Remedial/Summative Evaluation of

THE SUGAR FROM THE SUN *EXHIBITION*

for

The Garfield Park Conservatory Alliance, Chicago

Eric D. Gyllenhaal, Ph.D.
Selinda Research Associates, Inc.

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TABLE OF CONTENTS

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EXECUTIVE SUMMARY

Introduction. *Sugar from the Sun* was a project managed by the Garfield Park Conservatory Alliance (GPCA) and funded, in part, by the National Science Foundation. The major focus of the project was the creation of a 6,400 square foot living exhibition at Garfield Park Conservatory about plants' production of sugar from water, air, and sunlight. Additional components of the project included a printed *Exhibit Guide* for use during and after a visit and hands-on demonstrations set up in the exhibition on weekends and special events. The big idea that guided exhibit and program development was, "Through an amazing and complex process hidden within their leaves, plants use sunlight energy to make sugar energy from water and air." The project was targeted particularly at students in middle school and above, although the team realized they would also need to engage both adults and younger children within the exhibition.

Description of the *Sugar from the Sun* project. The 6,400 square-foot *Sugar from the Sun* exhibition was constructed in the *Sweet House* at Garfield Park Conservatory. The overall immersive experience was established using living plants, naturalistic structures built with rocks and ironwork, lighting, and sound. The exhibition included five major sections: One each for the four major components of the sugar-making process (air, water, sunlight, and sugar), and a central plaza that synthesized these components. As the project team developed interpretation for the exhibition, they kept in mind that most visitors came to enjoy and socialize in the warm and plant-rich environments rather than to learn complex scientific ideas. Therefore, they developed a signage system that fit with the lush green and naturalistic environment of the exhibition, and they kept texts brief and free of technical terms (including "photosynthesis"). The team did not employ exhibit techniques commonly associated with science centers, like models, interactive devices, and multimedia presentations. The project team also developed printed materials and prototype *Exploration Cart* activities for use in the exhibition.

Overview of the evaluation. This report is the culmination of three major phases of evaluation completed by Selinda Research Associates (SRA): Front-end (2002-2004), formative (2005-2006), and remedial/summative (2008). The findings from the first two phases guided exhibit development and informed this final phase of the evaluation. The research question for this study was, "As visitors engage with the immersive environments and interpretive messages in the *Sugar from the Sun* exhibition, in what ways and to what extent do their experiences contribute to achieving the project's goals?"

Methodology, methods, and design of the study. This study used a naturalistic inquiry methodology, which is an ethnographic and primarily qualitative approach to understanding visitors and their experiences within informal learning environments. On-site data collection used five primary methods: unobtrusive observations, intercept interviews, exit interviews, participant observations, and depth observations. Data collection included eighteen site visits to the exhibition during winter and spring, 2008. Respondents included both casual visitors to the exhibition and visitors who came with organized groups, like schools and preschools. In all, SRA staff spent about 67.5 visitor contact hours in the exhibition, collecting data from 55 smaller groups (143 individuals) and 36 larger groups (about 1400 individuals). Data analysis for this study was an on-going process using a modified inductive constant comparison and triangulation of data sources.

Visitors to the exhibition. The researchers were struck by the diversity of the audience visiting *Sugar from the Sun*, which was evident on many dimensions, including race, ethnicity, geographic origins, and age, but also motivations for visiting the Conservatory, relationships to plants, and interest in science. In many ways, Conservatory visitors felt like an amalgamation of the audiences from an art museum, city park, science museum, and children's museum. Not surprisingly, many respondents said they came here for the plants or for the overall Conservatory environment. Parents often focused on what the Conservatory offered their children, while still meeting their own needs. As the *Sugar from the Sun* team had suspected, some respondents said they were *not* here to read labels or receive an "education." Some active children also resisted attempts to slow them down and teach them. The *Sugar from the Sun* exhibition had to serve this diverse audience – to accomplish its goals without disappointing visitors who had come to the Conservatory for a wide variety of reasons.

Engaging with *Sugar from the Sun*. Visitors engaged with *Sugar from the Sun* in a range of ways, depending on their interests, group composition, and the discoveries they made along the way. Some visitor groups engaged primarily with the plants, walking slowly and stopping frequently as they located interesting plants, read identification labels, and talked about what they found. Other groups engaged in more sensory and aesthetic ways, enjoying both the overall environment and individual plants. Family groups with young children engaged in a range of ways. More active children looked for adventure as their caregivers trailed behind; families with scavenger hunt handouts systematically searched for plants listed on the sheet; other families lingered to hear stories from a caregiver knowledgeable about plants or listen as a parent guided the visit by reading labels. When facilitated activities were in progress, families often structured their visit around them. No matter their primary engagement style, entering the *Sugar* section transformed almost every family into plant hunters as they searched for fruits and read and talked about what they found. School and preschool groups also engaged in a range of ways, based on their ages, adult supervisors' interests, and lesson goals.

Visitors' experiences in *Sugar from the Sun*. As visitors talked about their experiences in *Sugar from the Sun*, their words often mirrored what they said about the rest of the Conservatory. Many respondents talked about their enjoyment of the plants, and most also appreciated the non-living aspects of its immersive environments. Although caregivers appreciated the engaging environmental components in the exhibition, like the waterfalls and narrower paths, visitors with active children sometimes wished there were more interactive components. Artificial elements, like iron branches and recorded sounds, were accepted as long as they did not fool visitors into thinking they were alive or intrude too much on the soothing, naturalistic environments. Overall, most respondents seemed to love the plants and immersive environments in *Sugar from the Sun*. However, feelings about what visitors called the "educational" aspects of the exhibition were mixed. Many respondents appreciated the efforts for young visitors, but some adults did not seem to feel that aspect of the exhibition was for them.

Visitors' perceptions of the interpretive signage. Many respondents made positive comments about the beauty of the circular glass signs and how well they blended in with the plant-filled environments. However, most visitors had trouble finding and reading the back-lit signs. Although the labels were a potentially important part of the experience to many visitors, the

hard-to-read signs contributed relatively little to most visitors' understanding of *Sugar from the Sun*. Even if visitors had been able to read all the interpretive labels, many would still have trouble extracting the intended messages and themes. Although many respondents appreciated that the label texts were brief, others found that the conceptual messages were incomplete, unclear, or too basic to meet their interests and needs. To help the project team think about potential revisions to the label texts, the report discusses visitor reactions to the different types of labels included in the exhibition.

Visitors' understanding of the overall exhibition. Visitors integrated their experiences with the plants, immersive environments, and interpretive signage into their overall understanding of *Sugar from the Sun*. When respondents knew the exhibition's name, it often communicated key parts of the overall message. Recognizing and understanding the four sections of the exhibition also was a key step in visitors making sense of their experience; however, few respondents remembered all four of the sections. As a result, many visitors developed incomplete or off-topic understandings of the exhibition's theme and main messages. Visitors who developed a more complete understanding of the *Sugar from the Sun* theme had visited more sections, read and understood more labels, and actively engaged with the exhibition. Goals for remediation of the exhibition should be based on these findings.

Contributions of programming. The facilitated activities prototyped for the *Exploration Carts* provided visitors with hands-on and interactive experiences and in-depth information that were not otherwise available. When prototype activities were set up on weekends, researchers noted increases in visitor engagement, overall time spent by participating groups, and visitor understanding of the exhibition. With facilitated activities in progress, *Sugar from the Sun* was much more effective; the activities seemed to replace experiences that were missing, rather than just supplement an otherwise successful exhibition. As the team considers ways to increase the effectiveness on the central plaza, they should consider adding an unfacilitated activity space that incorporates elements developed for the *Exploration Carts*.

Contributions of printed materials. Although the *Exhibit Guide* was available at several places in the Conservatory, researchers rarely observed visitors reading it within the exhibition. Rather, visitors briefly looked through the *Guide* near the Conservatory entrance or read it at home and applied what they learned during a subsequent visit. The cover did not specify the *Guide's* purpose, or where it was intended to be used. When visitors did read the *Guide* within the exhibition, it helped them make sense of what they were seeing; however, the *Guide's* potential effectiveness was rarely achieved. The *Hunting for History* scavenger hunt sheet was one of the most engaging experiences available to young visitors, effectively focusing their attention on individual plants. The project team should prototype and test a scavenger hunt designed to engage children with *Sugar from the Sun*'s messages and concepts.

What visitors took away from their experiences. Visitors came to the Conservatory seeking many things, and there were indications that they found most of them in *Sugar from the Sun*. Major outcomes for visitors included achieving their own affective, cognitive, and behavioral goals. However, outcomes relative to the project's cognitive goal varied widely. The report explores those outcomes within the framework of a knowledge hierarchy developed during the front-end and formative evaluations.

Conclusions. Most of the project's five goals were achieved for most visitors. However, the goal related to visitors' understanding of the big idea was only partially achieved. The project team set limits on how they could achieve the project goals and communicate with visitors about the big idea – they wanted to do so within the context of a naturalistic, immersive conservatory experience (as opposed to a classroom or science center experience). Their plan for meeting the project's goals was thwarted when many of the labels proved illegible. Other issues that undercut the effectiveness of the exhibition were the lack of engaging elements for younger children and the simplification of exhibit concepts in ways that left many adults feeling the exhibition was aimed at children. Because of these issues, the *Sugar from the Sun* project has not provided an adequate test of whether conservatory visitors can be inspired to think deeply about scientific ideas without losing their immersive experience.

Recommendations. To increase the effectiveness of the exhibition at meeting the project's goals, the report concludes with recommendations that the *Sugar from the Sun* team should undertake as staff time and funding allows. These include improving the legibility of the exhibition's labels, redeveloping the entrance signage and the central plaza, and rewriting the text for many of the section labels. Additional recommendations address issues with Conservatory signage and maps, printed handouts, and educational programming. The recommendations also address the development process for future exhibitions.

INTRODUCTION

Sugar from the Sun was a project managed by the Garfield Park Conservatory Alliance (GPCA) and funded, in part, by the National Science Foundation. The major focus of the project was the creation of a 6,400 square foot living exhibition at Garfield Park Conservatory about plants' production of sugar from water, air, and sunlight. Additional components of the project included a handheld, printed *Exhibit Guide*, designed for use in the exhibition and hands-on demonstrations set up in the exhibition on weekends and at special events. Elements that were still under development and not included in this evaluation included a printed *Universal Guide* about plants' production of sugar, designed to be used in any conservatory or public garden, and the *Sugar from the Sun* website.

Big Idea and Goals for the Project

The big idea that guided exhibit and program development was,

> *Through an amazing and complex process hidden within their leaves, plants use sunlight energy to make sugar energy from water and air.*

Based on this big idea, the exhibition team developed five major visitor goals for the *Sugar from the Sun* exhibition:

1. *Visitors will respond physically by pointing, touching, smelling, listening and looking up, down and all around.*
2. *Visitors will gain a heightened awareness and deeper appreciation for the beauty and variety of plants.*
3. *Visitors will engage in multi-sensory experiences that spark emotional responses: Imagination, wonder, and playfulness; feelings of being transported to another place; awe and amazement; mystery and intrigue.*
4. *Visitors will understand that inside their leaves, plants are using sunlight, air and water to make sugar.*
5. *Visitors will have social interactions and discussions that inspire them to ask questions about the role of plants in their lives and environment.*

The project was targeted particularly at students in middle school and above, although the team realized they would also need to engage both adults and younger children within the exhibition.

Previous Evaluations

This report is the culmination of three major phases of evaluation completed by Selinda Research Associates: Front-end (2002-2004), formative (2005-2006), and remedial/summative (2008). The first two phases are discussed in this section; the final remedial/summative phase is the focus of this report.

The front-end evaluation included three components: A literature review, a front-end study of potential visitors' prior knowledge and feelings about photosynthesis, and a study of the potential of disseminating the project to other conservatories. The findings of the first two components are reviewed in some detail, since they highlight the many challenges faced by the *Sugar from the Sun* team as they developed the exhibition and associated programs.

The front-end literature review discussed (a) research findings related to children's and adults' understanding of photosynthesis and related topics and (b) a review of research on immersive exhibitions (Gyllenhaal, 2002a). A version of the literature review's bibliography on immersion in exhibitions was published in *Visitor Studies Today!* (Gyllenhaal, 2002b). The literature review found that visitors were likely to enter the *Sugar from the Sun* exhibition with a range of incomplete and alternative understandings about where plants get their food and how the process of photosynthesis takes place. The literature cited specific alternative understandings related to each of the four major components of the photosynthetic process. The review recommended that visitors' alternative understandings be investigated further during front-end and formative evaluation, so that the exhibition could build on visitors' existing knowledge about photosynthesis without reinforcing their alternative understandings.

The literature review also found that the term "immersion" has a broad range of meanings within the informal education field, and that visitors were likely to show a range of thinking about what it meant for an immersive exhibition to feel "natural." The review found relatively little research that could guide the use of interpretation within immersive exhibitions. However, research suggested that immersive exhibitions were more effective at creating gut-level understandings of sensory experiences, rather than helping visitors learn and retain information (Gyllenhaal, 2002a).

Following up on the literature review, Garibay, Schaefer, & Cheng (2004) completed a naturalistic front-end study of Conservatory visitors' connections with and understandings about plants. They found that most visitors' perceptions and connections with plants were grounded in their daily experiences with plants rather than more abstract, scientific concepts. Their connections included personal memories of their experiences with plants, with strong aesthetic and affective associations and sometimes connections with broader environmental concepts. However, visitors primarily thought of plants' importance in terms of their effects on people as individuals, rather than how plants fit into the environment.

The front-end report developed a six-level hierarchy to describe the entire range of ways that Conservatory visitors thought about photosynthesis. Visitors who were on lower levels of the hierarchy focused on the things plants need to stay alive (such as sunlight and water) in practical, concrete ways, based on everyday experience with household plants. Only visitors at the highest levels of the hierarchy focused on the more abstract process by which plants take what they need (air, water, sunlight) and convert it to something they can use (sugar) – an understanding based on concepts these visitors had read or heard about in school. Students who had recently studied this topic in school were most apt to be at these higher levels. Adults had often shifted away from whatever scientific understanding of photosynthesis they had gained in school toward a more concrete and practical understanding grounded in their everyday experience. These findings implied that "moving people up the hierarchy will likely involve more than supplying information; it will require helping them change *how they relate* to that information" (Garibay,

Schaefer, & Cheng, 2004, p. v). It was recommended that exhibit interpretation help adult caregivers guide their children's interaction with the exhibit, despite the adults' limited knowledge of the topic. Also, because most visitors thought of sugar as table sugar or candy, the interpretation would have to help them think about sugar in new ways, consistent with its role in photosynthesis and plant nutrition. "It will be critical to help visitors understand what plants do with sugar – that this substance, produced through photosynthesis, is a building block for everything else that plants (and humans) need to live and grow" (p. vi).

