Alien Earths
Summative Evaluation
June, 2005

Prepared for Space Science Institute
by
Visitor Studies Services

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Introduction

In fall of 2004 Space Science Institute (SSI) contracted with Judith Koke of University of Colorado Museum of Natural History and Wendy Meluch of Visitor Studies Services (the evaluators) to design and conduct a summative evaluation of the Alien Earths exhibit during its stay at Lawrence Hall of Science at the University of California at Berkeley (LHS). The complete evaluation consists of four studies:

- an exit survey of adult casual visitors,
- a tracking and timing study of casual visitors,
- post-visit surveys of teachers who bring classes to the exhibit, and
- observations of ten school groups in the exhibit.

All data were collected during March and April of 2005. No minor visitors to LHS were approached or questioned by data collectors. School teachers and school groups were targeted based on grade level and time available for the Exhibit. Studies with casual visitors followed random sampling protocol and are representative of the LHS visitorship. Please see Appendix A for sample descriptions.

Executive Summary

A four-part summative evaluation of Alien Earths shows it to be a successful exhibit with casual visitors and school groups. Casual visitors linger in the exhibit for over 23 minutes on average which represents an impressive sweep rate of only 172 square feet per minute.[1] While visitors use a relatively low percentage of elements (panels and interactives combined) their dwell times with many of them evidence thorough and thoughtful use. Indeed, upon exiting, over half of casual adult visitors correctly identify at least one of Alien Earth's main messages, primarily focussing on the possibility of extraterrestrial life. Visitors are very clear that astronomers study life on earth to guide their search for life on other planets. Visitors who can discuss methods used to search for other planets most readily identify Planet Wobble and Planet Transit (the Kepler Project). Alien Earths also positively impacts visitor understanding of the difference between stars and planets in a small but notable number of respondents.

The variety of hand-on elements and content presented in Alien Earths makes it engaging for a wide range of visitors and school groups. Teachers appreciate this range of activities and subject matter; their expectations were well met in almost every case.

Elements with the highest visitation include: Planet Models, Molecules in Motion, Pressure Ball, Planet Densities, Mission Invisible, Boiling Water, and Our Solar System (orrery). Those with the longest dwell times include: Close Knit Neighbors, View Space Theater, and Design a Solar System.

[1] Per Beverly Serrell's work in Paying Attention: Visitors and Museum Exhibitions, 1998, a sweep rate of 300 square feet per minute or less is an indicator of a well-used exhibit.

Summary of Findings

Tracking and Timing Summary

Exhibit Dwell Time (n=50):

Minimum:	1:22
Maximum:	51:15
Mean:	23:17
Median:	23:38

Sweep Rate: 171.82 square feet per minute
(These calculations are based on 4,000 square feet in the LHS layout; SSI's official plan is intended for 3,000 – 3,500 square feet.)

Number of Exhibits Used Out of 53 Elements and Panels (n=50):

Minimum:	0.00
Maximum:	37.00
Mean:	14.56
Median:	13.50

Favorite Exhibits: these exhibits were attended to by half or more of the visitors tracked in this study (n=50).

- Planet Models
- Molecules in Motion
- Pressure Ball
- Planet Densities
- Mission Invisible
- Boiling Water
- Our Solar System (orrery)

Elements with longest dwell times in minutes:

	Mean	Maximum
• Close Knit Neighbors	3:10	12:35
• View Space Theater	3:47	11:11
• Design a Solar System	3:46	10:03
• Planet Models	1:06	8:36
• Other Worlds	1:57	8:32
• Are we alone?	2:06	8:28
• Microbial Mat	1:40	6:46
• Mission Invisible	1:55	6:38
• When Planets Form	2:21	6:23
• Pressure Ball	1:12	6:16
• Looking for Life	2:49	6:01
• Listening for Life	2:15	5:35
• Life Scanner	2:23	5:32

For more information please see Tracking and Timing Study Data Table in Appendix H.

Do visitors perceive and understand Alien Earths' main messages?

- People are looking for planets.
- People are looking for life on other planets.
- There are scientific methods used in these efforts.

Alien Earths successfully communicates its three primary messages with a total of 52% of respondents touching on at least one of the first two, and 38% being aware of the third.

Adult visitors to Alien Earths most readily perceive this Exhibit to be about extraterrestrial life (40%). Most of their comments address the possibility of life on other planets, some touching on the number of other planets and/or conditions necessary for life. Other topic areas cited include planets and/or the solar system (16%), the search for other planets and how it is carried out (12%), and life on earth (10%). Please see Exit Survey Results Questions 2 and 4 for more detail, and Appendices B and D for all verbatim responses.

Do visitors notice and understand methods used to search for other planets?

Less than half (38%) of Exit Survey respondents reported that they saw something in the Exhibit about techniques used in the search for other planets. When asked to name two such methods, 8% could name one and 14% could name two. Planet Wobble was listed by 18%, Planet Transit (Kepler project) by 16%. Please see Exit Survey Results Questions 4a and 4b below for more information, and Appendix D for all verbatim responses.

The Tracking and Timing Study tells us that 46% of visitors in that sample read, watched or used the Planet Transit element (Kepler Project) and 56% the Planet Wobble panel and/or manipulative. Please see Appendix H for Tracking and Timing data.

Though no Exit Survey respondents referred to the coronographic method as a means of searching for planets, 44% were observed to read, watch and/or use the Coronagraph element in the Tracking and Timing Study. This element lends itself to discussion and cooperation among visitors. That respondents don't associate it with the search for other planets may be a function of its relative low-tech approach and/or its ease of use even when one does not read the explanatory panel. Please see Appendix H for Tracking and Timing data.

What do visitors learn from and/or remember about Alien Earths?

Most memorable to these visitors were the exhibit elements about life. Visitors felt they learned something new from and/or most enjoyed the Microbial Mat, the Life Scanner, Life Detectors, and Biomass. Second-most cited were lessons and elements about the solar system including Our Solar System (orrery), Planet Models, Design a Solar System and When Planets Form. Other theme areas mentioned include stars, size and scale, and the search for other planets.

Please see Exit Survey Results Question 3 below for more detail, and Appendix C for verbatim responses.

Why do visitors think that researchers interested in extraterrestrial life study life on Earth?

Visitors exiting Alien Earths readily understand that scientists study life on earth to guide their search for other life in some way. Fully 86% of respondents voiced something along these lines; 16% specifying guidance about what life might be like, and 14% focussing on identifying conditions necessary for life. Please see Exit Survey Results Question 6 for more detail, and Appendix F for all verbatim responses.

Do visitors understand the difference between stars and planets?

Compared with pre-test data collected during the front-end evaluation, Exit Survey data suggest a positive impact of Alien Earths on visitor understanding of the nature of stars vs. planets.

When asked about the difference between stars and planets, about half of Exit Survey respondents make reference to the idea that stars are gaseous and planets are solid (52%; down from 60% in the front-end study). Some reference to heat, shining or fusion was offered by 18% in this study, up from 4% in the front-end study. In the evaluators' experience, it is very difficult it is for a single museum visit to change visitors' strongly held misconceptions, making this is a notable finding. Please see Exit Survey Results Question 5 for more detail, and Appendix E for all verbatim responses.

How do field trip groups use Alien Earths?

Evaluators observed ten field trip groups grades 2/3 through 8. Predictably, older students tend to spend more time with elements and work with them more thoughtfully than younger students.

Fieldtrip Dwell Time in minutes (n=10):	Minimum:	6
	Maximum:	38
	Mean:	20

Though Our Solar System (orrery) is not used by all groups, several of them used it as a sort of anchor for the visit. Teachers made good use of it as an introduction to astronomy and/or the exhibit. Having the Planet Models in close proximity enhances their discussion.

Several exhibit elements tend to engender constructive use and cooperation: Design a Solar System, Pressure Ball, Coronagraph, Life Scanner, Biomass, and Listening For Life. Students and other visitors using Pressure Ball tend to get a bit excited, i.e., jumping up and down as they pump, but they always watch the

"explosion" with interest and sometimes end up reading the label to see what's going on.

Other elements get lots of attention, but students don't seem to take in their messages: Mission Invisible, Stellar Life Cycle, Salt Room, Planet Transit (Kepler Project), Molecules In Motion, and Boiling Water (older students are more focussed).

Note that the LHS exhibit layout does not allow the evaluator to see the entire gallery from a single vantage point. For more information, please see the Field Trip Data Table in Appendix K.

How do teachers react to Alien Earths?

Seven teachers responded to the Post-visit Teacher Survey (four grades 3-4; three grades 8-12). About half of them had done some preparation for the trip; most had some plan for follow-up activities; only two had used the LHS website about the exhibit.

