes No

Age (*Circle one*): 8-12 13-17 18-20s 30s 40s 50s 60s+

Microscope Imaging Station In-Depth Interview

Data Collector: _____ Survey Number: _____
 Date: _____ Start Stop: _____ Total time spent: _____ Total stops: _____
 Crowding: (*circle one*) High Medium Low Elements not working: _____

Interaction Codes: ROL = read out loud I=interacting w/touchscreen C= call/called over P=point T=Talk
 IF=focus IJ=joystick IB= blue light IZ= zoom (worms)

Stop	Interaction Code	Specimens	Total time	Comments
1		Z A W		
2		Z A W		
3		Z A W		
4		Z A W		
5		Z A W		
6		Z A W		

The Exploratorium - Microscope Imaging Station Demonstration

TELL US WHAT YOU THINK!

Now that you've seen the demonstration, please rate your reaction to each statement.

Circle the appropriate number to tell us how much you agree or disagree.

	Strongly Disagree	Don't Agree	Neutral	Agree	Strongly Agree
This demonstration was interesting.	1	2	3	4	5
This was interesting because I could see life processes happen live, right in front of me.	1	2	3	4	5
This was interesting because it allowed me to see the microscopic world.	1	2	3	4	5
This was interesting because it demonstrated how things work.	1	2	3	4	5
This was interesting because it showed the importance of scientific research.	1	2	3	4	5
This was not interesting because I didn't understand what I was seeing.	1	2	3	4	5
This was not interesting because I have seen or done this before.	1	2	3	4	5
This was not interesting because it was not relevant to human life.	1	2	3	4	5
I wanted more information.	1	2	3	4	5

Please tell us about yourself

I am (*check one*): Male Female

Age (*check one*): 8-12 13-19 20s 30s 40s 50s 60s 70s+

I am here (*check all that apply*): With a school group With a tour group With family With friends On my own

TELL US WHAT YOU THINK!

Now that you've seen the demonstration, please rate your reaction to each statement.

Circle the appropriate number to tell us how much you agree or disagree.

	Strongly Disagree	Don't Agree	Neutral	Agree	Strongly Agree
This demonstration was interesting.	1	2	3	4	5
This was interesting because I could see life processes happen live, right in front of me.	1	2	3	4	5
This was interesting because it allowed me to see the microscopic world.	1	2	3	4	5
This was interesting because it demonstrated how things work.	1	2	3	4	5
This was interesting because it showed the importance of scientific research.	1	2	3	4	5
This was not interesting because I didn't understand what I was seeing.	1	2	3	4	5
This was not interesting because I have seen or done this before.	1	2	3	4	5
This was not interesting because it was not relevant to human life.	1	2	3	4	5
I wanted more information.	1	2	3	4	5

Please tell us about yourself

I am (*check one*): Male Female

Age (*check one*): 8-12 13-19 20s 30s 40s 50s 60s 70s+

I am here (*check all that apply*): With a school group With a tour group With family With friends On my own