Finally, the front-end study identified key qualities that maintained visitors' feelings of immersion in Conservatory exhibitions. These included feelings of "being in a particular time and place, engaging all the senses, fostering a sense of discovery, allowing for contemplation, and being in environments that feel authentic (i.e., the Conservatory rooms and plantings do not feel false or contrived)" (p. vi). The report concluded that, "because visitors come to see a living collection ('real plants') in a Conservatory, the need for authenticity and realism may be more important than in a traditional museum gallery, where visitors may have different expectations about immersive environments" (p. vii).

The formative evaluation included two components: Evaluation of full-scale prototype versions of the exhibition (Gyllenhaal, Perry, & Cheng, 2005), and formative evaluation of the proposed *Sugar from the Sun Universal Guide* (Gyllenhaal & Cheng, 2006). The exhibition formative found many indications that the completed exhibition would provide an enjoyable immersive experience for both adults and children. In particular, the prototype successfully maintained an immersive environment for almost all respondents. However, the prototype exhibition was not very effective at providing visitors with appropriate intellectual challenges or at getting them excited about the amazing things that plants do and their importance in the world. Rather, the concepts in the prototype *Sugar from the Sun* were neither new nor particularly exciting to many visitors. The exhibition tended to remind most visitors about their existing understandings about "what plants need" and "how plants make sugar." Adults – especially those in adult-only groups – sometimes decided this exhibition was for children. Researchers recommended that the exhibition team focus on presenting visitors with appropriate intellectual challenges that would help them get excited about how and why plants make sugar, and that the final exhibition should also explain why this is important to life on Earth.

The X-shaped layout of the prototype exhibition was only moderately effective at getting unprompted visitors to all parts of the exhibition. However, the four-sections-and-a-central-plaza layout none-the-less appeared to make sense to visitors conceptually once they had spent some time in the exhibition and began to figure out its big idea. Researchers recommended that the final design use physical elements, such as positioning of sections and plants, to increase visitors' use of all parts of the final exhibition. Also, there were many indications that visitors would benefit from extensive orientation at the exhibition entrances, especially to the ways in which the exhibition's concepts mapped onto its layout.

The label systems developed during prototyping were moderately effective at shaping visitors' behaviors and perceptions of the themes of the exhibition. Importantly, these labels did not appear to detract from the overall immersive feel for most groups. The labels within the four sections were moderately effective at helping visitors understand the major concepts in each

section. Although stand-alone concept labels in the central plaza did not attract much attention from visitors, it was clear that visitors needed something in the plaza that would help them synthesize their experiences. Researchers recommended redeveloping section labels to provide clear statements of the purpose and concepts important to each of the four sections, as well as developing synthesis labels that included a visual or diagrammatic overview of the sugar-making process.

The prototype exhibition tried several approaches to actively engage visitors with key concepts, including activity labels that suggested things visitors could do, unsupervised activity stations with hands-on materials, and the Sugar Dance, which used choreographed dance steps glued on the floor to step visitors through the process of photosynthesis. The prototype activity labels and activity stations effectively engaged both children and many adult visitors, although they sometimes failed to clearly relate the activities to the big idea of the exhibition. The Sugar Dance elicited enthusiastic participation from many visitors, but it needed to get more visitors thinking and talking about how plants make and use sugar. Researchers recommended refining and extending the activity labels and activity stations to all four sections of the exhibition, and making the activity labels more explicit about how the activities illustrate each section's concepts. Researchers also recommended reducing and simplifying the steps in the Dance, focusing on those steps that relate to the process of making sugar, and developing a more effective way of linking the Dance steps to the process of making sugar.

Prototype versions of artificial fruits hung on living plants during this evaluation were unacceptable to some visitors, although artificial leaves mounted on frameworks seemed more widely accepted. Researchers recommended limiting the use of artificial components in the Conservatory setting.

Key findings of the *Universal Guide* formative are included here because they shed light on the use of printed guides in conservatory settings. The prototype *Guide* was enjoyed most by visitors who were open to active, educational experiences, but less successful with visitors who picked up the *Guide* expecting orientation to the Conservatory or information about specific plants, or with visitors who were looking for more aesthetic or contemplative experiences. The *Guide*'s cover played a critical role both in helping visitors decide whether to pick up the *Guide* as they entered and in setting their expectations for its use. The cover needed to help visitors recognize what kind of experience they could expect from the *Guide*, so they could make an informed choice about whether to pick it up.

Completing the formative evaluation of the *Universal Guide* also advanced the researchers' thinking on a number of issues that were initially raised by the front-end evaluation. It was clear that understanding the dual roles of sugar – as both an energy source and the basic building block for life on Earth – would be an important aspect of visitors' overall understanding of the importance of photosynthesis. The report developed knowledge hierarchies dealing with visitors' understanding of the process of photosynthesis and the importance of this process for life on Earth. Edited versions of these hierarchies are included in Appendix A: Knowledge Hierarchies about Photosynthesis.

Description of the *Sugar from the Sun* Project

This section includes a description of the *Sugar from the Sun* exhibition and its major components. The photographs referred to in the text are in Appendix B: Photographs of the Exhibition and Programming.

Sugar from the Sun *Exhibition*

The 6,400 square-foot *Sugar from the Sun* exhibition was constructed in the *Sweet House* at Garfield Park Conservatory. The overall immersive experience of the exhibition was established using living plants, naturalistic structures built with rocks and ironwork, lighting, and sound. Unique approaches to labels and graphics interpreted and synthesized the themes of the exhibition.

Figure 1 (below) shows the overall layout of the *Sugar from the Sun* exhibition. The exhibition was approached from the east through the *Palm House* (Fig. B-1) and from the west through the *Children's Garden*. Like the prototype version of the exhibition, discussed above, the completed exhibition included five major sections: One each for the four major components of the process of photosynthesis (air, water, sunlight, and sugar), and a central plaza that synthesized these components. The *Air* and *Water* sections were located in the east end of the *Sweet House* (Fig. B-2), closest to the Palm House, and the *Sunlight* and *Sugar* sections were located in the west end of the *Sweet House*, closest to the *Children's Garden* (Fig. B-3). The *Central Plaza* was in the center of the Sweet House, separating *Air* and *Water* on the east from *Sunlight* and *Sugar* on the west (foreground in Figs. B-2 and B-3). The five sections are discussed in greater detail in the following paragraphs.

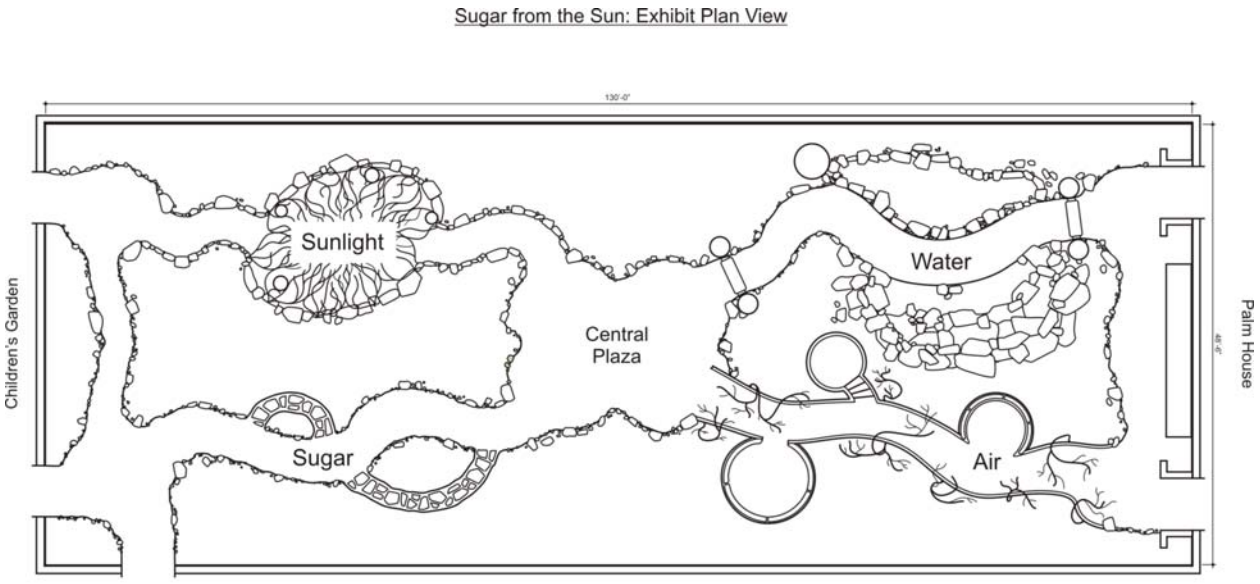

Figure 1. Floor plan for *Sugar from the Sun*, showing the major sections of the exhibition (*Air*, *Water*, *Sunlight*, *Sugar*, and *Central Plaza*). (Left is west, right is east.)

The stated purpose[1] of the *Air* section was, "For visitors to experience air in a variety of ways so that they begin to think about it as having substance and contributing to a plant's process of making sugar." As visitors entered this section from the *Palm House*, they walked past a backlit map of the exhibition and an introductory label (Fig. B-4), and then up a shallow ramp (Fig B-5). Above the path, growing on impressionist tree branches made of welded ironwork, were plants that live in tropical treetops, including epiphytes or "air plants," like bromeliads and orchids, and vines (Figs. B-5 and B-6). On either side of the path were fragrant plants, like gardenia, and more bromeliads. Visitors could step off the main path and onto three circular turnoffs, including one surrounded by hanging vines (Fig. B-6) and a raised platform that overlooked the adjacent *Water* section (Fig. B-7). The label texts in *Air* focused on two messages: "Air has substance;" and "Air contributes to sugar-making in plants." The *Sugar from the Sun* label texts are discussed in more detail in Interpretive Signage, below.

The purpose of the *Water* section was, "For visitors to experience water in a variety of ways so they begin to think of it as having different forms and contributing to a plant's process of making sugar." The *Water* section could be entered directly from the *Palm House* (Fig. B-8), as well as from the *Central Plaza* (Fig. B-2, left) or via a cross-path from the entrance to *Air*. In keeping with this section's theme, notable features in *Water* included mist cascading over the entrances (Figs. B-8 and B-9), waterfalls (Fig. B-10), and a pool with mangrove trees (Fig. B-11). Mangroves exemplified a second notable feature of this section: plant roots, visible in several forms, including the stilt-like mangrove roots and hanging roots draped from plants growing in baskets high above the path (Fig. B-8). The label texts in *Water* focused on three messages: "Water is malleable;" "The oxygen people breathe comes from water;" and "Water contributes to sugar-making in plants."

The purpose of the *Sunlight* section was, "For visitors to see and experience light and leaves in a variety of forms and situations so that they begin to think of sunlight as a contributing factor in a plants process of sugar-making." As visitors entered the *Sunlight* section from either the *Children's Garden* (Fig. B-12) or the *Central Plaza* (Fig. B-3, right), they walked under an iron-work trellis where hanging and vining plants were beginning to form a network of green through which sunlight filtered on sunny days (Fig. B-13, right). In contrast to the green leaves of most plants, some plants growing on the ground in this section had darker pigments that obscured the green chlorophyll in their leaves or mottled leaves with no chlorophyll (e.g., lower left corner of Fig. B-12). The label texts in *Sunlight* focused on four major messages: "Sunlight is energy;" "Plants use sunlight to make sugar;" "The energy in sugar comes from sunlight;" and "Plants absorb sunlight through their leaves."

The purpose of the *Sugar* section was, "For visitors to see and experience sugar in a variety of forms so that they begin to think about it as the product of an amazing and fascinating process." As visitors entered the *Sugar* section from either the cross path from *Sunlight* (Fig. B-14), the *Children's Garden* (Fig. B-15) or the *Central Plaza* (Fig. B-3, left), they encountered a variety of plants that concentrated sugar. These plants included sugar cane along the cross path from

[1] The purposes and educational messages for each section were extracted from a project document, entitled "SFTS - Purpose and Educational Messages."

Sunlight (Fig. B-14, center left) and a variety of fruit-bearing tropical plants, including bananas (large-leaved plants in Figs. B-16 and B-17), pineapples (Fig. B-18), papayas, and orange, kumquat, and grapefruit trees. Flagstone side paths allowed visitors to explore under the banana plants (Fig. B-17). The label texts in *Sugar* focused on five messages: "Plants make sugar;" "Sugar has substance;" "Sugar is a form of energy;" "Plants use the sugar they make to live and grow;" and "Plants store sugar in all parts of the plant."

Visitors could enter the *Central Plaza* from any of the other sections of *Sugar from the Sun* (Figs B-2 and B-3). The purpose of the *Central Plaza* section was, "For visitors to visually and physically connect with the four interpretive sections of the exhibition and to intellectually synthesize the main message of each." The *Central Plaza* was an expanse of concrete that provided space for programming (see below). Embedded on this concrete were metal strips to define impressionist stems leading from the other four sections to large leaves in the center of the Plaza (e.g., Fig. B-19). Each leaf contained an embedded text, spelled out in metal letters, discussed in the next section of this report. The four label texts in the *Central Plaza* focused on one major message: "Inside their leaves, plants use Sunlight, Air, and Water to make Sugar."

Several additional elements included in the exhibition were environmental rather than interpretive. For instance, artificial leaves and fruits were embedded in the concrete path, including artificial leaves and fruits of the kumquats and miniature oranges in the *Sugar* section (Fig. B-21). In addition, a multi-speaker sound system broadcast natural sounds throughout the exhibition, including calls and songs of dozens of species of birds, frogs, and insects from throughout the world. Because the speakers were hidden among the foliage, the sounds seemed to come from animals hidden in the plants.

Interpretive Signage

As the project teamed developed interpretation for the exhibition, they kept in mind that most visitors don't come to the Conservatory to learn about complex scientific concepts. Rather, the team anticipated that visitors would want to enjoy and socialize in the warm and plant-rich environments, experience a variety of amazing plants, and maybe pick up some practical knowledge that will help them care for the plants in their home environments. Given that, the *Sugar from the Sun* team felt that a science center-like exhibition (or for that matter a classroom or laboratory setting) would be out of place for a Conservatory audience.