Most teachers expectations of the exhibit were well met. They felt Our Solar System (orrery), Planet Models and good variety of hands-on exhibits were particularly effective. They make specific reference to Mission Invisible, the Salt Room, Molecules in Motion, and Life Scanner. Their list of elements most enjoyed by students includes the above as well as Pressure Ball, Design Your Own Solar System, and Understanding Numbers.

Teachers state that more information in advance of the exhibit, and staff facilitators would enhance their experience of Alien Earths. Exhibit organizers can effectively prepare teachers and students for an exhibit experience. Host museums should inform fieldtrip planners about exhibit organizers and other materials as they are developed.

Exhibit Elements – Impacts, Observations and Recommendations

Presented here are highlights of findings across studies in this summative evaluation. For more results about individual elements, please see Tracking and Timing Summary above, How do field trips use Alien Earths? above, Post-visit Teacher Survey responses below, Exit Survey Responses in Appendices C and D, Field Trip Observation Data in Appendix K , and Tracking and Timing Data in Appendix H.

Note that numbers used to identify exhibit elements and panels were assigned for ease of data collection and management in these studies. A floor plan with exhibit names is included in Appendix I. A complete list of exhibit elements by number and name is included in the Tracking and Timing Data Table, Appendix H.

Our Solar System (orrery) (1) **and Planet Models** (15)

These exhibits are popular among casual visitors and helpful to teaches who use them as an introduction to astronomy and/or the Alien Earths exhibit. Their proximity to each other enhances their usefulness. These elements impress visitors strongly enough that 16% are left thinking that the Big Idea relates to planets and our solar system.

Coronagraph (19), **Life Scanner** (36), **Biomass** (37), **Listening For Life** (40)

These exhibits are attractive, popular and easily accessible with minimal reading. They engender much communication and social learning behavior among visitors.

Planet Wobble Panel (26) and **Planet Wobble Interactive** (25)

These work well together naturally, attracting about one third of visitors. Upon exiting, visitors readily cite this method of searching for planets more than other methods. The lesson appears to be easy to grasp and is echoed by Design Your Own Solar System which can demonstrate this phenomena.

Molecules In Motion (44), **Boiling Water** (46)

These two are attractive, in part because of the noise they make. Once attracted, about half of users read and discuss the labels. They enjoy more constructive attention than the next group listed below.

Mission Invisible (5), **Pressure Ball** (6), **Salt Room** (10), **Planet Densities** (16), **Planet Transit (Kepler Project)** (22), **Stellar Life Cycle** (7),

These popular elements enjoy much playful and energetic attention from visitors and students, but relatively little reading or focussed manipulation. Users of Mission Invisible are excited to see themselves imaged; many seem to read and talk about warm and cold spots on their hands and feet, etc., but the conversation stops there. Pressure Ball and the Salt Room are similarly attractive in a physical way, kids jump as they pump, and throw themselves against the walls respectively. Many students and others who interact with Planet Transit (The Kepler Project) do so by cranking the handle with little if any attention to related labels.

Microbial Mat (48)

This element has an obvious knob to turn on the front of the tank which houses the Microbial Mat. Turning the knob increases the light shining down onto the mat. The position and orientation of the light makes it almost invisible from the user's vantage point; visitors have to be interested enough to look around and eventually lean over and peer back up at the device before they understand what's happening. Visitor experience of this element will be enhanced by a more obvious change in light upon turning the knob, or some other indicator that clues in the user

to the change in light level. Note that SSI has addressed these shortcomings at the time of this writing.

When Planets Form (2), **When Stars Form** (4)

These panels contain information critical to the exhibit's mission, but are overlooked by most visitors. Competing with so many exciting interactives is hard for a static panel. Stronger illumination in the form of a spot light from above, or some internal source might improve visitor attendance to these elements.

Many other panels have similarly low attraction rates. In most cases, those panels face the wall of the gallery and/or are on the reverse of areas with interactives. These may well enjoy greater attention in other venues where the may be more visible to the passerby.

Again, with so many exciting hands-on elements, panels will have a hard time competing for visitor attention. Remedial work may want to consider employing a questions/answer format that visitors manipulate, or a video element on the most important panels; something to make panels more dynamic.

Computer screens throughout exhibit

Museum visitors are accustomed to touch screen technology. The screens in this exhibit use graphics that invite touching before visitors realize that they are to use the track ball device on the counter. An arrow graphic, or something of the kind, on the monitors may help guide visitor fingers to the appropriate interface.

Exit Survey of Adult Casual Visitors – Summarized Survey Results by Question

Question 1a.
Prior to coming here today, how interested would you say you are in the topic of the search for life and other planets, using this scale of 1 to 5?

Response Scale	%; n=50
1 – not at all	14%
2	12%
3	20%
4	32%
5 – extremely interested	22%

Question 1b.
Now using this scale… Prior to coming here today, how strong is your background knowledge in this area?

Response Scale	%; n=50
1 – significantly less than most people	24%
2	18%
3	46%
4	10%
5 – I'm an expert	2%

Question 2.
What would you say is the 'big idea' about science that the museum hoped you'd learn in this exhibit?

Response Category	**Description**	**%; n=50** (multiple answers accepted)
Extraterrestrial Life	Most comments address the possibility of life on other planets, some touching on the number of other planets and/or conditions necessary for life. One respondent: "that we're not alone."	40%
other		24%
Solar System	These respondents focus on the planets of our solar system. Two include comment on distance/scale.	16%
Search for Other Planets	That there is an active search for other planets, and how it is done	12%
Life on Earth	To teach about the basics of life on Earth.	10%
Spark Interest	To encourage interest in ourselves, this world, and the like.	6%
Vague; Too Broad	These respondents felt the exhibit was unclear or unfocussed.	6%
Funding	Comments on the need for more financial support for space exploration.	4%

Please see Appendix B for a complete list of all verbatim responses.

Question 3.
What is something new or interesting you learned in this exhibit today?

Response Category	Exhibit Element Referenced:	%; n=50 (multiple answers accepted)
Life on Earth and/or how that relates to searching for other life.	Microbial Mat, Microbe Section, Life Scanner, Looking For Life, Biomass	22%
Solar System and/or Planets	Our Solar System (orrery), Planet Models, Design a Solar System, When Planets Form	14%
Nothing		14%
Star	View Space Theater, Stellar Life Cycle, Pressure Ball	12%
Size/Scale	Planet Models, Milky Way Galaxy Entrance Mural (powers of 10),	12%
Search	Planet Transit, Wobble, Spectroscopy, Entry Panels	12%
Other	Mission Invisible (1)	12%
We are stardust.	When Stars Form	6%
History of Astronomy	Planet Hunting Murals and Timeline inside the Dome	4%

Please see Appendix C for a complete list of all verbatim responses.

Question 4a.
Did you see the information about how scientists look for new planets?

	%; n=50
yes	38%
no	62%

Question 4b.
Can you tell me 2 different methods scientists use to look for planets?

Number of Methods Accurately Named:	%; n=50
0	78%
1	8%
2	14%

Method Cited/Described	%; n=50
Planet Wobble	18%
Planet Transit (Kepler Project)	16%
Vague or confused	12%
Other	6%
Spectroscopy	4%

Please see Appendix D for a complete list of all verbatim responses.

Question 5.
What do you think is the difference between what planets and stars are made of?

Stars vs. Planets	Category Description	Exit Survey (n=50)	Front-end Study (n=310)
Density	some reference to the idea that stars are gaseous and planets are solid	52%	60%
Stars burn	reference to fusion, nuclear reactions, heat, shine	18%	4%
Other	various including one reference to "we are startdust" and one reference to Coronagraph	18%	11%
Don't Know		12%	25%

Please see Appendix E for a complete list of all verbatim responses.

Question 6.
Why do you think scientists interested in finding life on other planets study life on earth?

Why study life?	%; n=50
As a general guide to what to look for, how to make comparisons.	56%
As a guide, specifically to what life might be like, what to look for	16%
As a guide, specifically to what conditions can or might support other life	14%
Other	14%
Don't Know	--

Please see Appendix F for a complete list of all verbatim responses.

Post-visit Teacher Survey Results

(7 respondents; all responses appear in this section)

Question 1.
What grade class did you bring to this exhibition? How many students?

Grade(2)	Number of Students
3	31
3	20
3	20
3,4	19
4	26
8	13
9, 10, 11, 12	12

Question 2.
What activities or exercises had your students completed prior to the field trip to prepare for this content area?