While actualizing this exhibit philosophy, the team faced a range of decisions about the size, type, and wording of interpretive signage for *Sugar from the Sun*. They developed a signage system that would fit in with the lush green and naturalistic environment of the exhibition. In addition, they tried to keep texts brief and free of technical terminology. For instance, the exhibition labels did not use the term "photosynthesis" (although it was included in the *Exhibit Guide*). The labels also avoided botanical terms like "chloroplast," and chemical terms like "carbon dioxide," although it did use terms considered more familiar and commonplace, like "oxygen" and "nutrients." In addition, the labels did not include an equation for photosynthesis (although, again, an equation was included in the *Exhibit Guide*). Finally, the team purposively did not employ exhibit techniques commonly associated with science centers, like models, interactive devices, and multimedia presentations, hoping instead to focus visitors' attentions on the plants themselves and their immersive environments.

The five types of interpretive labels were written to communicate the major messages discussed above: *Exhibit Entrance/Orientation Map, Section Entrance, Engagement Cue, Addressing Misconception,* and *Synthesis*. The five types of interpretive labels are described in the following paragraphs. The complete texts for the interpretive labels in *Sugar from the Sun* are reproduced in Appendix C: Texts for Interpretive Labels.

Each of the four entrances to the exhibition was marked by an *Exhibit Entrance/Orientation Map* label (Fig. B-22). These circular labels, about 18 inches in diameter, were backlit glass with black text on a green background. They were mounted on bent steel rods, about three feet above the floor (Fig. B-4). As laid out in a document entitled, "SFTS – Message Path and Flow," the purposes of these labels were to introduce the title and main concept of the exhibition – *Inside every leaf, plants are making Sugar from the Sun* – and to help visitors orient themselves within the exhibition using a map marked "You are HERE." The same label design was used at all four exhibition entrances; only the position of the "You are HERE" text changed.

At each entrance to the *Air*, *Water*, *Sunlight*, and *Sugar* sections were *Section Entrance* labels. These were steel plates mounted on rocks, with text and decorative elements cut out (Figs. B-23 and B-24). The dark rocks behind the steel plates were painted white to help highlight the text. The purposes of these labels were to identify the section and to introduce the key concept for that section. For instance, the *Section Entrance* label at the entrance to *Water* (Fig. B-23) read,

Water
Water moves
from the roots
to the stem,
through the branches
to the leaves.

See Appendix C: Texts for Interpretive Labels for additional examples.

Within each section were three different *Engagement Cue* labels. These were derived from the activity labels tested during formative evaluation.. In the *Water* section, these circular labels were made of bronze, about 18 inches in diameter, with larger text and decorative elements raised and smaller text etched into the metal (Fig. B-25). *Engagement Cue* labels in the three other sections were of similar construction to the *Exhibit Entrance/Orientation Map* labels: Circular, about 18 inches in diameter, were backlit glass with black text on a green background (Figs. B-26 and B-27). The stated purpose of these labels was to reinforce the concepts in each section through visitors' actions, as suggested in the labels. For instance, the *Engagement Cue* label on the *Water* section's waterfall (Fig. B-25) read,

Water is moving
Feel the flowing water
Plants are moving water
through every leaf around you.

See Appendix C: Texts for Interpretive Labels for additional examples.

A second type of label within each section was the *Addressing Misconception* label. These were presented as either a circular bronze label embedded in a rock (in *Water*) or as backlit circular glass disks mounted either on steel rods (in *Air*) or in rock slabs (in *Sunlight* and *Sugar*, Fig. B-28). The purpose of the *Addressing Misconception* labels was to help change visitors' thinking about some common alternative understandings about the process of making sugar. For instance, the *Addressing Misconception* label in *Water* read,

Breathing water?
As plants change water within their leaves,
they release a large part of it into the air
as the oxygen you breathe.

See Appendix C: Texts for Interpretive Labels for additional examples.

In addition, each of the four sections was represented by one *Synthesis* label in the floor of the *Central Plaza*. The full set of *Synthesis* labels read as follows:

Leaves take what they need from the air.

Leaves use sunlight to split water into its basic elements.

Leaves capture energy from the sun.

When sunlight, air, and water meet within a leaf, sugar happens.

Read in their entirety, these labels included the major messages of the *Sugar from the Sun* project.

A sixth and final type of label in the exhibition was the *Plant Identification* label (e.g., Fig. B-29). These were dark rectangular labels with white text, mounted either on stakes stuck in the soil or fixed directly to a plant's container. These labels gave the common name (usually in English), scientific name, plant family, and geographic area of origin for each plant. Each type of plant within the exhibition was marked with at least one *Plant Identification* label.

Printed Materials

Visitors to the Conservatory could pick up three pieces of written interpretation related to the *Sugar from the Sun* exhibition. The *Exhibit Guide* reviewed and extended the concepts included in the exhibition. Figure B-30 shows both the folded *Guide* (in center) and front and back sides (above and below, respectively). Note that both a photosynthesis equation and an exhibition map were included on front side of the *Guide*. In addition to the *Guide*, visitors could pick up a two-sided rack card, which provided a much briefer review of the exhibition's key concepts (Fig. B-31). Finally, the *Hunting for History* scavenger hunt sheet (Fig. B-32) provided a more interactive approach to exploring the exhibition and other parts of the Conservatory. Visitors placed stickers on the *Hunting for History* map as they found the plants described on the sheet.

Visitors could pick up copies of printed materials at the front desk (Fig. B-33) or rack card display (Fig. B-34) in the Conservatory lobby; at the brochure rack in the Children's Garden (Fig. B-35); or during programming in the exhibition (described below). Additional scavenger hunt sheets were available to school tours and on-line.

Publicity and Directional Signage

During its opening months, the *Sugar from the Sun* exhibition received quite a bit of publicity in local media. On-site publicity for the exhibition included posters about the opening (Fig. B-36) and signage over the main Conservatory entrance (Fig. B-37). However, directional signage within the Conservatory was updated on a slower schedule. During data collection, the Conservatory map in main lobby referred to the exhibition's building by its original name, "Sweet House," rather than *Sugar from the Sun*, (Fig. B-38), as did directional signage located just inside the entrance to the *Palm House* (Fig. B-39).

Programming in the Exhibition

The *Sugar from the Sun* project team developed a number of facilitated activities to accompany the exhibition. These activities were planned for an *Exploration Cart* that could be wheeled into the exhibition, but this Cart was not completed during data collection. Therefore, prototype versions of the Cart activities were set up on tables in the exhibition on weekends and during special events. The activities were supervised by specially trained education staff and volunteers, who rotated between *Sugar from the Sun* activities and Children's Garden activities on an hourly basis through a programming day.

Although a number of activities were prototyped during the first four months the exhibition was open, most evaluation data was collected from two activities. The prototype *Explore the Power of the Sun* Cart activity (Figs. B-40 and B-41) used solar powered toys and a magnifier to demonstrate ways that sunlight can provide energy here on Earth, as a prelude to discussing how sunlight energy drives the process of photosynthesis. The prototype *Inside Every Leaf…* Cart activity (Fig. B-42) used a light table to show the variety of pigments in leaves from the exhibition and microscopes to focus on the green pigment (chlorophyll) inside leaves and their cells. In addition to the main activities, Cart staffers also experimented with "activities in a bucket" aimed specifically at pre-school aged children, including streams and sprayers that would engage them with air, water, and other components of Sugar from the Sun (Fig. B-43).

Goals of this Evaluation

This final study is a remedial/summative evaluation of the completed exhibition and selected programs that support the exhibition's goals. The research question for this study was:

> *As visitors engage with the immersive environments and interpretive messages in the* Sugar from the Sun *exhibition, in what ways and to what extent do their experiences contribute to achieving the project's goals?*

In order to answer the research question, SRA researchers developed a detailed topical framework in collaboration with the *Sugar from the Sun* project team (Appendix D). The topical

framework was a list of issues or topics that were explored during the evaluation. It was phrased as a series of questions to be answered by observing and talking with visitors as they explored the *Sugar from the Sun* exhibition and its included programming. The rest of this report describes the methodology and methods used to answer the topical framework questions and discusses the findings and recommendations of the research study.

METHODOLOGY AND METHODS

In this study, *Methodology* refers to the overarching framework that guided the study. *Methods* refers to the data-collection strategies or techniques used during the study, and *Design of the Study* refers to the specific ways in which those methods were applied.

Methodology

This study used a naturalistic inquiry methodology, which is an ethnographic and primarily qualitative approach to understanding visitors and their experiences within informal learning environments. Naturalistic inquiry is a rigorous approach to understanding experiences in the natural context in which they occur (Lincoln & Guba, 1985). The goal of naturalistic methodology is to provide a holistic understanding of visitors' experience in an exhibition from a variety of perspectives. It usually includes collecting data from a variety of sources and triangulating that data to develop a thorough understanding of the subject of investigation. This approach to visitor research is particularly useful for complex projects such as *Sugar from the Sun* because visitors will come to the project with varied experiences, interests, and levels of knowledge. Rather than looking for an average experience, naturalistic inquiry aims to describe the range of experiences and understandings. As such, naturalistic inquiry provides powerful tools for exhibit and program planners who are concerned with reaching complex audiences.

One of the strengths of naturalistic evaluation is that unanticipated findings often emerge from the data, often in visitors' own words. This type of inquiry allows the researcher to follow up on threads and themes that characterize how visitors think about their experiences. This approach also allows the exhibition team to develop a rich understanding of the ways in which users may react to, interpret, and learn from the *Sugar from the Sun* project.

Data Collection Methods

A number of data collection strategies were developed to answer the research question and to address the topics included in the topical framework. Each strategy is briefly described in this section.

On-site data collection used five primary methods: (a) *unobtrusive observations*, (b) *intercept interviews*, (c) *exit interviews*, (d) *participant observations*, and (e) *depth observations.* In addition, to aid in development of recommendations for this report, findings from these methods were supplemented by critical reviews of *Sugar from the Sun* interpretation.

During unobtrusive observations, the researcher stood back and watched visitors as they explored the *Sugar from the Sun* exhibition, trying to stay unobserved by the group being watched. Notes were made about which exhibits and activities the group stopped at, how long they stayed, and what they did and said at each exhibit and activity. As part of these observations, the researcher sought to describe the range of Visitor Engagements displayed by that group, as described below. The data collection protocol for these observations is included in Appendix E: Sample Data Collection Protocols.

A depth interview is an open-ended and relatively unstructured conversation between a researcher and one or more respondents. Depth interviews were conducted with respondents in two situations. First, after completing an unobtrusive observation at a particular exhibit or component, the researcher sometimes approached the respondent group to request an interview. (The researcher did not approach groups of school children or children unaccompanied by adults.) This is referred to as an intercept interview. Second, the researcher sometimes observed visitor groups during their entire visit to *Sugar from the Sun*, and then approached them as they prepared to leave the exhibition and asked if they would participate in an interview. This is referred to as an exit interview. Starting with the questions in the topical framework, the researchers developed a depth interview protocol for the two interviews that focused first on what respondents had done with the exhibits and then opened up to a broader range of topics. The interview protocol is included in Appendix E. The protocol represented the starting point for our conversations with visitors. During each interview, the researcher asked probing questions and developed new lines of inquiry based on the responses received from that respondent group. With respondents' permission, visitor interviews were tape recorded and transcribed for further analysis.

In addition to the unobtrusive observations described above, researchers also conducted participant observations with some visitor groups. In these cases, with visitor permission, researchers joined an individual or group once they had begun interacting with an exhibit component and asked them what they are doing, thinking about, and experiencing. Participant observations often yielded information that was not possible with un-cued, unobtrusive observations described above. During some participant observations, researchers gave visitors pieces of cardstock with text for labels that were otherwise very difficult for them to read. Because naturalistic inquiry by definition recognizes that the researchers influence what they are studying, researchers tried to note and understand the nature of their influences as they watched and talked with participant observation groups.

Depth observations involved selecting specific respondents who were already known to the interviewers, and with whom they had already established a high level of trust. For instance, respondents included friends and relatives of the evaluators. Each depth observation consisted of meeting the respondent at the Conservatory and giving them a brief overview/orientation to the process. Their role was explained as that of a visitor, and they were encouraged to behave as they would if they were going through the exhibition on their own and were not part of the evaluation. They were encouraged to say their thoughts out loud whenever possible. The researchers participated in the visit, but usually let the respondent decide where to go, what to see, and how long to stay. During the entire visit, the researchers took detailed notes about where the respondent went, what they looked at and interacted with, places they became confused, comments they made and conversations they had. A depth interview with the respondent was conducted when the walk-through was completed, and follow-up questions were often asked during shorter interviews during the days after the visit.

Critical reviews were based on the expertise and experience of two visitor studies specialists, who also served as researchers in this study. Based on their knowledge of earlier informal education research and evaluation studies, the researchers developed hypotheses about why some

aspects of the exhibition's interpretation were not working for many respondents, what might be more likely to work, and what would continue to present significant challenges to visitors. While this review was based on the collective expertise, knowledge, and experiences of the researchers, the only way to truly assess whether the suggested revisions and recommendations will work, will be to test them with visitors in the field during the remediation process.

Design of the Study

Data Collection

Data collection included eighteen site visits to the Conservatory by SRA researchers from February 28 through June 15, 2008. Site visits lasted two to six hours at a time, depending on attendance patterns that day and type of data collection planned. Site visit dates and times were selected to maximize the breadth and diversity of visitor experiences included in the study. Visits were scheduled on both weekends and weekdays, including school visit days, school holidays, and Conservatory special events.

Respondents

During a site visit, researchers observed and often interviewed a series of visitor groups, following protocols discussed above. Typically, visitor groups were selected according to procedures outlined below, observed unobtrusively during their time in the exhibition, then approached to seek permission for an interview, and then interviewed at a quiet place within or immediately adjacent to the exhibition. At the conclusion of an interview, respondents were thanked and presented with a token of appreciation from the Conservatory. The researcher then adjourned to an office space away from the exhibition to type up a debrief and prepare for the next group of respondents.

Respondents for the observations and interviews with *Sugar from the Sun* visitors included both casual visitors to the exhibition (including visitors who came singly, as part of small social groups like families), and visitors who came with organized groups (such as school and preschool groups). Children were interviewed only if their parents were present and gave permission. All respondents were purposively selected according to standards for naturalistic inquiry (Lincoln & Guba, 1985; Miles & Huberman, 1994) to ensure as broad a range of experiences as possible. The decision to observe a group was based on the evaluation's purposive sampling goals. For instance, sometimes researchers strove to maximize the diversity of such characteristics as age, gender, social configuration, ethnicity, and presence of a disability. In other cases, groups were selected because they had stopped at a particular exhibit of interest, or because they were engaged in a way that seemed likely to expand understanding of an issue of interest. Brief, tabulated descriptions of the respondents are included in Appendix F: Description of Respondents.