- Physical science - labs, experiments, work on electricity, atoms, etc.
- We hadn't done much in this area yet.
- There were some things the kids were familiar, with for example: the guessing of grains of salt (estimation). But mostly it was geared for new knowledge.
- We had just started our Solar System Unit but had I been notified of the content area, I could have prepared my students more.
- Experiments & study of moon & planets - size only, order
- None
- Not applicable [as] substitute teacher attended the filed trip.

Question 3.
Please explain how you expected this field trip to fit into your curriculum.

- Computers, math/science, interactive games, laser luminations experiment, electricity, brain research, etc.
- Helps meet science standards
- Science is not a subject we have every day, so I wanted the kids to have a hands-on approach to all the things we studied, [as well as] what we did not.
- I had no expectations because I had no information. I was happy to see that many of the exhibits were about size, position & movement of planets!
- Fits in with our benchmarks in our study of moon.
- Mystery room & chemical clues lab
- ? Not familiar with the classroom teacher's goals.

Question 4.
How well did the students' experience meet your goals? (Please circle one number.)

Scale	Frequency of Response
1. Not at all	0
2	0
3	2
4	0
5. Exactly as I had hoped	5

Please explain your answer:

- They enjoyed the Alien Earth exhibit & all that the Lawrence Hall of Science has to offer in math/science.
- I wished students could have stated more directly what they learned from the exhibit.
- They loved it. Everything we have been reading, they did.
- My students were very excited to actually see models of planets to compare sizes & also the model of how they orbit. Much easier to understand than a worksheet or picture.
- Reinforced students' study of the moon.
- Deductive thinking required
- Not enough students observed the exhibit due to its location. [Not all of this substitute teacher's students attended to this gallery during their visit to LHS.]

Question 5.
In your opinion, what was the most effective part of this exhibition?

- All the interactive choices that the exhibit gave to each student. They were thoroughly engaged in all areas. We spent 1.5 hours at the Alien exhibit.
- Hands-on activities
- The planet sizes was effective. They had no idea of their relative size to each other.
- Effective? I think that the degree of effectiveness depends on the background knowledge that students have prior [to] viewing it.
- The model -- light, sun, moon -- seeing the phases of the moon
- Girls loved the heat sensor & funny mirrors.
- The hand-scan & the water molecules due to the hands-on & cause-->effect

Question 6.
In your opinion what change(s) could we make to improve your students' experience?

- None
- An activity center/demo station where Lawrence Hall of Science staff are available
- I think it was great. Even more hands-on activities.
- Provide teachers with a packet that gives basic information about main exhibit, some suggestions of what to look for or try. Also a map with.
- I would have loved for you to show kids the Big & Little Dippers & where North Star is.
- A Lawrence Hall of Science staff member to help explain exhibits. Something about aliens, because that's what the students expected.

Question 7.
What did the students seem to enjoy most?

- All the Alien exhibit & the hand-on projects from the exhibits -- truly engaged in all areas.
- The mirrored room, the hand scan, getting the star hot
- The activity with the air & balls
- Those that they could understand or interact with, such as the Design Solar System. How stars are formed. The students also talked about the display that showed what your body consists of by putting their hands on screen?
- Water molecule exhibit, hand scan, solar system distances, finding out the number of salt grains per package

Question 8.
What follow up activities did you use in the classroom after your field trip?

- Five questions on the Lawrence Hall of Science, exhibits, lab we did with an instructor (Laser Luminations Lab).
- None yet
- We talked about it all first & they had listed their favorites & what they did & why.
- We will continue with our studies of the Solar System. The students are to write about one thing that they learned, one that they liked, & one that they want to learn more about.
- Worksheets on the moon, experiments showing eclipses - lunar & solar - with hands-on activities
- Estimate how many grains of salt per container in the classroom

Question 9.
Did you make use of the Lawrence Hall of Science web site in advance of your field trip or as a follow-up to it? Please explain.

- No (3)
- Yes, I looked to find information. The book also helped.
- I did not use website before but I will see if there are some follow-up activities to do with my students. Use of website before coming to exhibit should be encouraged/stressed at time of signing up for workshop.
- Will, but not yet
- Yes

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Appendix A

Sampling Methodology

All data were collected during March and April of 2005. No minor visitors to LHS were approached or questioned by data collectors. School teachers and school groups were targeted based on grade level and time available for the Exhibit. Studies with casual visitors followed random sampling protocol and are representative of the LHS visitorship.

Sample Descriptions

Exit Survey Sample Description (n=50)	
Male	60%
Female	38%
Intergenerational Group	90%
Visiting Alone	6%
Adult only group	2%
Number in Group	
1	4%
2	24%
3	36%
4	22%
5	10%
8	2%
Age Decade	
18	4%
20	4%
30	38%
40	40%
50	8%
60	2%
80	2%

Tracking and Timing Study Sample Description (n=50)	
Male	42%
Female	58%
Intergenerational group	86%
Visiting alone	4%
Adult only group	4%
Subject Age Decade	
20	16%
30	46%
40	18%
50	12%
60	6%

How interested are these visitors? How well informed do they feel?

Visitors to Alien Earths report that they are very interested but only minimally knowledgeable about this exhibit content. Over half of these 50 randomly selected adult respondents to the Exit Survey describe themselves as *very* to *extremely interested* in this topic (55%). Nearly half feel that they know as much about this topic as *most people* (46%), another 42% feel that they know *less* or *significantly less* than *most people*. Only 10% claim to know more than most people, and 2% claim to be experts.

Appendix B:

Responses to Question 2: What would you say is the 'big idea' about science that the museum hoped you'd learn in this exhibit?

Extra Terrestrial Life

- That we're not alone
- That there are other solar systems , more planets, stars, and the certain conditions needed for life – distance to star.
- Learning about life on planets & how it works.
- That there might be life on other planets
- Out of all the planets, what percentage might have life, & be able to support life & intelligent life forms
- The likelihood of more life being out there in the universe
- How they would find life on other alien planets & if they would be other earths with life on them
- That you need water for life. In order for water, you need certain condition, not too hot, too cold, energy from sun which makes life, & also need carbon.
- The probability of life on other planets & what it takes to find out if it's there.
- The possibility that there's alien life on other planets
- The possibility we're not alone and the vastness of it all.
- To ask yourself the question, "Is there intelligent life on other planets?"
- That there's a lot of stars out there & a lot of planets & possibilities of other life.
- Considering things beyond us that are alive; that they might be in many different realms.
- To keep an open mind about the possibilities of life or anything else out there.
- That there are signs that we can study the other planets & maybe there's life out there.

Solar System

- That the universe and the earth -Earth's place in the universe; what's bigger & what's smaller.
- To learn something about the solar system
- The exhibit only educates you more about our own solar system, but I think by the title, they wanted to get across the scope of the universe.
- Trying to familiarize you to planets - differences in size & weight
- The varieties among the planets.
- Showing the kinds the future & planets.
- Planets

Search for Other Planets

- That exploration is [a] continuous process. Don't know why bacteria part was there.
- The idea that there is so much more than our solar system. They're making discoveries all the time. That the universe is so much bigger & more complicated than just us.
- That these are projects trying to identify other planets.
- A general indicator of where they are now with looking for planets, and what they can tell and what [they are] looking for.
- That earth is probably a fraction of what's really out there
- That we're working to discover more
- That we're getting closer to finding other planets.

Life on Earth

- To teach about the basics of life & how it is formed
- What life is made of

Vague; Too Broad

- Billions of years & light years, & the nebula. Tried to refocus too big idea, unsuccessfully.
- Quite frankly I wonder. There's the microbes, the history, modern telescope projects. It was all over the place.
- Actually, I was disappointed. The big idea was not clear. [Guess] there is life everywhere.

Spark Interest

- Get us interested in ourselves & in where we live.
- Stimulate your ability & curiosity about the universe, galaxy, world & life.
- Don't know. "keep your mind open; it's a big world out there."

Funding

- There sure would be nice to be more funding for space exploration.
- Support for space program

Other

- What they wanted you to know about how many stars - billions
- Learning more about earth science
- Get a sense of how relative everything is to each other from us to the universe
- Maybe a comparison between life on earth & other planets
- That there exists life in everything really

Mixed

- I think … I think it's to encourage people to go on to look for life on other planets & to take care of life on earth. It's all connected.
- They want you to learn about different kinds of life & that maybe there's life on other planets.
- The relation between all life & the solar system
- Dimensions - the scale from large to small. Unprompted 4-year-old: We're not alone. The same bacteria are on the asteroids as on the earth, so we're not alone.
- What life is - the definition of life; the odds of finding that; how to find that, and; general solar system knowledge.

Appendix C

Responses to Question 3.
What is something new or interesting you learned in this exhibit today?

Life

- Different types of bacteria & how that works in an ecosystem
- The microbes section, all that. Also didn't know we are made of 65% oxygen. The carbon content in people was smaller than I expected, and nitrogen is really small
- All was new to us. [One thing you'd remember?] Comparison between microbes, plants & animals; the percentage that inhabit the earth.
- I learned a lot but didn't get to read because of being with my 3-year-old. But still learned from doing the interactives. Liked especially raising the weights for microbes, plants, animals. I think my son has an idea of the impact tiny things can have now.
- The hand-scan thing was very interesting.
- About the bacteria & being able to sense life by learning about bacteria.
- I liked the section about what is life & how to tell if it is life. I didn't know that we had so much technology to figure out if there's life out there.
- that every human has a certain amount of certain elements. We should compare that to other life on other planets.
- The interactive [part] that shows how many microbes are living on you.

Solar System and/or Planets

- The exhibit about building your own solar system made me see how specific the system has to be to work.
- Making your own solar system was really cool & fun.
- How solar systems are put together, develop & evolve
- I really liked "Build Your Own Solar System." Seeing the planets clump together & run into the sun.
- About the planets - if you put them too close to the sun & it explodes

Star

- Everything - this horse-head nebula - that was really neat.
- Learned about exploding supernova; watched several times, in fact.
- The temperature going higher, then exploding. I knew it, but it made it so vivid.
- The pumping & getting the star to explode
- I'm seeing this for the 6th time. [At age] 80 now, I've had a chance to really absorb the content of the films.
- The part about igniting a star was cool. And the one where you could move the planets around the sun. Hard to learn with kids or while chasing the kids. How long it took to go around the sun if far away from it.

Mixed

- [Looks into door of exhibit] I can't say. [Something you'll remember?]: Liked the models, seeing the relative size of the planets.
- I really liked the models of the planets showing their scale.
- The life mat (?) that gives off oxygen - that was really fascinating. Also vast distances in space
- Not really anything new. [Can just be interesting] The infrared camera was really cool. Also video with form of life or not a form of life [as] I got a bunch wrong & read about them.

Size/Scale

- The relative size of everything
- That if you were at nearest star system looking back here, you couldn't see the earth.
- The same thing - the scale from [very large to very small - referring to powers of ten]

Search

- I didn't know about the project to detect when a planet goes in front of a sun. Thought they could already do that.
- We learned about spectroscopy & the ability to detect stars & planets by detecting wobble.
- This first thing, talking about the different missions into space & their objectives
- 134 planets discovered outside our solar system. I didn't know that before.
- The sound patterns that they can hear out there.

We are stardust

- That my body is made of star stuff; "I am a rock star." I didn't really learn much. Too much reading (dense & heady) & not enough for kids to learn through DOING.
- That the building blocks for our bodies come from the stars
- Earth is the dearest planet. We are made from the same things stars are.

History of Astronomy

- The history of events as you progress in time, closer to discoveries.
- The history aspect - Copernicus & Galileo - the development

Other

- About molecules & water, and different temperatures. Knew that but it was really good.
- How interactive the exhibits were & that I didn't have to read it to learn.
- The picture diorama. Everything else is like a supporting cast.
- It was so overwhelming [with] all the video. I can't say just one thing.
- That in a package of salt, there's over 3 million pieces - well, lots of grains in a salt box
- How infrared works. What passes infrared through & what doesn't. I'd heard the phrase before but hadn't really thought about it.

Appendix D:

Responses to Question 4b: Can you tell me 2 different methods scientists use to look for planets?

Planet Wobble

- Wobble -planets will [wobble], affecting orbit of other planets
- Motions of the stars near them
- The wobble from the orbit [of stars] pulling on each other.
- Wobble as described above.
- Wobble effect from gravitational pull
- Gravitational
- Changes in sun's orbit
- Wobble.

Planet Transit, Kepler Project

- Changes [in] intensity of light.
- When the planet travels in front of sun & light dims
- Looking at stars - wobble effect
- The dimness in the pulse of the light coming from it.
- Changes in light form nearby stars
- The light & the dips in measured light
- Light dims as planets transit across sun.
- Change in light as it passes in front of stars
- They send out telescopes like Kepler project.

Spectroscopy

- Spectrograph - chemicals show up [characteristics of cooler bodies].
- Spectronomy. Don't remember any others.

Other

- Interferonomy, but I'm cheating [as] I knew that already.
- I don't think so. [guess] : Well, they use telescopes & also they guess based on the information they can see.
- Telling the difference between natural & intelligent signals
- Infrared from sunlight changing between planets & occlusion when light gets blocked.

Confused

- The signals they can get from outer space
- Looking for water in radiation spectrum
- Husband said: I can't, [I'm] "plotting energy states. That's how they found Neptune & Uranus."
- This big cloud, the Horsehead cloud with stars at the end
- They can't really know. Impossible to know about things that far away. We can never catch up with what's actually going on because light is old by the time we see it.
- Something about gases.

Appendix E:

Responses to Question 5: What do you think is the difference between what planets and stars are made of?

Density (stars are gas, planets are solid)

- Stars are dust & planets are rock, or matter.
- Planets [are] gases or organic material; stars [are] particles & dust
- Don't know. {Guess] that planets are more dense matter than stars.
- I think they're all the same, only the stars are denser.
- Gases versus solids, density, & planet's aren't on fire.
- This is a guess - gases are stars & planets are more solid matter, more complex matter
- The stars are usually made of gas, & the planets are made of elements.
- Stars are made of gases, & most planets are made of more solid stuff, except Neptune & Uranus; they're gases too.
- I believe stars are made of gases, but "everything is made of carbon", so …. And planets have more carbon, I guess.
- Stars are lighter, less dense materials than planets.
- The materials they're made of. Stars are more gaseous; planets are more minerals & compounds. Planets are orbiting with us on them.
- Different matter. Planets are dense matter, stars are more gaseous
- Suns have more lighter elements [like] helium & hydrogen. Planets have more complex components. Does sun's heat keep them from forming?
- Different types of matter - stars burn hotter - made of gases - or more gases.
- Stars are made mostly out of gases; planets [are] made out of rocks & minerals.
- I don't know, [guess] gas are stars [while] planets are dirt & rock.
- Stars might be gases. Don't really know. Planets are inorganic matter.
- Comparing planets, they're more dense & stars are made of gases.
- There are many differences, I'm sure. Planets are made out of stuff that is dense. No. Stars are made of gases; planets are denser solid matter.
- Stars are made of gas. I don't know. Planets have microbes. I didn't get anything else, really.
- Solids & gases or really planets are solids, stars are gases.
- Stars are gases, planets are more solid, but some of them are gas, have gas too.
- Stars are made of gas. Planets have more material, mass, rock at center, even if it's a gas planet.
- Planets are more solid than stars.
- I thought stars are mainly gas, & planets are mainly matter & minerals. I didn't learn that today though; it's a preconception.
- Planets are more like solid & have carbon in them. Stars are more gaseous & have less matter in them.

Stars Burn

- Stars are principally hydro helium fusion; planets may be those, but also heavier elements, metals.
- With stars there's more gas & heat involved; and [with] planets, there's more matter in a solid state.
- Stars are big hot balls of gases. Planets have more rock & are not flaming balls of gases.
- Stars are made of hydrogen & something else, with fusion turns into helium. Planets made of carbon - don't ignite with _____. Stable - don't compress more.
- Our star has nuclear reactions. I think of gases going through nuclear reactions on stars. Planets have heavier elements & heavier gases (gases in stars are more basic - hydrogen & helium)
- I think it has something to do with temperature & pressure. Stars have greater temperature; planets [have] greater pressure.
- Have no idea. [Guess?]: Difference is the energy inside it. Stars [are] on fire, & planets' energy is in there but not all on the surface.
- Planets are made of interstellar dust, stars hot gases
- I learned that stars shine & planets don't, but I don't know about what they are made of.

Other

- I think time - more time is built into planets than stars. I'm not a scientists; it's my weak point.
- I'm guessing the stars are the basic elements. I thought they were made of the same things, but maybe not.
- No idea. Wait - I guess that there's no difference though [as] it's all matter; because I learned in there that I'm made of the same thing as stars.
- I don't know, [guess] liquid is in stars
- Stars are typically made of hydrogen, & planets are made of hydrogen & other materials like carbon & helium.
- Almost none except for the hydrogen; without hydrogen we wouldn't be here.
- Don't know. Maybe water content. [One has water while other not?] Both have it. I really know nothing about any of this.
- Don't know. [Guess?}: Stars are made [of] gases; planets made of, oh, I don't know, sugar & spice.
- I think planets are more evolved & closer to the stage of life. And stars are made of gas. Stars may have life, but not like we know it.