Because both SRA and GLSC were committed to the ethical treatment of respondents, throughout this study researchers adhered to standard professional practices for conducting naturalistic research in settings of informal learning and ensured that the disruption of visitors' experiences was kept to a minimum. During all periods of data collection, signs were posted informing visitors of the research, and during initial verbal contacts visitors were given a clear option to not participate in the study. Confidentiality was maintained by not asking for visitors'

names and by removing from transcripts any identifying information that was inadvertently revealed during the interview.

In all, SRA staff spent about 67.5 visitor contact hours in the exhibition, which included time for observing and interviewing visitors and for debriefing about the resulting data. Researchers collected data from 55 smaller groups, such as families and groups of adults, including 143 individuals. In addition, researchers observed 36 larger groups as they engaged with the exhibition. These included about 1400 individuals touring the exhibition with organized school, preschool, Head Start, and day care groups. See Appendix F for more information on respondent groups.

Analysis

Data analysis for this study was an on-going process using a modified inductive constant comparison approach (Lincoln & Guba, 1985). This method takes each unit of data and systematically compares it to all previous units of data. For instance, data analysis for the interviews took place at three junctures. The first was during the actual interview. During the interview, preliminary understandings were developed and tested out with respondents. The second juncture was after an interview, when the researcher sat down with a computer and typed up a formal debrief. The debrief summarized the data collection session, recorded the researcher's interpretation of the session, and compared it to previously collected data. At the same time, the researcher also developed questions to be explored in subsequent data collection sessions based on what was found to-date, including any special areas of interest. The third juncture took place during the planning and writing of the final report, as the researchers revisited the debriefs, analyzed the transcripts, discussed the findings as a whole, developed preliminary conclusions, compared them with data collected from other parts of the study (e.g., the literature review), and wrote and revised the report.

Because of the iterative nature of the analysis, readers will not find a one-to-one correspondence between a piece of data and a conclusion or recommendation. Rather, the findings discussed in this report result from synthesized data, gathered from a variety of sources.

Visitor Engagements

As part of the data collection, four types of visitor engagements with the exhibition and activity carts were of particular interest: physical, intellectual, social, and emotional. These four types of engagements are not – and are not meant to be – mutually exclusive. They are described below.

Physical engagements were all the physical things visitors did at the exhibits or activities, such as standing, running, bending over, reading a label, looking closely at a plant, touching the water or mist, and so forth.

Intellectual engagements were all the ways in which visitors engaged cognitively and intellectually with the exhibits and activities, including ways visitors thought about, processed, and made meaning of their experiences. Intellectual engagements might include a respondent being thoughtful and reflective, or it could include expressions of confusion. Although some types of cognitive interactions could be judged through observations and overheard

conversations, most data about intellectual engagements came from the interviews and participant observations.

Social engagements were the ways in which visitors engaged with each other to make meaning of their exhibit and activity experiences, including verbal exchanges and body language. Researchers attended to the extent to which, and ways in which, visitors engaged socially with others in their groups and with GPC staff and volunteers, paying particular attention to their storytelling, teaching and learning interactions, and other social engagements that contributed to active meaning-making.

Emotional engagements were all the ways that visitors engaged emotionally with the exhibition's plant, environments, and interpretation. Researchers looked for indicators of relevant emotional engagements such as appreciation, excitement, feelings of calm or peacefulness, surprise, satisfaction, frustration, or confusion.

While researchers looked for the variety of intended engagements developed during the formative evaluation, they also noted all the additional ways (both positive and negative) that respondents engaged in the exhibition. Engagement data was collected during the site visit and then analyzed in order to understand why some exhibits seemed to achieve their goals effectively and others did not.

Limitations

Due to limited resources, this study was necessarily limited in scope. When conducting an evaluation study using naturalistic methodologies, it is standard practice to continue collecting data until a state of redundancy is reached. Redundancy is the point at which no new information is gleaned, despite repeated attempts to elicit additional findings. In this study redundancy was achieved for many of the issues listed in the topical framework. However, some areas of interest could not be explored in enough depth to reach redundancy. Where appropriate, the report identifies issues that could not be resolved satisfactorily.

Finally, while this study included respondents who had engaged with the prototype Cart activities, the facilitated activities were not a primary focus of this study. Rather, researchers investigated the ways in which engaging with the activities contributed to visitors' understanding of the themes and concepts presented in the *Sugar from the Sun* exhibition. This study should not be considered to be an evaluation of the overall effectiveness of the prototype Cart activities.

FINDINGS

This section details the findings from this study, often using visitors' own words as they talk about *Sugar from the Sun*. These quotations are included from interview transcripts illustrate the themes and issues that emerged during the research. They were selected as examples of the range of ways in which respondents talked about the topic in question. However, the number of quotations used in the report does not represent the relative frequency or strength of a particular response.

Who Came to the Exhibition?

The researchers were struck by the diversity of the audience visiting the Conservatory and thus for *Sugar from the Sun*. (Because the Conservatory's indoor exhibitions were arranged in a closed, circular pathway, almost all visitors to the Conservatory eventually passed through *Sugar from the Sun*, even if it was only on their way to somewhere else.) The diversity in the *Sugar from the Sun* audience was evident on many dimensions, including race, ethnicity, geographic origins, age, and more. The audience was also diverse in its motivations for visiting the Conservatory, their relationships to plants, and their interest in science. In many ways, the researchers felt as if they were observing and talking with an amalgamation of the audiences from an art museum, city park, science museum, and children's museum.

One of the more interesting dimensions that emerged was visitors' previous experience with the Conservatory. We were particularly struck by comments made by those who were visiting the Conservatory for the first time. Here are some things first-time visitors said, which betrayed both their motivations for coming to the Conservatory and their initial reactions to their experiences:

> *[I've] never [been here before]. We're from Wheaton, nearby, and grew up in this area. So, friends have said, "Gotta go, it's a treasure!"* [080531-04]

> *[The best part for you?] Just seeing [my son] excited, that was my first thought. I've never been here before, so this whole thing is a big treat for me.* [080318-04]

> *This is my first visit here. It was just nice seeing the Conservatory, just all the plants. One thing I've noticed, how they've changed it, based on what I've read, they've changed the exhibits. Just seeing everything, it's really nice.* [080320-09]

Some Chicago area visitors described their chagrin at not having visited before.

> *This is the first time we've come. I don't know why. I don't know why, I don't know what's wrong with me! I've lived [in this area] for so long.* [080318-03]

> *This is the first time we've been here, also. Ever, ever, ever. How embarrassing is that? I was born and raised in Berwyn, but now we live in the northwestern suburbs of Chicago. So, we're being better Chicago citizens.* [080325-03]

Some recent first-time visitors seemed destined to become regular visitors.

> *We came here for the first time about three weeks ago, and [my preschool-aged son] is totally hooked.* [080407-04]

> *This is our second time. We were here about three weeks ago. And so, we found out about the Monday activity for kids. So, this is our second Monday.* [080407-03]

Researchers talked with other visitors who had been coming to the Conservatory for years – sometimes just once or twice a year, sometimes more often.

> *I come here like once or twice a year. And, it's great! We enjoy it every time we come. We love going from one stage to the other. It's warmer here, it's cooler here, and it's great!* [080320-09]

> *[We come here] probably, maybe four, five, maybe six times a year. Different times.* [080322-04]

Some visitors said they came for their own enjoyment, while others focused their visits on their children's interests and needs.

> *Yeah, we come here pretty often. We do, we live in Chicago. So, we come here throughout the winter to get a nice warm feeling. We used to live in Hawaii, so it reminds us of that. We need a little sunshine and plants.* [080320-06]

> *[My 4- and 5-year old boys are] homeschooled. So we take advantage of everything the Conservatory has to offer. We normally come on Mondays for Mini Masters. And then some times just come to kind of explore, or there's like a Saturday program full of activities.* [080320-07]

A few respondents said they had grown up visiting the Conservatory with their parents and were now bring their own children.

> *My Mom's a Chicago public school teacher, so she started taking us when we were pretty young. I don't remember how long [ago]. I grew up in Chicago, so, for awhile.* [080407-02]

Some long-term visitors said they had been following the revisions to the old Sugar House and anticipating the opening of the new exhibitions.

> *We've been looking forward to the opening soon.* [080320-06]

When respondents were asked about their reasons for visiting the Conservatory, they provided a range of responses, sometimes from within the same group.

> *It's what's you're here for. Everybody's going to be here for something different.* [080504-01]

Not surprisingly, many respondents said they came here for the plants or for the overall Conservatory environment.

> *You can see when the flowering periods are. It's fun, 'cause it's changing all the time. That's what I like about it.* [080324-01]

> *It's great in the winter. It's just so beautiful, and it's so nice for them to have a place to run around. And then that children's room in the back is so cute….It's so nice it's free. There's nowhere to take kids that's free anymore.* [080407-02]

Like several previous respondents, many parents focused on what the Conservatory could offer their children – while still meeting their own needs.

> *I grew up on a farm, so really want my kids to have some connection with growing things.* [080407-03]

> *A lot of it is that it's laid back, for me, and I'm the decider. It's laid back, and quiet and calm. There aren't huge crowds, which I really prefer that kind of an environment. And [my children] can have free rein and run around like this. And the activities for the kids are really fun. They made these little necklaces. And the woman reads a book to them, which they really enjoy. They love that slide…They went down that about a hundred times today. And then the other activities are great, on the floor, I think that's really great. They have floor activities, hand puppets, and last time we put together a puzzle....It's quiet, I mean it's just a very nice place.* [080407-03]

As the *Sugar from the Sun* team had suspected, some respondents said specifically they were *not* here to read labels or receive an "education."

> *I was looking more at the plants. I wasn't looking at the signs.* [080504-01]

> *I wasn't going through to be educated. I was much more going through to experience it, on strictly an intuitive rather than a rational level.* [080504-01]

> *I guess there's an underlying message of teaching about the natural world. But, a lot of people go [to the Conservatory] just because there's pretty flowers and nice plants, especially in the winter when you want to see green things*. [080427-01]

It was also not surprising that some children also resisted attempts to "educate" them, even with hands-on programming.

> *He never has time to stop here, because he's too busy looking at everything. I know you have a wonderful [kids'] program here, he won't stop.* [080407-04]

The *Sugar from the Sun* exhibition had to serve this diverse audience – to accomplish its goals without disappointing visitors who had come to the Conservatory for a wide variety of reasons.

The next section of the report discusses the ways and extent to which the exhibition fulfilled the hopes, needs, and expectations the wide range of visitors who came here.

Engaging with *Sugar from the Sun*

Visitors engaged with *Sugar from the Sun* in a range of ways, depending on their interests, group composition, and the discoveries they made along the way.

Some visitor groups engaged primarily with the plants, walking slowly and stopping frequently as they located, examined, or photographed interesting plants, read identification labels, and talked about what they found. This pattern was typical of adult groups, although some families with interested children also focused on the plants. Some of these groups included gardeners; others were guided by visitors who had grown up or visited the tropics, and who had personal stories to share with their companions. These groups usually moved very slowly through the exhibition, often staying for 10 or 20 minutes or more.

Other groups engaged in more sensory and aesthetic ways, enjoying both the overall environment and individual plants as they walked through and talked about the exhibition. These groups walked slowly, stopping briefly to examine plants, talk, take photographs, or just soak in the experience. Most of these groups moved through the room in 3 to 5 minutes, but some lingered longer.

Family groups with young children engaged in a range of ways. More active children looked for adventure on the narrow paths, under the misters, and in the water, sometimes dropping or throwing pebbles as their caregivers trailed them through the exhibition. Groups with *Hunting for History* scavenger hunt sheets systematically searched for plants listed on the sheet, moving to the next exhibition once they found them, but sometimes returning to locate plants they missed the first time around. When an adult caregiver was interested and knowledgeable about plants, they often shared their experiences with their children, stopping to point out particular plants and tell stories about them. Other families were guided by adults who played a teacher-like role, trying to interpret the exhibition for their children even if they knew little about what they were seeing. These groups seemed most apt to read the interpretive signs and incorporate them into their experience. When prototype *Exploration Cart* activities were in *Sugar from the Sun*, family groups often structured their visit around them. Usually the children did the activities as their adults mostly stood back and watched, sometimes contributing a comment, trying it themselves, or talking with the program staff. No matter their primary engagement style, entering the *Sugar* section transformed almost every family group into plant hunters as they searched for fruits and read and talked about what they found. The time spent by family groups varied widely. Groups with active children often moved through *Sugar from the Sun* in less than 2 minutes, but sometimes returned once or twice as they followed the lead child around the Conservatory circuit. Groups that participated in prototype activities stayed for 10 to 30 minutes and sometimes returned for more after a restroom or snack break. Other family groups usually spent 3 to 10 minutes exploring *Sugar from the Sun*.

School and preschool groups also engaged in a range of ways, based on their ages, adult supervisors' interests, and lesson goals. Some groups marched through in a line, with their

teacher periodically stopping the group for a short discussion of what they found. Some preschool groups stopped only briefly in *Sugar from the Sun* as they quickly moved to their Children's Garden destination. Large school groups often broke up into subgroups of two to six students, lead by parents. These groups engaged more like families, in the ways described in the preceding paragraph. When a group had scavenger hunt sheets, those usually dominated their experiences; as children found what they were searching for, they drifted off a bit to explore on their own or stayed closer to the group to help their companions. Finally, some groups came with their own agenda, ranging from Conservatory-created activity kits to teacher-created worksheets or art projects they were assigned to complete. Like family groups, school groups spent widely varying times in *Sugar from the Sun*, from less than 2 to more than 30 minutes.

Based on their wide ranging engagements with the exhibition, visitors had many things to say about their experiences in *Sugar from the Sun*. Those are discussed in the next section of the report.

Visitor Experiences in *Sugar from the Sun*

Experiencing the Exhibition's Components

As visitors talked about their experiences in *Sugar from the Sun*, in many ways their words mirrored what they said about the rest of the Conservatory. For instance, many respondents talked about their enjoyment of the plants.

> *I love the plants, it's beautiful.* [080614-03]

> *I always like to see the different plants.* [080504-03]

Even younger children were sometimes fascinated by the plants and learned their names.

> *There were bromeliads, orchids, hibiscus tree.* [6-year-old girl; 080531-04]

The fruit-bearing plants in *Sugar* attracted lots of attention from both children and adults.

> *We're looking at the fruit. We like fruit…You know, I hadn't seen some of these fruit plants before, and it's interesting to see those.* [080504-03]

> *We looked at all the fruits that were edible, that we recognized, that we thought was interesting to see what the plant form looked like… We find the fruits at our table that we eat. It's interesting to see where it came from, the plant. At the supermarket we don't see where it's grown.* [080325-02]

Seeing the plants that grew familiar fruits was a recurring theme as respondents talked about their experiences.