Appendix F:

Responses to Question 6: Why do you think scientists interested in finding life on other planets study life on earth?

Guide – general

- Study what you know; try to make comparisons.
- So they know what to look for out there.
- So they can learn what to look for
- So they know what to look for
- Under the theory that life & circumstances would be the same on other planets, though that might not be true at all
- Have no idea; [guess] that they'll know what they're looking for?
- They see the life here as available & use it as a base to compare to other planets. Of course, it may not be relevant to life on other planets; that's another question. But they start here because it's available.
- So they can compare it & maybe find new results, new inventions or creations
- To see the possibilities. If we know more about ourselves, we can know more about the possibilities for other life. We could be way off though. Tricky thing is, will we recognize it if we see it?
- To see how life on other planets could - this planet is like a control set. Learn in context of own, using our world as a reference point
- If you look at what we have & know about life here, having carbon, needing water, then look for similar things in outer space. Unless other thing are needed for other life forms on other planets. In that case, we'd be looking straight at it and not see it.
- To make comparisons, make hypotheses
- Probably to draw similarities &, if you understand life here, you know what to look for on other planets
- To make comparisons. If they can find things out there similar to things here, maybe they can identify life.
- To compare the two?
- If you knew how to detect life here, what signature we give off, that's what you'd be looking for out there.
- To get some clues about where to start, what to find out there
- Because there's presumably a correlation between life here & anywhere else, if you understand it here, maybe you can understand it in other places.
- To understand what to look for or where to look for it
- You have to have a frame of reference. This is our only frame of reference. It's only because of our understanding of this world & life that we can even think about life in other places. The displays are really well done.
- To find some correlations between the two, other than that, I have no idea.

Continued…

- You have to have a basis to compare things to.
- I guess they have to know what life here needs, to look for it elsewhere. How our planet works, with carbon-based life forms, water, oxygen.
- In order to find what life is made of, what to look for, conditions conducive to life
- To determine what to look for
- To have patterns to compare to.
- Because they have to study life here to be oriented to the parallels that exist on other planets. You have something to work with her [on earth].

Guide – life

- To help guide them - how we evolved here & how we're made.
- To see what constitutes "life."
- So they know what life outside the earth might be like
- Because I think they're trying to compare life here & see if there are traces of current or former life on other planets
- To see under what conditions life forms, and the extremes that can be tolerated by different life forms.
- Because if we have an understanding of our own evolution, we might understand life elsewhere. The laws that create life presumably [are] the same everywhere. Planets with similar conditions might also get life.
- Because it gives you more things to go search for. Of course if scientists are only looking for life forms about 1.5 meters tall with 4 appendages, they'll probably be sorely disappointed.
- I assume that life would still have the same basic building blocks - DNA or other structures.

Guide – conditions for life

- Because if you're looking for life like us, you need to understand our needs, [i.e.,] what the conditions are that would produce carbon-based oxygen-breathers.
- To find out the basic needs for life [&] to look for other planets that could sustain life forms like us.
- They need to find some water or air in the other planet
- I assume they're looking out [for] conditions that facilitate life & make it possible.
- Because the conditions that allowed life to develop here might be similar to or identical in other places: water, oxygen, carbon.
- Because they're looking for patterns of how life exists to find the same pattern elsewhere
- So they can draw creative hypotheses about what life requires & see if they can spot it somewhere else

Other

- Because it would be something good to know if it's true (that there was life on other planets). I don't think it's true, though, that there's life on other planets.
- Because they want other planets for us.
- It's the one we know the most about.
- Because of wanting to inhabit other planets at some point

Appendix G

Exit Survey Form

Date:_____ Interviewer :_____

Visitor: **M F** Age Decade: **18-19 20's 30's 40's 50's 60's 70+**

Social Group: **alone Intergen. group adult group teen group**

Hello, we're collecting some feedback about the exhibition you just saw in order to improve it. May I ask you 6 short questions?

1a. Prior to coming here today, how interested would you say you are in the topic of the search for life and other planets, using this scale of 1 to 5?

Not at all **1 2 3 4 5** Extremely interested

1b. Now using this scale… Prior to coming here today, how strong is your background knowledge in this area?

Significantly less than most people **1 2 3 4 5** I'm an expert

2. What would you say is the 'big idea' about science that the museum hoped you'd learn in this exhibit?

3. What is something new or interesting you learned in this exhibit today?

4a. Did you see the information about how scientists look for new planets? **Y N**

4b. Can you tell me 2 different methods scientists use to look for planets?

5. What do you think is the difference between what planets and stars are made of?

6. Why do you think scientists interested in finding life on other planets study life on earth?

Appendix H

Tracking and Timing Study Data Table; Exhibit Element Use & Dwell Times

Element	Description	No. Visitors to Use	% Visitors to Use (n=50)	Min Dwell Time	Mean Dwell Time (n=No. Users)	Max. Dwell Time	read	read aloud	manipulate	discuss	call over	cooperate	intergen.	point out	watch others	sit	watch vid
Planet Hunting I, a Time Line Mural,	circular panel located overhead in dome	5	10%	:24	1:50	4:31	5	0	0	2	0	0	1	0	0	0	0
1. Our Solar System (orrery)	solar system model	25	50%	:03	1:14	4:47	13	4	1	6	0	1	8	7	0	0	13
2. When Planets Form	panel	3	6%	:15	2:21	6:23	2	0	1	1	0	0	1	0	0	1	0
3. Design a Solar System	interactive	20	40%	:10	3:46	10:03	6	5	14	4	1	1	10	4	5	9	3
4. When Stars Form	panel (we are star dust)	4	8%	:07	:24	:45	3	1	0	1	0	0	1	0	0	0	0
5. Mission Invisible	infrared camera and table (no mist)	26	52%	:08	1:55	6:38	10	6	18	4	0	6	10	4	14	0	2
6. Pressure Ball	manipulative with pumps	30	60%	:07	1:12	6:16	13	4	24	10	1	4	11	0	12	0	1
7. Stellar Life Cycle	video, speed and direction controlled by visitor using a SpinBrowser	18	36%	:11	1:07	4:32	3	3	4	5	0	0	7	2	7	0	9
8. View Space Theater	video with subtitles and seating	16	32%	:05	3:47	11:11	0	2	1	4	2	0	4	1	0	11	15
9. Telescope	LHS prototype interactive	n/a	n/a	n/a	n/a	n/a	--	--	--	--	--	--	--	--	--	--	--
10. Salt Room	mirrored hexagonal space that visitors can enter	24	48%	:05	:41	1:13	7	4	0	7	1	0	9	0	0	0	0
11. Searching for Life From a Nearby Star	panel	6	12%	:05	:20	:50	3	2	0	0	0	0	0	0	0	0	0
12. Are we alone?	Drakes estimation formula computer interactive	19	38%	:15	2:06	8:28	13	3	13	6	0	0	8	3	1	1	13

Element	Description	No. Visitors to Use	% Visitors to Use (n=50)	Min Dwell Time	Mean Dwell Time (n=No. Users)	Max. Dwell Time	read	read aloud	manipulate	discuss	call over	cooperate	intergen.	point out	watch others	sit	watch vid
13. Understanding Numbers	salt estimation interactive (guess how much salt in a container and lift flap for answer)	16	32%	:05	:45	1:50	8	5	7	3	0	0	7	1	0	0	2
14. Salt Manipulative	salt estimation with scale manipulative	--	--	--	--	--	8	2	9	2	0	0	1	0	1	0	0
15. Planet Models	scale planet models and panel text	33	66%	:02	1:06	8:36	12	12	13	9	2	0	15	6	1	0	0
16. Planet Densities	manipulative about density	30	60%	:04	:46	2:39	10	10	24	8	0	0	14	6	1	1	1
17. Milky Way Mural LED Display	panel with LED display to trigger by pressing button	8	16%	:10	:21	:30	8	2	5	1	0	0	1	2	0	1	1
18. Milky Way Galaxy Entrance Mural	series of large panels discussing scale and powers of ten	8	16%	:04	:38	1:50	5	3	1	2	0	0	2	2	0	0	0
19. Coronagraph	panels and manipulative re: Coronagraph	22	44%	:23	1:01	2:09	10	4	13	6	0	0	11	0	5	12	5
20 (+21). Planet Hunting II	Be a Light Detective panels near Planet Transit	7	14%	:03	:43	1:26	6	0	1	2	0	0	1	0	0	1	0
22. Planet Transit (Kepler Project)	crank-controlled man-ipulative with computer screen read-out	23	46%	:11	:55	3:21	10	6	11	3	0	1	6	3	6	0	5
23. Planet Transit (Which Graph manipulative)	manipulative next to Planet Transit (Kepler Project)	8	16%	:05	:22	1:09	6	0	3	0	0	0	0	0	2	0	1
24. Planet Hunting III	panel with photos and infor. about astronomers	3	6%	:18	:39	1:07	2	0	0	0	0	0	0	0	0	0	0
25. Planet Wobble Interactive	table with balls/rods to manipulate; demo of wobble	24	48%	:03	:43	1:50	6	6	19	6	1	0	7	1	5	0	1
26. Planet Wobble Panel	panel near wobble manipulative	16	32%	:07	:27	1:06	13	1	4	3	0	0	0	2	0	0	0