> *It makes it easier, by actually seeing and touching [the fruit plants]. Because, even though I'm an older person, my mother had told me about the farm. But I still found it amazing about the little oranges, and pineapples. Because in the grocery store, they polish everything up! But here, it's just like at the farm – organic*. [080320-08]

I came through with my nephews, who are 6 and 10. And it was nice to see them be very excited about it....And especially in the Sugar *part, like seeing all the different types of fruits, and being surprised the pineapples grew so close to the ground, thinking they were in the trees. So it was nice to see it with them, through their eyes.* [080322-04]

For some visitors, the fruits and other plants had special meaning.

Mother: I love plants. It brings back memories of my country, Ecuador.
Her daughter: My grandfather was a gardener, and they had an entire block with only plants. [080504-02]

Gardeners frequently talked about their own efforts to grow plants, and how the Conservatory contributed to their avocation.

Makes you feel inspired! Makes you excited! [080325-03]

I'm growing orchids in my house, I'm having a windowsill. I'm an amateur at it. I'm just starting at it. And I just wanted to see how -- see the different types of orchids that you growing in here. And get the feel of the [conditions], I'm never going to get the right humidity levels in my house.…I just love plants, and this is the best place… If I even won the lottery, I'm building one of these in my backyard....This is awesome, this is the place to be. [080324-01]

Of course, *Sugar from the Sun* was much more than plants, and visitors had many positive things to say about the non-living aspects of its immersive environments.

I love it! I think the nice natural rocks, so much is real. [080320-06]

The architecture, the waterfall and the pathways over there with the platforms are interesting. [080504-03]

I was just noticing the metalworking. I like that a lot, too. [080320-06]

The integration of the sculpted and the woven steel elements, those were kind of nice and different than you see in most places. I don't know, I like that. [080322-03]

It was kind of fun to be able to walk up that next level to get to the top of the waterfall where you normally wouldn't have an opportunity to be. [080504-01]

I like the waterfalls and some of the colorful plants, and like the pathways, and stuff like that. [080324-01]

The pathways were a source of enjoyment for many respondents.

I like the way it meanders, it isn't just a straight through. It gives it a more realistic feel to it. [080324-01]

I liked the part where there were these little paths that went off of the main path so you can walk by the plants. [080325-02]

Of course, water in all its forms was popular with all ages.

I like the part of the hands on, the water, how the kids can kind of feel the water, and actually touch it, or might just get a little mist of the water spray on them. [080320-07]

I always like the water, too, I like to see that water moving around…I like the where the kind of air conditioner up there with the mist coming down, and the fan. That was kind of refreshing. [080504-03]

I liked the misters. When you walked through the Water *[section], the water was everywhere*. [080531-05]

Interactivity in the Exhibition

During the formative evaluation, the project team prototyped a number of components that were intended to make *Sugar from the Sun* a more engaging experience for young children (Gyllenhaal et al., 2005). The goal at that time was to inspire active young children to stop and focus on plants and ideas in the exhibition. The *Engagement Cue* labels were a direct product of those efforts. The opportunities to search for fruits, touch plants and water, climb steps, and explore narrow pathways also were intended to engage the young (and old). However, the prototyped interactive exhibits tested during formative evaluation, like the Sugar Dance and unsupervised activity stations, were not included in the final design.

Many caregivers appreciated the engaging environmental components, and some even asked for more of them.

Maybe more interactive, more going through, like looking through the banana plants. Walk right through tighter, so that you're really in. More different levels, because that was kind of fun, going up behind the waterfall, where you're really getting closer and looking down. [080504-01]

However, as SRA researchers have noted on other projects (e.g., Gyllenhaal, 2002c), visitors to a range of informal educational institutions, from parks to botanic gardens, often bring expectations for hands-on and interactivity in exhibits that are based on their experiences in children's and science museums. Although the project team took pains to avoid a science-museum feel for *Sugar from the Sun*, visitors with active young children sometimes said they would not have minded finding, for instance, the kinds of interactive models they had seen in museums.

Just to show how something travels through a stem, and how something turns from water into sugar and travels up the stem. I think that's valuable, and I don't think that's too sciency. [080318-04]

As one respondent pointed out, there were already giant interactive models in the Children's Garden, so why not in the adjacent exhibition?

> *I thought [of] the way you integrated the jungle gym things that looked like plants, I think that was fine, because it was kids' play area, you use materials that are good for a play area to induce play, which I thought was good. I think you could do the same thing to induce kids looking at something and pointing at something, and saying "Oh wow!" You know, it's like in science museums when they are trying to show you the ant farm or the bee hive, and they cut a section of the bee hive or the ant farm, and put it behind the glass. You know it's the same kind of thing. They still can run around, but they can also inspect something very closely. I think kids like to inspect things closely.* [080318-04]

The report returns to the theme of interactivity in the sections on Engagement Cue labels and programming in the exhibition.

Artificial Components and Sounds

The formative evaluation also found that many respondents disliked finding "fake" plant parts in Conservatory exhibitions, particularly fake fruits that were placed on real plants (Gyllenhaal et al., 2005). Therefore, the researchers talked with respondents about a range of artificial elements included in the finished exhibition.

It turned out that some artificial elements were totally accepted by visitors, especially environmental elements like the pools and waterfalls (which no one even seemed to think of as "fake"). Other artificial elements, like the iron branches in *Air*, proved very popular with visitors.

> *And I loved the -- it's not stainless steel, I don't know what it is -- but it looks like branches and it looks like trees, but you know it's not real, but it really, I think it looks like it's going to grow into it. Does that make sense? The [plants] that's on it looks like it's going to grow into it. It looks very part of it already.* [080322-04]

> *I was impressed with all the iron work that you have there. It was beautiful. How you integrated it into the real. Very beautiful.* [080325-03]

Also, the "fake" leaves and fruit embedded in the concrete floor elicited no negative comments, and received some positive feedback from visitors.

> *I also liked the cement with the leaves that are in there. Embossed or imprinted. Artistically done. Very beautiful. OK with me [that it's not real]. I look at it as an artful thing….It adds a lot more character than if it's just flat, and than if just trying to be dirt colored. I really like that.* [080325-03]

Respondents were a bit more divided about the sounds. The "real or not real" issue played out here in several ways. Some respondents liked the sounds, which got them thinking about real birds.

I like the sound system in there now, too. That's what I told my wife I would do at the Conservatory, too, is put the birds in there, too. It's a good touch. I like it. [080324-01]

I like the sound, pumping in the birds and the monkeys or something. I have seen a bird in here every once in awhile, but I didn't think they were real. [080407-02]

However, other respondents weren't sure, at first, if the sounds were real. Respondents sometimes were fooled and went looking for the origins of the sounds.

I noticed the sounds, and then the kids [noticed]. I think it was a bullfrog which drew my attention. And we were wondering if it was real or recorded. But I figure it's recorded. [080407-03]

Respondent 1: We were trying to find the frogs. Then we realized they were being piped in, so I was disappointed….I was just hoping that they were real, because I love amphibians.
Respondent 2: Well, we did spend five minutes trying to find the frogs. [080325-03]

Some respondents also said they thought the sounds were a bit too loud and intrusive,

I think the piped in bird sounds are little too much. That's what I noticed when I started walking through. [080504-03]

Maybe a little bit less of the piped-in bug noises. They're fine, [but] it just makes it seem a little less real. [080320-06]

Combining these findings with what was learned during the formative evaluation, it seemed that artificial elements were accepted as part of the *Sugar from the Sun* experience as long as (a) they did not fool visitors into thinking the artificial elements were alive, and (b) they did not intrude too much on the soothing, naturalistic feelings induced by the immersive environments.

The Overall Experience

Some respondents, instead of focusing on specific elements, stepped back and talked about their overall experience of *Sugar from the Sun*.

I was just enjoying the whole exhibit, you know, and all of that. Nothing really specific caught me. Ultimately, what I think of it is, it's delightfully done! [080322-01]

I like the way it's laid out. It's more open space; it's more open feeling space. [080504-03]

I really like the design. It's a really well put together garden. The inorganic pieces that they have, like sculptures and things, it just, it adds a really nice element. I think it's very easy to navigate through. It's just a beautiful space. [080324-02]

Thank you for the time for doing it, because it's really well put together. There's enough space for you to enjoy the plants. It's not just a mass of green. It's very thoughtfully put together. [080325-03]

The Fern Room was always my favorite, but I think this is maybe my new favorite room. [080320-06]

However, as visitors noticed the various sections of the exhibition, they sometimes worried if they were supposed to go through it in a certain way.

I'm not even sure if I was supposed to go from one side and start and go around. I wasn't sure about that. We just kind of went around and then came back. [080318-03]

You read different signs, and it kind of carries you through that, and then it ends near the waterfall. Or that might be the beginning. We came from this way the last time. So it does give you the idea….The entrance, I guess that would be the east end of it. And it had the Air, and telling you to feel the air. And you do kind of feel it, a little breeze over there. [080320-07]

Some respondents were also thinking about how *Sugar from the Sun* fit into the overall flow of the Conservatory.

But, I like the way it flows in the new building, you know, this is a new part, right, as well? I love the way that it flows through with the rest of the Conservatory. [080322-04]

However, some visitors saw the exhibition near the end of there visit, which may have limited their enjoyment of it,

Respondent 1: This is one of the last rooms we've been in. I say it's a little, not as exciting as some of the other rooms in the Conservatory. So we kind of went through it quickly. Also it's the last room we've been through.
Respondent 2: It's probably got to do with the "last room syndrome." [080504-03]

Finally, it's important to note that some respondents – especially families with younger children – came through *Sugar from the Sun* more than once in a day. Some were trying to find items on the scavenger hunt sheets. Others said they were following young children who liked to wander.

I think this is may be the third time I've been in there today. [080320-09]

These visitors seemed more likely to visit all four sections of the exhibition.

Comparison to Other Conservatory Exhibitions

Because respondents said so many positive things about *Sugar from the Sun*, researchers wondered how they felt it compared with the other parts of the Conservatory. Some respondents focused on the overall environment.

*It's definitely brighter in [*Sugar from the Sun*], which it's meant to be, obviously, talking about the sun and things. And, so, it does feel a little different. There's fruit trees and stuff in there, which you don't have in the rest of the place. So, it's definitely different. I think, you know, ultimately you achieved what you wanted to.* [080322-01]

Others focused on how the numbers and sizes of plants differed from room to room in ways that were not necessarily favorable to this exhibition.

It seems like there's more diversity in the other rooms. [080504-03]

I think also just the fact that a lot of the plants in the other rooms are so large, so mature. [080504-03]

It's nice to have always the taller plants in a setting like this, as difficult as that is. Especially if you're looking at this part of the exhibit. You don't have a lot of height variation, and I think that that would be it. If there were taller plants that would envelope you more, that would just be a cool feeling. [080504-01]

These visitors felt better when the researchers or floor staff explained that the exhibition was new, and the plantings would eventually grow to fill it.

[The educator] was explaining that the vines would grow bigger and separate the sections better, and you'd get more of an effect of the different conditions for the different plants, and how they capture different fragrances and humidity. [080601-01]

Finally, some visitors said they were impressed that *Sugar from the Sun* was designed as a learning space, as well as a plant-filled naturalistic environment.

There are, obviously all the signs, about water, and, I guess, educational a little bit….It's trying to [be] more educational. [080504-03]

It was interesting that, when they talked about the more "educational" aspects of the exhibition, many respondents seemed to assume that *Sugar from the Sun* was designed for children.

I just like the whole set up of it. I thought it was completely different from all the other rooms. It's nice. It seems more educational for the children. Like the leading from kids' room into there, it seemed like one, what do you see? The photosynthesis. [080324-02, Respondent 1]

It was teaching you parts of sugar. I like that they have a theme. Something a little more accessible for kids. You can tell the rest of the Conservatory is designed for families or for adults. Walking around and overhearing some conversations, people are talking about things they are going to put in their garden, they're talking about different plants. For children, or people like myself who don't know very much about plants, it gave it an

extra element to draw your interest. There were other things to read, other things for them to get out of it. [080324-02, Respondent 2]

It had a lot more description for the children. That was nice, with the air and the sugar and all that. [080407-02]

If educational exhibitions were for children, then what about the adults? Some respondents worried that other visitors (like adults) might not be expecting this sort of exhibition in a Conservatory.

*I think it's hard to be teaching people things at a place where people basically are coming with the idea that they are going to observe and look and experience nature, not necessarily learn in more a hard factual kind of way….The other rooms, it's more just the ambiance and observing and then, and [*Sugar from the Sun*] has a lot of ambiance, I think. It creates a real environment, but people aren't mentally prepared to be taught in this kind of a fashion, I think...It looks too similar to the other rooms to think that it's going to be something that's quite different, that's more about teaching you things about scientific processes.* [080427-01]

Overall, most respondents seemed to love the plants and immersive environments in *Sugar from the Sun*. However, feelings about the "educational" aspects of the exhibition were mixed. Many respondents appreciated the efforts for young visitors, but some adults did not seem to feel that aspect of the exhibition was for them. We will discuss possible reasons for this feeling later in the report.

Visitor Perceptions of the Interpretive Signage

This section of the report examines visitors' perceptions of the interpretive signage developed for *Sugar from the Sun*. The next section looks at how visitors were integrating their experiences with plants, immersive environments, and signage into an overall understanding of the exhibition.

Design of the Signage

Visitors to *Sugar from the Sun* often commented about the circular glass signs that they found at the entrances and within the four sections of the exhibition. Many respondents had positive comments about the beauty of the signs and how well they blended in with the plant-filled environments.

Those [round signs] were neat, the art part. Looked like the steel pieces? They were kind of fun. And there were a few pieces that looked like they were back lit, on glass? They were really kind of nice. [080322-03]

These are beautiful signs. You know, I really love that somebody had a great vision on just the whole [thing]. I love the metal and the glass, the way you've used them on the signs. The writings on the leaf. [080601-01]

They were integrated and nicely done. It's a beautiful display. [080504-01]

Respondents found both good and bad aspects to the subtle, almost hidden nature of the circular signs.

That does do a nice job of blending them in. I kind of like the subtlety. I don't think I'd like it if they were bright yellow. And so the subtlety is nice, but it makes them a little harder to read. It's kind of a balance. [080504-03]

It's just that they were a little hidden. They were trying to look like leaves, so I get that's why they were in the background. But, they were a little hidden. [080531-05]

I think some of the signs are almost too well integrated? You know what I mean? So, we weren't really reading the signs very much. [080318-03]

Many other visitors complained that they had trouble finding and reading the signs, especially the back-lit glass.

My only criticism was those green plaques were a little bit tough to read. Otherwise, I thought it was a pretty cool exhibit. [080322-03]

The ones that are backlit, I had trouble with that. [080601-01]

For some, the signs seemed too dark.

Personally, I found some of the signs hard to read. They're a little dark, there's not enough contrast for me. [080504-03]

Maybe background is a little bit dark, and it's a little bit hard to read. [080531-04]

However, respondents also found the labels hard to read in brighter light.

I think the [green signs] were tough to read when it was this bright, though. I had a tough time reading them. [080322-03]

With glare from the sun, I think it's sometimes a little more difficult to see those. [080322-01]

Respondents also had trouble reading the smaller texts on many of the labels.

It's a little bit hard to read small letters. You need to be really focused to read this. [080531-04]

In addition to the other issues, respondents noticed that the labels were even more difficult to read when they got wet and dirty.

This is very difficult. It's tiny and dark. Cause it's dirty, it will get steamy and dirty again. [080601-01]

Although adults often complained that they had trouble reading the signs, some respondents also were concerned that children were not well served by the current signage.

I wouldn't have noticed [the sign] if you hadn't actually brought me back over here. So maybe there could be some colors in there to captivate the eye of a child. [080614-01]

Maybe, it would have been helpful for him if there were, maybe, a little bit bigger signs point[ing] out the different things? Because [my son] knows how to read, but they kind of blend in a little bit, because they're dark colors. So maybe signs that caught his attention more, so he would learn on his own. [080318-03]

I suppose it's targeted to adults and kids, right? I think that the kids don't really notice, I saw it had air and water written on the rocks and stuff. I don't think kids notice that kind of thing. You know, they need more the colorful… A little more hit them over the head. [080407-03]

Respondents who were less interested in the 'educational" aspects of the exhibition said they did not mind that the signs were not too noticeable.

It doesn't seem that [the signs are] yelling at me, any messages or anything. [080324-01]

Respondent 1: It's nice not to have the science forced on you.
Respondent 2: I didn't feel it was forced at all. If I want to look at it I will, and if I don't, nobody is pressuring. [080322-03]

However, as another respondent pointed out:

[I was] forced to look at the labels carefully because I can't read them. [080228D01]

Also, the signs were important part of the exhibition to many families.

[My son] just asks a lot of questions, so every sign that tells us anything, he wants to know about. [080407-04]

Families with young children need labels that parents can read quickly, at a glance. When they can't do that, they just don't get the point of the exhibition.

[I was] trying to [read signs]. If I didn't have the littler one with me, we probably would have taken a lot more time to read what was there. But the other one, he wants to go in the dirt. [080318-03]

Finally, some respondents had paid attention to the ways the signs were distributed through the exhibition – many signs, placed throughout the exhibition, each with a small amount of text. Some comments were positive.

> *I thought it fit very well. The labels were spaced well throughout the exhibit. It allowed you to stop and read from, but not be overwhelmed at the same moment. And you got to continue on.* [080325-02]

But others seemed bothered by what they perceived as the non-sequential arrangement of the signs.

> *I would like kind of more step by step instead of scattered.* [080504-03]

> *I think we're probably all trained more for one thing, which is seeing something that's more sequential.* [080504-03]

Finally, some respondents expressed their disappointment that the signs did not answer their many questions about the plants – especially the fruiting plants.

> *Maybe with the fruits, if there was like a little informative, ah -- like that circle right over there that gives information? Maybe telling when it would be a good time to pick them? Explaining things like that. About how long it takes for them to develop fully? Because right now the pineapple is pretty small, and the oranges are really small, and the bananas aren't even on the tree yet so far. So maybe information like that would be nice.* [080320-07]

These visitors seemed more interested in the individual plants than in how plants make sugar – the signage had not succeeded in focusing their interest on the large themes of the exhibition.

Label Texts

Despite visitors' difficulties reading the exhibit interpretation, the researchers found ways to focus visitors' attention on the text. This required reading label texts aloud to them, or sometimes handing respondents a piece of cardstock with the label texts printed in black-and-white. The results suggest that, even if visitors had been able to read all the interpretive labels, many would still have trouble extracting the intended messages and themes.

Many respondents noticed that the label texts were brief, and that was appreciated by some respondents.

> *All the little plaques were short and, like, too the point.* [080322-03]

> *They don't give too much information that it's overwhelming, you know.* [080407-04]

However, in part because of this brevity, other respondents found the conceptual messages unclear.

It's pretty subtle. So it's pretty easy to walk by it, and just say, "Ah, OK, I just don't [get it]. And when I say subtle I wasn't meaning visually, I meant in terms of the message. It's a little vague, in terms of the educational message. [080504-03, Respondent 1]

Like I understand what they're trying to say, but if I didn't know the process or anything, I think some of them are a little too vague. [080504-03, Respondent 2]

Other respondents felt the short texts were too basic to meet their interests and needs.

Is that all?...Maybe this is just going over my head. It feels like it's way under…[It's a] very, very, tiny concept.…It's so basic. It may be a lot more complex than I'm realizing and feeling, but I'm not getting enough fast enough to 'string the beads to form the necklace.' [080228D01]

To help the project team think about potential revisions to the label texts, here are some specific visitor reactions to the different types of labels included in the exhibit interpretation.

***Exhibition Entrance* labels**

When visitors noticed these labels, they often read aloud the title of the exhibition. However, many visitors missed these labels when they first entered the exhibition; they either read them as they left the exhibition, or they never noticed them at all. Also, visitors rarely read the smaller "Inside every leaf…" text to others in their group.

Respondents who had looked at these labels rarely realized that the entrance sign was also map, in part because the "you are here" text was easy to miss. Hence, they did not realize that the entrance label laid out the overall organization of the exhibition. (Instead, some respondents thought the graphic looked like a diagram of the inside of a leaf.) If respondents had noticed that the signs at the four entrances were maps, then they began to think about what those might tell them.

I was just, thought you kind of wander through it. I didn't notice that those signs were maps. It's a small enough exhibit, I mean I don't know you don't really need a map, but I guess having the map makes it more clear what each section is and how they kind of come together. [080427-01]

Because the *Exhibition Entrance* labels were not very effective, some visitors seemed to feel adrift in the exhibition. As one visitor said,

Maybe what they need is more an introductory area. So you can sort of get that picture like they do in many places, that you're going to read an introductory overview. And then you go into the area and get, "OK, now I understand, I can relate that back to what I just read." [080504-03]

Actually, this visitor's suggestion mirrors a recommendation from the formative evaluation report. The report suggested that visitors be provided with an extensive orientation at the

exhibition entrances, especially to the ways in which the exhibition's concepts mapped onto its layout (Gyllenhaal et al., 2005).

Section Entrance **labels**

The researchers heard many visitors read aloud the first word on these labels as they entered the sections: "Air!" "Water!" "Sugar!" Caregivers and school group leaders often read a few more words on these labels, and sometimes read the whole label out loud. However, these rarely led to discussions within visitor groups. It seemed that most adults did not know how to discuss even these simplified ideas with their children.

Each *Section Entrance* label was perceived differently by respondents, and each seemed to support the exhibition's big idea to varying degrees. Respondents found the *Water* label clear although perhaps incomplete.

> *That's nice, that's good. That just says right what it does. There's not a statement of purpose, but, you know, if you're meant to infer that, or you're meant to find that out later. In other words, why does water flow?* [080614-03]

Note, however, that this respondent focused on water flow, rather than the contribution of water to making sugar.

When respondents read the label at the entrance to *Air*, they were more confused.

> *[Laughs] It's true, but so what? What are you saying?* [080614-03]

The lack of specifics in this text left them confused about the purpose of this section. Similarly, the reaction to the Sunlight entrance was, "What's the point?"

> *[Laughs, shakes head] Yeah, well the fact that we're eight light minutes from the sun isn't germane to any understanding. It's interesting, it's true, but, "Thousands of years to be created." You're talking about astrophysics there, which really doesn't have much to do with plants.* [080614-03]

The label at the entrance to *Sugar* also left visitors confused, and sometimes a bit angry.

> *I guess it's kind of poetic and philosophical, it's not direct. I mean, it depends on what your aim is…."Sugar makes things." I mean that's like, it's groovy and all, but it doesn't really say anything.* [080614-03]

> *It doesn't really tell me anything about why sugar is so important. It just tells me that it is important. Like, why do plants need sugar? I have no idea.* [080614-02]

> *It requires additional explanations. Because like, if "sugar makes things happen," it is not obvious from this text how sugar makes things happen. You need to explain it in more detail. This is just for discussion, rather than education.* [080531-04]

It's poetry. Bad poetry. [080228D01]

These label texts will require extensive revision to provide appropriate support for the big idea.

***Engagement Cue* labels**

When families were able to read the *Engagement Cue* labels, they sometimes found them very helpful.

I thought they were good also to tell you what you were trying to do in the different areas. You have the one that's in Air*, and the* Water *section. That was helpful.* [080531-05]

I like the one over there, it's talking about how leaves capture sunlight, and telling you to look up at the leaves and see the sunlight coming through. That was kind of neat. [080504-03]

However, many caregivers did not read the second sentence, which suggested the action visitors should carry out. Hence, they missed the chance to engage their children with the ideas in the exhibition. One issue was the illegibility of this type of label, but another was the arrangement of the ideas. The suggested activity came second and was in smaller type. It was not designed to catch the eye and get visitors moving and thinking.

Some of the actions suggested on these labels confused respondents. For instance, one visitor complained about a *Sunlight* label.

It said to look at a leaf and see all that is happening inside it, but I can't see what's happening. [080228D01]

She explained that, rather than making her contemplative about the concepts, the label just made her angry. Visitors also expressed frustration with the label in *Sugar* that told them to look for fruits.

Where are they? I'm getting really frustrated. [080228D01]

Finally, the parts of the *Engagement Cue* labels that explained key concepts also varied in their effectiveness. The smaller font paragraphs in *Sunlight* and *Sugar* made sense to most respondents (when they were able to read them); the comparable level of text in *Air* and two of the three *Water* labels seemed too vague to many respondents.

***Addressing Misconception* labels**

Although no visitors were able to read these labels in the exhibition, when presented with the text on cards, the basic ideas in these labels seemed interesting and at an appropriate level of challenge to many visitors. Although the *Sugar* label was clear to most respondents, the other three sections need revisions to make them understandable to a broader range of visitors.

For instance, in the *Air* section, visitors seemed more familiar with the term “carbon dioxide” than with carbon. The following conversation was with an eight-year-old.

> *[Have you heard of carbon?] I've heard of it, but I don't really know what it means. [What about carbon dioxide?] That's air that you breathe out, and it's also used in cars, exhaust. It comes out of the mufflers.* [080615-04]

As his mother said,

> *I think it may not be clear that the carbon [plants] take up is in the form of carbon dioxide.* [080615-04]

Some respondents also had trouble understanding the *Sunlight* misconception label, in part because they did not understand the significance of “green” (which was explained only at the end of the text). The issue with the *Water* label was that it did not specifically link the release of oxygen to the sugar-making process.

> *The connection isn't real clear. I mean, it does, but it's not obvious from the sign.* [080615-04]

> ***Central Plaza* labels**

When the floor was dry or consistently moist, and the light was right, some visitors were able to make out text embedded in the central plaza floor. However, most visitors could not read all four at once. Because so few visitors had read and understood the labels in the four exhibit sections, most respondents also had trouble making sense of these texts.

For instance, when asked about the text, "Leaves use sunlight to split water into its basic elements,” respondents said things like,

> *That one could be a little more user-, reader-friendly, I believe. ’Cause when you say leaves split the water, for kids sometimes it's hard to interpret what that means. What does it mean by split the water, does it actually just split the water?* [080614-01]

> *How does it do it? What are the basic elements it needs to create energy? Those are the questions I guess I'm having.* [080614-02]

Introducing the term “oxygen” helped clarify the meaning for these visitors.

Asked about "Leaves take what they need from the air," one respondent thought the label was talking about,

> *Like the nutrients and things that they need to grow, right? I studied it in school before, but you know, as an adult it goes away.* [080614-01]

Again, introducing the term “carbon dioxide” helped clarify this text.

The two other texts in the section – "When sunlight, air, and water meet within a leaf, sugar happens" and "Leaves capture energy from the sun" – made more sense to most respondents. However, respondents said they wanted more from this part of *Sugar from the Sun*.

> *I think I'd like more, like, something to have that would give me more explanation of the four components and how they work together. 'Cause I would have liked to maybe explain that more to my nephews. They're very inquisitive, and it's sort of nice to sort of work with them in answering questions. But it would be nice as an adult coming through there with a young person to be able to have some information about what the flow is and the connection between the four sections.* [080322-04]

> *I guess I get why [the text] has to be short, because it's in big lettering and it's on the ground. But none of these really have any explanation to them. It just says what happens, and it doesn't really give any insight into the process. I guess that's kind of where I'm kind of left, like wondering, what's happening here.* [080614-02, Respondent 1]

Some respondents also had issues with the arrangement of the text, in a circle on the floor.

> *[I would be OK with this] if presented in an orderly way. I'm a very linear. It's not the modish way.* [080614-03]

Plant labels

During the formative evaluation, researchers discovered how important plant identification labels are to most visitors – when they were left out of the first iteration of the prototype, there were many complaints (Gyllenhaal et al., 2005). Similarly, most adults and older children consulted plant labels as they walked through the exhibition, and they said they appreciated them.

> *I liked that there's signage. There are signs that say, for those of us who go past and say, 'What's that?' It's nice to see all the signs with the actual name, the botanical name, and the country of origin.* [080325-03]

> *I like the way that there are these signs, so that people can remember things about plants.* [080504-02]

These labels seem to be fulfilling their purpose.

Visitor Understanding of the Overall Exhibition

This section examines how visitors were integrating their experiences with the plants, immersive environments, and interpretive signage into an overall understanding of *Sugar from the Sun*.

Name of the Exhibition

Many, but not all, visitors recalled that the name of the exhibition was *Sugar from the Sun*. When respondents knew the name, it often communicated key parts of the overall message. It got visitors thinking about two of the four components of making sugar – the source of energy and

the final product. Even when they just knew the word sugar was part of the name, visitors had something important to work with.