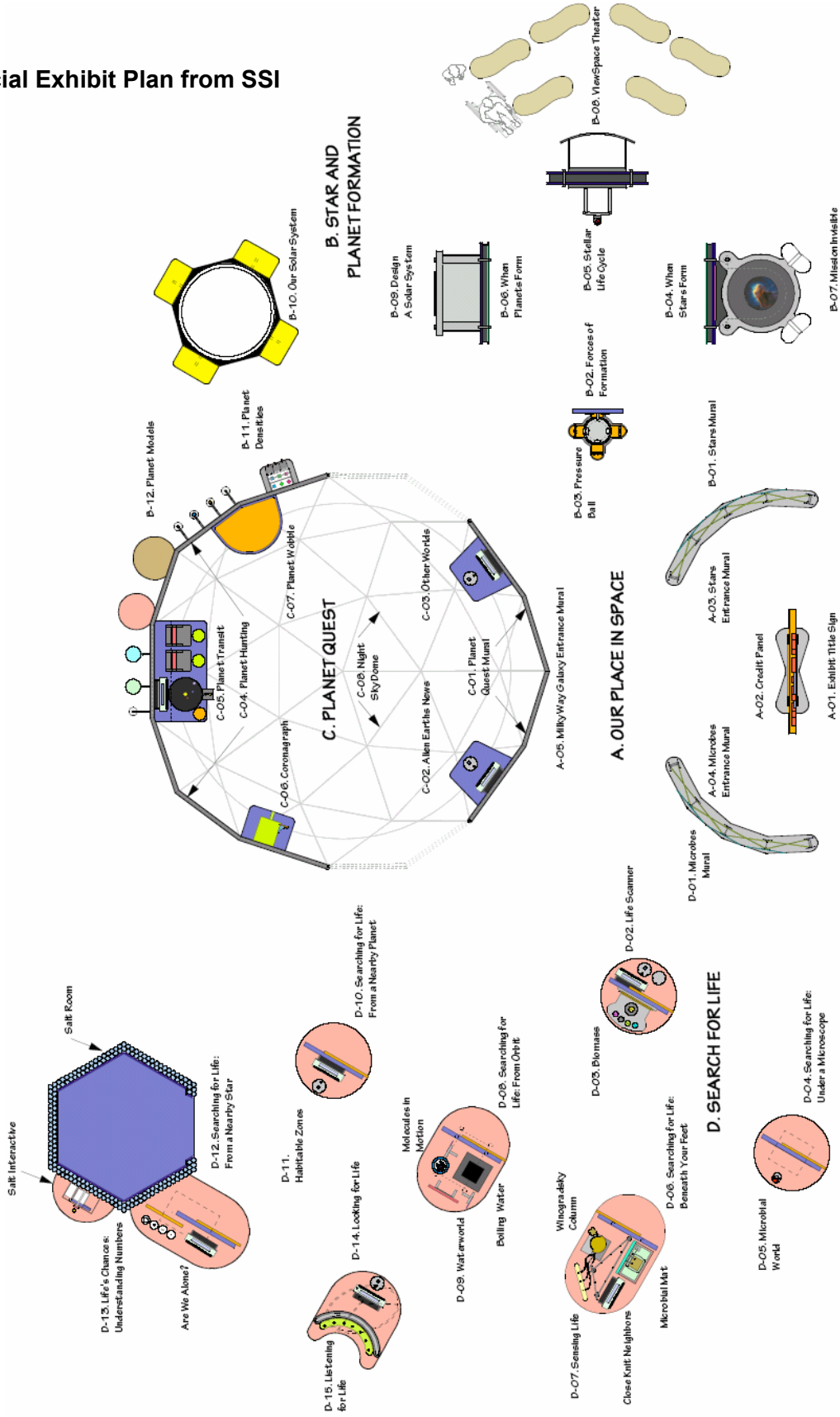
Element	Description	No. Visitors to Use	% Visitors to Use (n=50)	Min Dwell Time	Mean Dwell Time (n=No. Users)	Max. Dwell Time	read	read aloud	manipulate	discuss	call over	cooperate	intergen.	point out	watch others	sit	watch vid
27.Other Worlds	computer interactive	16	32%	:08	1:57	8:32	7	6	11	2	0	0	7	3	3	0	7
28/29. Planet Quest Mural	two large panels	3	6	:05	:34	;53	2	1	0	0	0	0	0	0	0	0	0
30. Alien Earths News	computer interactive	14	28	:04	:38	2:15	5	3	9	0	0	0	2	0	2	1	7
31. Stars Mural	large panel	6	12%	:09	:58	3:43	5	1	0	1	0	0	1	1	0	1	1
32. Stars Entrance Mural	large entry panel	10	20%	:03	:12	:43	8	2	0	0	0	0	0	0	0	0	0
33. Exhibit Title Sign	center entry panel	8	15%	:03	:11	:23	6	2	0	0	0	0	0	0	0	0	0
34. Microbes Entrance Mural	large entry panel	11	22%	:03	:21	1:03	9	2	0	0	0	0	0	0	0	0	0
35. Microbes Mural	large panel on reverse of entry panel	1	2%	:06	:06	:06	1	0	0	0	0	0	0	0	0	0	0
36. Life Scanner	“hand print” and computer interactive	23	46%	:26	2:23	5:32	8	12	18	9	0	1	15	3	4	0	11
37. Biomass	manipulative with computer read-out	19	38%	:06	1:00	4:24	6	7	15	3	0	0	8	4	3	0	2
38. LHS Docent-led Human Orrery	concentric circles on carpet; photos and other items only when docent is present	9	18%	:05	:54	3:00	0	1	3	1	0	1	3	0	0	0	0
39. Looking for Life	computer interactive	11	22%	:28	2:49	6:01	7	3	8	2	1	0	4	1	2	0	9
40. Listening for Life	manipulative with audio and video read-out	18	36%	:31	2:15	5:35	9	4	14	9	0	0	8	3	3	7	10
41. Habitable Zone	computer interactive	17	34%	:05	1:34	4:08	11	4	10	4	0	0	4	3	1	4	12
42. Searching for Life from a Nearby Planet	computer interactive	5	10%	:03	:19	:52	4	0	1	0	0	0	0	0	0	0	0
43. Water World	panel	6	12%	:05	:32	1:13	4	1	1	0	0	0	0	0	0	0	0
44. Molecules in Motion	manipulative	32	64%	:12	1:01	3:22	14	10	19	4	0	0	18	2	9	0	0
45. Searching for Life from Orbit	panel	7	14%	:08	:22	:42	6	1	1	0	0	0	0	0	0	0	0
46. Boiling Water	manipulative	26	52%	:16	1:13	2:47	15	7	19	9	2	0	10	4	3	0	2

Element	Description	No. Visitors to Use	% Visitors to Use (n=50)	Min Dwell Time	Mean Dwell Time (n=No. Users)	Max. Dwell Time	read	read aloud	manipulate	discuss	call over	cooperate	intergen.	point out	watch others	sit	watch vid
47. Searching for Life Beneath Your Feet	Panel	4	8%	:07	:28	:54	3	1	1	2	1	1	2	1	1	0	0
48. Microbial Mat	microbial mat with manipulative and computer read-out	17	34%	:07	1:40	6:46	8	7	9	3	0	0	6	1	3	0	3
49. Close Knit Neighbors	computer interactive	13	26%	:06	3:10	12:35	8	3	7	2	0	0	4	4	3	1	2
50. Winogradsky Column sniff bottles	W. column with hoses to bottles so visitors can manipulate and smell the column layers	10	20%	:05	:49	2:45	4	3	7	2	0	0	4	2	0	1	0
51. Winogradsky Column and flashlights	flashlights to shine on column	12	24%	:08	:38	2:13	6	4	8	4	0	0	3	3	2	0	0
52. Searching for Life Under a Microscope	panel	4	8%	:07	:23	:32	2	1	2	0	0	0	1	0	1	0	0
53. Microbial World	video, speed and direction controlled by visitor using a SpinBrowser	15	30%	:03	:51	2:41	4	3	8	6	0	0	4	2	1	0	9
54. Docent Table	diversity of life card game; not always present	1	2%	3:58	3:58	3:58	0	0	1	1	0	0	0	0	0	0	0

Appendix I

Exhibit Floor Plan at Lawrence Hall of Science

Official Exhibit Plan from SSI



Appendix J

Teacher Post-visit Survey Form (response spaces eliminated)

Thank you for helping us better understand how the Alien Earths exhibit works for school groups. Your input will allow us to make the changes necessary to improve future school group visits.

1. What grade class did you bring to this exhibition? _____
   a. How many students? _____

2. What activities or exercises had your students completed prior to the field trip to prepare for this content area?

3. Please explain how you expected this field trip to fit into your curriculum.

4. How well did the students' experience meet your goals? (Please circle one number.)

Not at all	1 2 3 4 5	**Exactly as I'd hoped**

Please explain your answer:

5. In your opinion, what was the most effective part of this exhibition?

6. In your opinion what change(s) could we make to improve your students' experience?

7. What did the students seem to enjoy most?

8. What follow up activities did you use in the classroom after your field trip?

9. Did you make use of the Lawrence Hall of Science web site in advance of your field trip or as a follow-up to it? Please explain.

To receive your Lawrence Hall of Science family pass and the astrobiology poster, please enter your name and mailing address in the space below. Your identity will not be recorded with the data in this study. Your responses will remain anonymous.

Name: _____
Mailing Address: _____
_____
_____
_____

Appendix K

Field Trip Observation Data Table

Note: the LHS floor plan is such that one cannot observe the entire gallery from any one vantage point.

Group	1	2	3	4	7	8	5	6	9	10
Grade	3	3	2/3	2/3	3	3	6	6-8	6-8	6-8
Number in Group	25-30 (incl. 5 adults)	11-12 (incl. 3 adults)	20-30 (incl. Several adults)	4 (incl. 1 adult)	6 (incl. 1 adult)	11 (incl. 3 adults)	6 (incl. 1 adult)	3 (incl. 1 adult)	10 (incl. 2 adults)	14 (incl. 5 adults)
Dwell Time in Minutes	21 (called away to lunch)	14 (called away to planetarium show)	18	19	14 (adult pulls them away for Prove It area and earthquake)	22 / 27 (group leaves in two parts)	6 (called away to lunch)	23	18 (called away to classroom)	38
Group M.O.	Fan out and use exhibits independently; teacher gathers them to read entry panel and later for short discussion at Orrery. Students are focused and use nearly all exhibits thoughtfully. Teacher operates bi-lingually w/ Spanish. She occasionally reads aloud in gallery	As group enters, teacher reads aloud. Group stays together at first and eventually disperses. Adults circulate with kids occasionally reading aloud. This group is somewhat calmer than many; they read and use many exhibits well. They start in biology and move through dome, missing the rear area of the gallery.	Group enters and disperses immediately. They enter in two groups and leave in two groups. Most kids sort of flit about, one girl slowly progresses through many exhibits reading and doing ("interested girl").	This is one pod from a larger field trip group. One boy wanders on his own while the other 3 mostly stay together. About half way through visit, a few more kids from their class join them in the otherwise empty gallery.	This appears to be a pod from a larger class group. Kids run from one element to another touch and glance at exhibits. Occasionally they gather where the adult is reading or demonstrating. Adult occasionally reads aloud – sound bites for the students. Adult is only one to read aloud. No one is ever at an exhibit for more than a minute.	Scatter widely running from element to element frequently returning to crank Planet Transit handle. One of the adults follows kids around. No adults read or facilitate. One adult reads panels to self not interacting with students. One student and adult pair take time with many exhibits to read and manipulate.	This appears to be a pod from a larger class group. Most students wander alone to do and read. They gather now and then.	This appears to be a pod from a larger class group. They tend to move together and work near each other , but not necessarily on the same element.	Very interested and cooperative. This group includes students with hearing impairments and mild developmental delays. They wander the gallery but stay near each other; the gallery is bustling with younger kids running around.	They dribble in and scatter. Kids and adults tend to stay together in pods. In general they take their time to manipulate, read and discuss. Most begin with biology side and then work their way around. Much longer stops than observed with younger groups.

Group	1	2	3	4	7	8	5	6	9	10
1. Our Solar System (orrery)	Teacher gathers students for discussion of planets, uses planet models	None observed	None observed	One boy observes this and planet models. Tries to call over friend.	Child checks all four panels for buttons to push, does not read, then leaves. Adult, "look, this is how the planets go!" then all rush off.	One adult photographs. Later several gather briefly to look.	None observed.	None observed.	On and off students pass and glance, they return later when adult is narrating it.	One pair of boys seen to stop and look briefly. Adult gathers several kids to watch, read and discuss, eventually most students are gathered, leaning in to study as teacher discusses; adults circulate and discuss. Two students linger to watch and discuss.
3. Design Solar System	Teacher and 6+ kids do this together	Two students cooperate here	Several cooperate to do this, call over others "Who wants to be an alien?" Several come over and leave again, one child continues. Interested girl works with it later.	Two boys together work on this for several minutes.	None observed.	Two students dabble independently, very briefly. Eventually two kids and an adult actually do it.	Three girls go directly to this, read aloud and call over friends. Eventually there are four students, one leaves but returns to take her turn.	Look briefly, none seen to engage.	Two students are seen to work this, but don't stay long.	Adult and girl take time to do and watch. Teacher leads group to work on this after orrery and planets. They watch and wait for turn.
4. When Stars Form	None observed	None observed	None observed	None observed	None observed	None observed	None observed	None observed	None observed	Students read aloud, adult supports and discusses.
5. Mission Invisible (infrared table)	1 student works with this; later large group comes to use it, get excited and mount table	Twice groups of kids gather here. Two kids actually read flip books. Kids call adult over, he reads aloud, kids wander away.	Several children play with this, mostly looking at body parts in the camera display.	None observed.	None observed.	One student calls over other children, one adult joins them. Clutches gather there on and off during visit. Much excitement and entertainment, "my foot's on tv!" etc.	None observed.	None observed.	None observed	Large group gathered here to read aloud and play, students are leaning in to touch and see. Much calling and laughing.
6. Pressure Ball (pumps)	Not present	Not present	Not present	Not present	Three to four kids together jumping as pump, excited by explosion.	On and off during visit many pump energetically and then peek in.	Not present	All go to pump, manipulate, read, peek inside.	Three students are pumping and peeking into chamber. When asked, adult reads aloud and explains, then students continue, enjoying it. Take turns peeking.	Students from this and other groups cooperate on this. Much energy.

Group	1	2	3	4	7	8	5	6	9	10
7. Stellar Life Cycle	Many stop to spin and watch none read.	None observed	Many students quickly look at this; one uses it thoughtfully.	One boy uses breifly, calls over other boy and male adult. Boys drift away, adults lingers to use and read.	Student quickly turns dial, watches briefly and runs away.	None observed.	One student sits here to manipulate and watch.	None observed.	Students seen to spin dial and watch briefly, one does linger to watch more.	Adult talks several students through this reading and pointing.
8. View Space Theater	Teacher tries to direct students here, a few follow her, none stay to watch	None observed	None observed	None observed.	None observed.	One student is seen sitting to watch a bit. Other look briefly as exit.	None observed.	Adult forces students to sit and watch this. Reads aloud when captions appear. Stay here for several minutes.	None observed	None observed
10. Salt Room	Many gather here to play	None observed	Much excitement and interest in playing here – throwing selves into the walls and posing for pictures. Several children go fetch others to join. Teacher also sends some over.	All spend time in here together. Adult male discusses perspective.	Students are playing here when adult comes to read label aloud as kids play, they she leads them back to orrery.	Adult guides students back here to see and play before exit gallery.	None observed.	One enters then exits to call over friends; all bang around in there for a bit.	None observed	One pod takes quite a while in here. Large group plays here before class moves to planets and then exits gallery.
12. Drakes Est. Comp. Interactive	None observed	One student works this alone.	None observed	None observed.	Adult guides one student through this as other kids run willy nilly in exhibit.	One boy works his way through several pages, “Yes! I’m pretty good at this!” He is pulled away and reprimanded to stay with his chaperon.	Brief stop.	None observed.	None observed	None observed
13. Understanding Numbers	Several small pods and individuals use	None observed	None observed	None observed.	None observed.	Several adults and students are engaged here by docent. Later a small group gather to use and discuss. Amusement.	None observed.	None observed.	None observed	None observed