> *I know it's the sugar exhibit. I imagine, although we didn't read any of the stuff, that it's about how sugar is used in plants, and its role, and how it makes the fruits. [080407-03]*

However, during data collection some Conservatory signage, maps, self-guided materials, and teacher preparation packets still referred to the exhibition area as the *Sweet House*. As a result, some visitors either called the area by its old name or invented a hybrid of old and new. Even that could be a good starting point.

> *Somebody told us about the Sugar House, and I thought it would be kind of fun to see all those, the fruit plants, and everything.…I didn't realize this when we were coming here, but it turned into a photosynthesis exhibit that we didn't know about....I kind of like the science side of it*. [080322-03]

The old name did not seem as effective at communicating what the new exhibition was about.

> *They named it the Sweet Room, which was for all the children, and people in general. What's neat about it, they're going to read [and] find out what's going on here, you know. It's going to pique their imagination, you know. So I love that, I love that. And just the name. Because I myself wondered, "Oh, the Sweet Room, I don't see any candy, you know!" But the plants, you know, the oranges, the pineapples, and you said some will grow bananas? That'll be something to see! I would like to see that!* [080320-04]

When visitors did not know the name of the exhibition, they were often at a loss to explain its purpose.

> *Not really sure what the room is called. It looks mostly like trees to me. Not palm trees, but like a jungle.* [080320-09]

It seems important that all visitors jump-start their understanding by learning the exhibition's name, *Sugar from the Sun*.

Sections of the Exhibition

Recognizing and understanding the four sections of the exhibition also was a key step in visitors making sense of their *Sugar from the Sun* experience. Most exit interview respondents had noticed one or more of the Section Entrance labels, and hence they knew the names of one or more of the exhibit sections.

> *You've got sugar, water, integrated, and all that.* [080325-03]

> *Each room, in my mind, was really well defined. We knew we were in the* Water *area 'cause we were getting wet. I knew we were in the* Air *area, I did feel, I don't know if this*

was intentional, but I did feel air blowing on me. It's very clean smelling in there. [080322-03]

However, few respondents remembered all four sections of the exhibition. Most respondents left out one or two sections, usually because they had not visited all parts of the exhibition. In addition, some respondents added a section to the list – one which was not actually part of the exhibition. For instance, several respondents mentioned visiting a section about soil.

Mother (talked to her daughter): There were four areas. Remember, when we came in, there was a sign that talked about four different parts that a plant needs. And we said that there was air...
6 year old daughter: Air, water, soil,…and light! [080531-05]

As they pondered what the various sections were about, some respondents began to guess at the reasons they were included in the exhibition – about how they might be related to a larger theme. In many cases, this theme differed from the exhibition's goals.

I could see like, it's a wet room, pretty much water's spurting out everywhere. And I can see that those plants really need the water. [080320-09]

I think that things were kind of divided by climate some, to some extent. Like you had, I guess, all the sugar plants, you had the citrus and bananas and pineapples all in one area. You kind of had the ferns in another area. [080322-03]

I guess we walked through the water area first, and then air last. And, it kind of seems to be from the ground up, like from the roots to the leaves is kind of how we moved. But I would have had to think a little bit about that. [080322-03]

A few respondents did remember all four sections of the exhibition, but were still a bit confused about how to fit them together with their understanding of the exhibition.

What's a little confusing though is, like you've got air, sunlight and water as like the three parts and they make sugar, and yet they're all kind of like equally represented here. They lead to, like you go through these three things, and then you get to sugar. [But] it's like sugar is one of the four, which confuses me a little bit. [080427-01]

By trying to make sense of the sections of the exhibition, visitors began to understand what *Sugar from the Sun* was all about.

What the Exhibition Was About

Beginning with their understanding of the exhibition's name and major sections, visitors tried to make sense of the overall exhibition. Note that, although many respondents mentioned at least one or two components of the sugar making process, very few mentioned all three (air, water, and sunlight), plus the end product.

Perhaps based on the exhibition's name, some focused only on the role that sunlight plays in plant's manufacturing of sugar.

> *Simplifying it down, the sun is converted to sugar.* [080601-01]

> *How the plants, they transform the sunlight into sugar*. [080531-04]

Other respondents recalled that sugar represented energy for plants, but did not mention sunlight when summarizing the exhibition.

> *The process of making sugar. How plants get energy.* [080324-02]

> *[This room] was recently reworked to exhibit how sugar or energy is in plants. That was just my understanding of it.* [080320-06]

And a few respondents focused only on the sugar part of the theme, ignoring the other components mentioned in the exhibition.

> *I was thinking, because it talks about sugar, how sweet all the fruit is. That it's naturally made, and it's sweet. I thought of that.* [080325-02]

> *All the green labels talked about the sugar, and how the plants grow from the sugar. That's what I saw.* [12-year-old girl; 080320-04]

Other respondents remembered that water or air played an important role in making sugar (but did not mention both).

> *It tries to represent the fact that just having sunlight come in and water, and how the plants form sugar in different ways.* [080325-03]

> *Sugar – from what I understand, that's the exhibit. I think it's wonderful in the sense that it teaches you or tells you how air and all of the source of elements in the air come together to, I guess, make some sort of plant, or give life to plants and so on.…That's what I picked up so far.* [080320-07]

Finally, despite the exhibition's name, a few respondents articulated an understanding that did not mention sugar or sunlight at all.

> *[It's about] how plants grow, and what happens to them. And also the energy that plants need*. [080531-04]

> *I'd say that it was the processes of a plant's life. Not as much life cycle, but just that whole. energy cycle of plants. But that's only because I know a little bit about it.* [080322-03]

Of course, many adults and older children knew a "little bit about it." They had studied photosynthesis in school, and had knowledge – sometimes dimly remembered knowledge – to

bring to bear on the subject. Some of these respondents remembered the name for the sugar-making process. Some used the term “photosynthesis” with confidence, but others seemed a bit uncertain whether they remembered the correct term and process. Many of these respondents asked the researchers if photosynthesis was the theme of the exhibition, rather than told them.

> *Plants through the process of photosynthesis convert sunlight energy into sugars, right?* [080615-04]

> *That room over there, is that supposed to be teaching you about photosynthesis? But not using the word?* [080318-03]

> *I thought that exhibit was about the photosynthesis. Wasn't it about turning sun into plant food?* [080318-04]

> *We've got orange trees and banana trees.…Teach you about sunlight? Um, yeah, is it more about how plants produce food, and photosynthesis? Light and water and sugar and all that?...Am I on the right path?* [080407-02]

As also happened during the formative evaluation, a few respondents remembered the wrong term for the process.

> *I understand a little bit about the Krebs Cycle in biology, so I know that sugar comes from the sun, anyway. I saw pineapples, oranges, fruits, things like that. I think that it's a good theme.* [080320-06]

Although some of these respondents just assumed they had read the term “photosynthesis” in the exhibition, others realized they had not. Some of the latter respondents said they understood why the term “photosynthesis” did not appear in exhibit labels.

> *[My five-year-old son] was interested in the sugar part, and I think that's why it's effective, because you guys didn't use the word, "photosynthesis," which would have tuned him out immediately.* [080318-04]

> *[It's] too academic of a term for young kids, like beginning readers.* [080324-02]

Although most respondents were at least on the right track when discussing the exhibition’s theme, others had developed their own understanding of what the exhibition was about. Perhaps inspired by a common theme in elementary school science, some visitors noticed the various sections on air, water, and sunlight and then guessed that the exhibition’s theme was “things plants need,” but without much reference to *why* plants need them.

> *[The exhibition is about] what plants need to survive.* [6-year-old girl, 080531-05]

> *The elements that are needed to grow plants, and how it affects them. The sun and the water and that.* [080601-01]

Other respondents walked away thinking about the exhibition plant habitats.

> *My assumption is, that looking at it, what I got out of it, like from the air, the water section, that there are certain plants that need water, like more water, and water-based, and that there are those that survive in different type of area.* [080322-04]

Note that both of these themes were commonly expressed by respondents during the formative evaluation. Although the completed exhibition communicated its theme more effectively than the prototypes, there were still these lingering misinterpretations.

Finally, some respondents found their own meanings in the exhibition, some of which were related to the exhibition's goals, and some not. Some focused their understandings just on the plants rather than a more process-oriented theme.

> *To me it kind of feels like [the exhibit is about] fruit-bearing plants. That's probably how I'd describe it. Different fruit-bearing plants.* [080322-03]

> *Oh, gee, it's all about plants, and life, and how they grow, and all the different types. There's plants you can eat, and there's the palms. Oh, I don't know, then there's the flowers, the orchids. It's just a nice combination of many different things from nature.* [080322-04]

> *There's lots of orchids, and like tropical plants. It's really humid in there, so all the tropical plants can grow. And then I'd probably say you just have to see it.* [080324-01]

And some seemed to organize their understanding around concepts that were personally important to them.

> *[The exhibition] gives [children] an opportunity to see different fruits, and how they're grown in their natural state, as opposed to just going to the store and picking up a pineapple, they can see how the pineapple is actually grown. And how they change, like the grapefruit, the color right now is green, so how eventually it will change to the color they would see in the grocery store.* [080320-07]

> *The importance of air is what I get out of this. You get more pollutants in the air, you're not going to have this. And the rain forest is depleting on the plant in the first place. It's like that reminds me whenever I come here, too. I'm reminded of that, and what we can try to do to slow it down. Floating islands, start making land.* [a gardener who spends much time looking at orchids; 080324-01]

Finally, a few respondents admitted that, although they had picked up a bit of information from the labels, they had not figured out the exhibition's theme.

> *I did see the reference to energy, fruit and energy, and looking for the fruit. I really didn't get a sense of the educational purpose.* [080504-01]

Based on the range of visitors' incomplete understandings of the exhibition discussed above, the *Sugar from the Sun* exhibition has a long way to go before it will effectively communicate its theme and major messages. Talking with visitors, it was clear that those who had developed a more complete understanding of the *Sugar from the Sun* theme had usually done two or more of the following:

1. Visited more sections of the exhibition.
2. Read – and understood – more labels.
3. Actively engaged with the exhibition, doing things and talking with others in their group.
4. Spent more overall time in the exhibition.
5. Visited *Sugar from the Sun* more often.
6. Read the *Exhibit Guide* or other printed material about the exhibition.
7. Talked with program staff at a prototype Cart activity.
8. Started out with a more complete understanding of photosynthesis.

If the exhibition is going to communicate its theme and messages more effectively on its own, the first four items on the list must be realized by more visitor groups. Remediation of the exhibition has to encourage visitors to see more of the exhibition, revise the labels so they are easier to read and understand, get visitors more engaged with the exhibition (and with their companions), and, as a result of the first three goals, inspire them to spend more time overall in the exhibition. Presumably, if the four goals are achieved, visitors will be more apt to return. The final three items – the *Exhibit Guide*, programming, and prior knowledge, will be discussed later in this report.

Contributions of Programming and Printed Materials

The facilitated activities, *Exhibit Guide*, and scavenger hunts offered visitors opportunities for hands-on and interactive experiences and in-depth information related to *Sugar from the Sun*. Of these three components, the activities were most effective at furthering the project's goals.

Prototype Exploration Cart *activities*

When the prototype activities were set up on weekends, the researchers noted increases in the range of visitor engagements in the exhibition, the overall time spent by participating groups, and visitors' resulting understanding of the themes and messages of the exhibition. With facilitated activities in progress, *Sugar from the Sun* was much more effective; the activities seemed to replace experiences that were missing, rather than just supplement an otherwise successful exhibition.

Respondents said they appreciated both the activities and the staff and volunteers who facilitated them.

> *I thought the solar [activity] was really interesting. And your interpreter did a nice job on this. Because they actually gave us information.* [080601-01]

> *The docent that was there, and showing the children the leaves, and what the pigments in the leaves do, and how it makes energy for the plant, was really kind of neat.* [080322-03]

The activities and their facilitators engaged visitors physically, socially, emotionally, and intellectually in ways that the exhibition did not. As a result, more visitors understood the facts and concepts explained in the exhibition labels.

> *[The staff] were explaining what the signs are saying, that all the plants around here produce sugar. And we didn't know that!* [080320-08]

Children who participated in the activities often increased their understanding significantly, building on what they had originally learned in school.

> *Some people say all plants are mostly green because of chlorophyll, but then I learned [from the activity] that all plants have chlorophyll, but they may not be green. And I thought that was interesting. [Where'd you find that out?] Over there, at one of the tables. Where I looked at through the microscope. When I looked through the microscope, I saw little holes in the leaves. They told me it's where the air goes in and out. The carbon dioxide goes in, and the oxygen comes out. [They] turn the carbon dioxide into sugar. They use the sun and water, and then they turn the carbon dioxide into sugar, and then they release the oxygen. [I learned that] partly in school, a lot in here, a lot in here, though I got reminded here. It's been awhile since school told me that.* [Fifth-grader, 080320-09]

It was also interesting to hear how often visitors asked questions that went beyond the subject of the activity and exhibition. Many visitors had a range of questions about the Conservatory, individual plants in the displays, and the plants they encountered in their home environments. They often took the opportunity ask these of program staff, maintenance staff, and sometimes even the researchers. It seems that there is an unmet need that could be filled through existing and future programming.

Although it is doubtful that the exhibition can be staffed continuously during open hours, it might be possible to redevelop some Cart activities as unfacilitated exhibit experiences. As the team considers ways to increase the effectiveness on the *Central Plaza*, they should consider adding an activity space that incorporates elements developed for the *Exploration Carts*.

Exhibit Guide

The *Exhibit Guide* was available at several places in the Conservatory, and we often noticed that visitors carried copies in their hands or pockets. However, researchers rarely observed visitors reading the *Guide* within the exhibition. More typically, visitors either (a) briefly looked through the *Guide* near the Conservatory entrance, right after they picked it up, or (b) had read it or shared it with their children often at home, and then remembered and applied what they had learned during a subsequent visit to *Sugar from the Sun*.

> *6-year-old boy: [It's] about how sunlight becomes sugar, how plants make sunlight into sugar.*
> *His mother: We talked about it when we got the [*Exhibit Guide*] map, because that was what it was about. We've talked about it at home before, so he knows.* [080318-03]

> *We did read the pamphlet, well I read that to them [at home]. So that was helpful to just kind of give them more information....It's like a trifold pamphlet,* Sugar from the Sun*, it has a few paragraphs that explain sugar and the air and the water, and how it works through the plants.* [080320-07]

A major problem with the *Guide* was that the cover did not specify its purpose, or where it was intended to be used. Visitors, when they discovered it did not include a map of the whole Conservatory, they often put it aside for later use. When we asked visitors to look at it closely, they were often surprised at the information and resources it contained.