Group	1	2	3	4	7	8	5	6	9	10
15. Planet Models	Teacher uses in discussion near Orrery	None observed	Several children look and touch as pass. One child, "this is the hugest!" hugs a model and calls over friends.	One boy engages briefly with these in tandem with orrery.	Running kids absently touch.	One student and adult take time. Other students hug and show planets to adults.	Idle touching.	None observed.	None observed	Most move to look, touch and discuss after discussion at orrery. Teacher reads aloud as class is gathered here. Spend quite a while here.
16. Pick Up a Piece of Planet	Many fiddle with this in passing, none use	None observed	None observed. Dangling blocks not present until later in the morning.	None observed.	Adult reads aloud, all take turns touching. Stay about a minute.	No real use observed, only idle touching.	Idle touching	None observed.	None observed	Several move to this to touch and read after orrery discussion.
17. Milky Way Mural LED Display	One student uses	None observed	One student observed using and reading	None observed.	None observed.	None observed	None observed.	All use and discuss this.	None observed	None observed
18. Milky Way Galaxy Entrance Mural (powers of 10 panels)	None observed	None observed	None observed	None observed.	None observed.	None observed	None observed.	Adult leads students in reading and discussing entire length of these panels.	None observed	None observed
19. Coronagraph	As one uses, others join, much cooperation	Adult guides a student. Several groups of students use this.	Many groups and individuals use this; it is often in use during this group visit	One boy does this and tries to call friends over.	Several students sit and engage with this, social.	Several small groups gather and cooperate with this during the visit.	Student engages briefly.	One student engages, another joins, they engage cooperatively and discuss, then explain it to adult who joins them and then takes a turn.	Two students discuss and cooperate with this.	One girl seen to read and manipulate this. Two boys cooperate and discuss this.
22. Planet Transit (Kepler Project)	Several manually spin table, handle and planets have been removed for repair.	Several manually spin table, handle and planets have been removed for repair.	Several manually spin table, handle and planets have been removed for repair.	Adult manually spins table, handle and planets have been removed for repair. Boys join to look, none linger.	Several students turn crank handle with no focus on exhibit content.	Many children repeatedly stop by this to crank the handle. No reading or focus on content is observed.	None observed. (Handle and planets are removed for exhibit repair.)	All read, manipulate and discuss this. As others leave one student remains to discuss further with adult.	As one student spins it, two read and talk about it a bit. They linger here. Similar scene observed later.	Two girls and adult read aloud, manipulate, watch and discuss. Three girls use and read a bit, but mostly just crank handle.
23. Planet Transit (Which Graph manipulative)	None observed	None observed	None observed	None observed.	None observed.	None observed.	None observed.	None observed.	None observed	None observed

Group	1	2	3	4	7	8	5	6	9	10
25. Planet Wobble Interactive	One seeing using	Adult guides and demos for several students.	Touch and play but don't use.	Briefly read and play with this.	None observed.	None observed.	None observed.	All read and manipulate this together.	Two students throw/spin elements, adult joins them briefly. No reading is observed.	Adult and students work together; adult reads aloud. Other students join in. Adult reads as student manipulates. Several others read but do not try or linger. Group moves here from IR Table, some read and manipulate.
27. Other Worlds	One seen using	Look and call others over, but none really focus on this.	None observed	None observed.	Adult engages this with a student breifly.	One adult and two children use and read this. Twice individual students are seen using it.	Student engages briefly.	None observed.	One student seen to use this.	Student manipulates and reads, adult joins. Adult and two students take much time to read and discuss. Boy sits to manipulate and read.
30. Alien Earths News Comp. Interactive	None observed	Look and call others over, but none really focus on this.	None observed	None observed.	None observed.	Touch and leave it. Later adult and two children read it a bit.	None observed.	Glance, not engage.	One student seen reading this. Several press button and leave.	Student observed idly pressing button and leaving. Boy sits to manipulate and read.
33. Exhibit Title sign	Teacher calls the group together to read aloud as enter.	Teacher calls the group together to read aloud as enter.	None observed	None observed.	None observed.	None observed.	None observed.	Adult calls over students and reads aloud.	None observed	None observed
36. Life Scanner	Several groups of students/adults gather and use this. Much discussion and laughter	Several children join students from another group, that adult reads aloud. Some visiting and giggling.	Adult is using and is joined by child who uses and calls over others.	Two boys begin, other boy and adult join in. All take a turn with hand print, children do it while adult reads aloud. Linger and discuss for several minutes. Boy reads and says aloud, "believe it or not we are made of star stuff." Adult explains this vaguely.	None observed.	Student is attracted, calls over adult, they read and work it together. Several groups gather here during visit. Amusement and attention.	None observed.	None observed.	This gets lots of attention and calling over. Boys are gathered here and watching explosion. All try hand and think that red light hurt/will hurt. Play with buttons. None read the copy.	Adult and girl read, discuss and do entire program.

Group	1	2	3	4	7	8	5	6	9	10
37. Biomass	None observed	Several kids use, squeal and call over others. Lots of interest, long use.	Several children use this alone and together.	None observed.	Adult is guiding and reading out measurements. Students gather with her.	Two students are see cooperating to use this. Several groups gather here during visit. One girl, "this is tight."	None observed.	None observed.	Several gather, engage, point and discuss.	Adult and student read do and discuss.
39. Looking For Life	None observed	None observed	None observed	None observed.	None observed.	One student and adult take time.	None observed.	None observed.	None observed	three boys observed sitting to manipulate and read.
40. Listening For Life	Small group works on this	None observed	Often in use. Interested girl is joined by others who work with her.	Two boys sit and do this, adult joins them. All linger and continue to do this.	Adult joins students here to name the satellite for them.	Several individuals are seen to use this on and off during visit. One student and adult take time.	None observed.	None observed.	None observed	Boys and adult observed to manipulate and read together.
41. Habitable Zone Comp. Interactive	Students observed working with this	None observed	None observed	All move to this from number 40 and do it together.	Adult sound bite as pass it, "Earth is not too cold or too hot, that's why we can live here." Works it briefly with one student.	One student and adult take time.	None observed.	None observed.	None observed	Girl and two adults read, do and discuss. Much interest.
42. Searching for Life From a Nearby Planet	None observed	None observed	None observed	None observed.	None observed.	One student and adult take time	None observed.	None observed.	None observed	None observed
44. Molecules In Motion	Many students use and play with this, not much reading but the bouncing balls sure are fun.	Much excitement and call over others, none linger very long.	Students are pushing buttons and call over adult who does not stay. Interested girl uses this. Later one child, "awesome!" and calls over others, one responds, "I played with that!"	One boy engages with this. Adult joins and discusses it with him.	Adult demonstrates this for children, no reading or real explanation.	Students press buttons and tap the jar. None are seen to read or consider. Student frequent this to press the button and watch the balls.	Two students engage with this and watch.	Students begin engaging with this, adult joins them.	None observed	Small group watches as one sits and manipulates. Unclear if they are reading/understanding. Adult leads large group to this, not much explanation or discussion though.
46. Boiling Water	Many students manipulate and watch this	Group gathers here to use and watch	One student works with this. Several others watch or touch briefly.	Adult and one boy do and discuss this together.	None observed.	One adult sits to read and manipulate.	None observed.	Students and adult use this together.	None observed	Boy sits to read and manipulate.
48. Microbial Mat	Students observed working with this	None observed	None observed	One boy engages briefly.	None observed.	Two try to figure out light on biomat.	None observed.	One student engages this exhibit.	One student asks adult about light and manipulates.	Boy calls over teacher, they do and discuss, others join, eventually most leave, two linger to continue reading/doing.

Group	1	2	3	4	7	8	5	6	9	10
49. Close Knit Neighbors	Students observed working with this	None observed	Interested girl works with this.	One boy engages briefly.	None observed.	One student works with this, tries to all over friends, continues to engage. Several times small groups gather to look at this.	None observed.	None observed.	None observed	None observed
50/51. Winogradsky Column	None observed	None observed	None observed	One boy engages briefly Adult and one boy linger here to work with this together..	None observed.	Adult guides students here, all enjoy and laugh as take turns smelling, but none address content. Students spin dial and watch, or gaze around.	None observed.	Students and adult work with this together reading, disussing and taking turn smelling. Students and adult briefly engage this with lights.	Student works to figure out and use flashlight on the jar and leaves.	Adult reads aloud, calls over, points, discusses, several join to sniff and react/discuss. Boy and adult do, read, discuss.
53. Microbial World	Several students observed using this	Teacher leads students here after entering and reads aloud.	None observed	All briefly stop and look.	None observed.	None observed	None observed.	All look, manipulate and discuss.	None observed	Two girls manipulate and look, then get called over to sniff W. column.