> *I thought it was something you would take away. The map [of the exhibition] kind of surprised me. 'Cause it seemed to me more explanatory. Like you can take it away and read it later, or you can look at it when you're in there if you want more information. It didn't seem much like there's a map inside. There's nothing that tells me there's a map inside. It looks more like an explanatory brochure, not a map type brochure.* [080427-01]

When visitors did read the *Guide* within the exhibition, it helped them make more sense of what they were seeing.

> *I think it's pretty good. As someone that doesn't have a strong science background, it helps me understand more what they're trying to teach. Because, I think it's potentially confusing….I just think the whole sugar from the sun thing is just kind of abstract. And this makes it more real.* [080427-01]

However, the *Guide's* potential effectiveness was rarely achieved. The formative evaluation of the prototype *Universal Guide* also found that the cover played a critical role both in helping visitors decide whether to pick up the *Guide* as they entered the Conservatory and in setting their expectations for its use. The report recommended that the cover be designed to help visitors recognize what kind of experience they could expect from the *Guide*, so they could make an informed choice about whether to pick it up and what to do with it (Gyllenhaal & Cheng, 2006). If funds become available to redevelop the *Exhibit Guide*, these recommendations should be taken into account.

Scavenger Hunts

Although the *Hunting for History* scavenger hunt sheet was developed for a different project (the Conservatory's 100th birthday celebration), it turned out to be one of the most engaging experiences available to young visitors in *Sugar from the Sun*.

> *I know the boys are having a great time with those little papers that they have. And they're finding the different palms, and the different plants. They like that.* [080322-04]

[We were] just looking for things for the scavenger hunt. But, I like going through, and walking through all the rooms, and just looking at all the plants. Seeing how they grow, like in the temperature that they grow in. [080320-09]

The scavenger hunt seemed very effective at getting children and their family or school groups looking at many types of plants as they searched for the types specified on the scavenger hunt sheet. It is also worth noting that, because it was a one-sided, unfolded sheet, it was obvious immediately what this handout was, and how to use it. That lesson might be applied to other types of handouts, as well.

It would be interesting to see if the project team could develop a scavenger hunt sheet specifically for *Sugar from the Sun*. The challenge would be to effectively communicate the messages embedded in the design of the exhibition, rather than just the names of individual plants.

What Visitors Took Away from their Experiences

As noted earlier in this report, visitors came to the Conservatory seeking many things. Respondents said they found most of them in *Sugar from the Sun*. Major outcomes for visitors included achieving their own affective, cognitive, and behavioral goals:

- They enjoyed the beauty of the plants and environment.
- They found a place where they could relax and rejuvenate.
- They learned the names and growth habits of interesting plants.
- They kept their children busy exploring interesting environments (sometimes together, sometimes barely keeping up).
- They socialized with family and friends.
- They had memorable experiences they could draw on in times of need (and sometimes preserved them with photographs and videos).
- They made art, and they appreciated the artistic creations that the Conservatory provided in *Sugar from the Sun*.

That said, the Conservatory and its funders had additional goals for *Sugar from the Sun*, which many visitors termed "educational" once they realized what was going on. The project-goal related outcomes for visitors varied widely, depending on what they brought with them and what they were able to do within the exhibition. This section examines cognitive outcomes within the context of a knowledge hierarchy developed during front-end and formative evaluations (as discussed in detail in Appendix A.) The following hierarchy is about visitors' understanding of the "how" of photosynthesis, and the basic hierarchy is fleshed out with findings from the summative evaluation.

Level Zero: ***"Don't know and don't care."*** *Visitors at this level often have not thought much about plants making sugar and have not developed any particular interest in it.*

Not surprisingly, many preschoolers were on this level. When caregivers were able to slow their children down and engage them with the idea that plants make sugar, at least four- and five-year-olds could move up a level or two, wondering about the topic or developing a beginning, if incomplete, understanding of what was going on. However, many parents had trouble slowing their children down, except in the *Sugar* section or to play in the mist and water. More effective *Engagement Cue* labels and the addition of unfacilitated hands-on and interactive components would benefit families with young visitors.

Researchers also talked with adults who started on this level, either because they had attended a school with no science program or because they had forgotten whatever they had learned in school science. Even the most basic idea that sugar was created was something of a surprise to these adults.

> *It kind of amazed me, because I didn't know that sugar was made. I know that from some plants, sugar can be made. But from other [plants], that I didn't know.* [080615-02]

This respondent moved up a level or two because she had participated in a prototyped Cart activity. Remediating the exhibition could make it more effective for all Level Zero visitors.

Level One: ***"Don't know, but I was wondering."*** *These visitors have formed questions about the topic in their minds, but they have not yet developed answers to their questions*.

Few respondents were at this level before they entered the exhibition. However, some Level Zero visitors moved through this level and beyond as they participated in programming or talked about the exhibition with their caregivers or companions.

Level Two: ***Incomplete and/or incorrect understanding: Know only "what plants need" or believe "plants get their food from the soil."*** *These visitors are interested enough in the topic that they have formed some understanding of it, but their ideas are unsophisticated, largely incomplete, and sometimes incorrect in important ways.*

As indicated in the section on What the Exhibition Was About, most respondents were at this level relative to the big idea in the exhibition. They showed a wide range of partial and alternative understandings of the sugar-making process. Although this may be an appropriate level of understanding for younger preschool children, a remediated exhibition should be able to move most visitors closer to Level Three.

Level Three: ***Basic understanding: Plants have a process by which they use sun, water, and air to produce sugar.*** *These visitors had a fairly accurate basic understanding of the topic, although they were fuzzy or sometimes incorrect on the details*.

Although program staff sometimes helped visitors move from a Level Two to Level Three understanding, most visitors who were at Level Three had entered the exhibition with a basic understanding of photosynthesis. For many adults, teens, and older elementary students, the information about sugar and the components of the sugar-making process was something they had heard about before, usually in school. By combining their prior knowledge with clues in the exhibition, these respondents were able to figure out the main idea. These visitors often viewed the exhibition as a pleasant reminder of an interesting idea from their past.

> *I studied a lot of biology classes….[Being reminded of the process] was nice. It was refreshing. It's like an easier way of looking at things visually, seeing how everything was working together, pulled together. It was nice.* [080324-02]

> *The things that were written, I already knew those. But it was nice how they combined it.* [080324-02]

It was unfortunate that these visitors could go no further with their understanding with just the exhibition, because the *Misconceptions* labels were impossible to read, and the *Guide* was rarely used in the exhibition.

Of course, some respondents recognized what was going on but did not enjoy their memories of school.

> *I thought about [photosynthesis]. I didn't really enjoy that part of high school, so I kind of try to block that out.* [080322-03]

For this visitor, the remediation goal should be to provide a more pleasant experience that supplements these unfortunate memories, at least to some extent. The researchers have seen this happen with an interactive exhibition about calculus (Gyllenhaal, 2006). It should be able to happen here, as well.

Level Four: ***Advanced understanding: Plants have a process, called "photosynthesis," by which they make sugar. The sun's energy drives the process, combining water and carbon dioxide to produce sugar and oxygen****. Visitors who came to their Sugar from the Sun experiences at this level sometimes had a particularly strong interest in plants, background in high school- or college-level biology courses, or direct experience working in science education or some aspect of science.*

Level Five: ***Sophisticated understanding: A more complete understanding of photosynthesis, including an accurate understanding of the chemical processes involved****. This level included visitors who had studied the photosynthesis extensively in school or have chosen a career related to the chemistry, biology, or ecology of life.*

Although these levels go beyond the goals of the exhibition, some visitors entered the exhibition with these levels of prior knowledge. Program staff sometimes helped Level Three visitors

approach higher levels as they answered their questions, and they sometimes filled in gaps in higher level visitors' understanding about specific plants and processes.

For these visitors, the goal for the remediation should be to make the exhibition more effective for all visitors, so that visitors with higher level understandings can better recognize and appreciate the Conservatory's efforts to present this subject to the public. The remediated exhibition should also help these visitors make stronger links between their prior knowledge and the exhibition by, for instance, making the *Misconception* labels easier to read and encouraging use of the *Exhibit Guide* during and after a visit.

CONCLUSIONS

Achieving the Project's Goals

The Findings section above discussed visitor experiences and the effectiveness of various aspects of the *Sugar from the Sun* project. In this section, the researchers step back and evaluate the ways and extent to which the project seemed to be achieving its goals during the four months of data collection. First, each of the five goals will be examined in turn (although in a slightly different order than they were originally stated). Then, the overall conclusions will be stated in reference to the project's big idea and the philosophy that the *Sugar from the Sun* team used as they developed the project.

> *Goal: Visitors will respond physically by pointing, touching, smelling, listening and looking up, down and all around.*

Visitors did respond physically to the *Sugar from the Sun* exhibition in all the ways mentioned in this goal. Of course, many visitors responded similarly to other rooms in the Conservatory; it can be said that *Sugar from the Sun* is well integrated into the overall visitor experience. However, visitors' physical engagement with the exhibition was not as effective as it could have been in terms of the overall goals of the project. For instance, most visitors missed opportunities for physical engagements specifically related to the exhibition's messages because they could not easily read the *Engagement Cue* labels.

> *Goal: Visitors will engage in multi-sensory experiences that spark emotional responses: imagination, wonder, and playfulness; feelings of being transported to another place; awe and amazement; mystery and intrigue*.

Visitors indeed shared many multi-sensory experiences with others in their group, and their emotional responses to those experiences seemed strong and memorable. Many visitors who had lived in or visited tropical places said they felt transported back as their memories were stimulated by the exhibition; other visitors said they felt as if they were walking through places they had not actually visited, such as jungles or rainforests. However, most visitors' responses were to the plants and the overall environment in *Sugar from the Sun*, rather than to plants making sugar. Also, younger children found relatively few opportunities for playful engagement with the exhibition. When there were no facilitated activities, most children quickly moved on to the Children's Garden or other areas of the Conservatory.

> *Goal: Visitors will gain a heightened awareness and deeper appreciation for the beauty and variety of plants.*

This goal seemed to be achieved in many ways, particularly in the *Sugar* section (with all the fruits) and the *Air* section (with the many fragrant, flowering, and epiphytic plants). However, a few visitors expressed their perceptions that some sections of the exhibition seemed less diverse than other parts of the Conservatory.

Goal: Visitors will have social interactions and discussions that inspire them to ask questions about the role of plants in their lives and environment.

Visitors shared social interactions about the epiphytic and flowering plants in *Air*, the flowing water and mist in *Water*, and especially the fruits in *Sugar*. These often inspired discussions of the roles that fruits and tropical plants play (or once played) in their own lives. Older visitors and visitors who were immigrants from tropical countries often shared personal stories of the plants they had know in their youth, when plants had played a larger role in their lives. Some families also discussed the role that plants play in supporting human life, often inspired by their explorations in the *Sugar* section. Beyond that, there was not much discussion related to the big idea of the exhibition, except among families who read the labels with their children or who interacted with staff conducting programming within the exhibition.

Goal: Visitors will understand that inside their leaves, plants are using sunlight, air and water to make sugar.

This goal was partially achieved for many visitors but completely achieved for few. For many visitors, their take-home message was an incomplete understanding of the exhibition's big idea: For instance, many talked about the things that plants need to survive and grow (like water, air, sunlight, and soil), rather than how "plants use sunlight energy to make sugar energy from water and air."

Most, but not all, of the project's five goals were achieved for most visitors. However, the goal related to visitors' understanding of the big idea of the exhibition was only partially achieved for most visitors. As stated at the beginning of this report, the big idea that guided exhibit and program development was,

Through an amazing and complex process hidden within their leaves, plants use sunlight energy to make sugar energy from water and air.

The extent to which visitors were thinking along those lines depended on their prior knowledge, the amount of time they devoted to trying to read the labels, and the people talked with in the exhibition. (If they talked to programming staff, or if a member of their group figured out what they exhibition was about, visitors were much more likely to understand the key ideas in the exhibition.)

Keep in mind that the project team set limits on how they could achieve the project goals and communicate with visitors about the big idea – they wanted to do so within the context of a naturalistic, immersive conservatory experience. The team was trying to communicate a vision – a feeling for the plant world – that combined scientific understanding with an aesthetic and emotional connection with plants and their place in the world. The team members themselves had achieved this level of understanding and connection through years of first-hand experience and study of plants. However, the team's tools for passing this vision on to visitors where limited by the need to preserve an immersive conservatory experience (as opposed to a classroom or science center experience). And their plan for meeting the project's goals was thwarted when many of the labels proved illegible.

Also, with the possible exception of the fruiting plants in the *Sugar* section, the *Sugar from the Sun* exhibition was less successful at getting children deeply engaged with the ideas included in the exhibition. Again, part of the problem was the illegible labels. Perhaps parents could have made effective use of the *Engagement Cues* if they had been able to read them. However, the researchers think back to the exhibit activities tested during the formative evaluation, and wonder if the results would have been different had some of these activities been incorporated into the final exhibition.

Finally, many adult visitors did not engage deeply with the ideas included in the exhibition, even when they were able to read the labels. This was in part because the ideas seemed so basic and simplified to many adults – more like something they had already learned in elementary school. The exhibition failed to challenge visitors who had already achieved a level three understanding of the exhibition's concepts, or beyond, and these visitors adjusted their perceptions of the exhibition accordingly. Although many adults said they appreciated the Conservatory's efforts for young children, others said the exhibition was a waste of their time.

Is it possible to develop an immersive conservatory experience centered on scientific ideas? Perhaps that question can be answered with a qualified, "Yes." However, because of the issues of illegible labels, limited interactivity, and simplified interpretation, the *Sugar from the Sun* project has not provided an adequate test of whether conservatory visitors can be inspired to think deeply about scientific ideas without losing the immersive experience.

Summary of Issues Raised During the Summative Evaluation

In summary, these issues seemed to stand in the way of *Sugar from the Sun* meeting all its goals:

- The exhibition began with a whimper – there was nothing that communicated what made it special or unique, or that prepared visitors for what they were going to experience.

- The layout of the entrances and paths did not encourage full use of the space by visitors, and additional features, like signage, did not overcome this problem.

- There were relatively few features that encouraged children to really stop and engage with exhibition themes – *Sugar* is most effective, *Water* somewhat, *Air* a bit less, and *Sunlight* and *Central Plaza* least effective.

- Caregivers who were looking for ways to interpret what they were seeing for their children often had trouble finding signage that would help them do that (other than the plant identification labels).

- Almost all the signage was difficult to read, bordering on illegible.

- The label texts were often vague and poorly structured and thus hard to understand.

- The *Central Plaza* did not tie things together – in part because it was just reading, in part because the text was easy to miss and hard to read fully.

- Very few visitors looked at the brochure in the exhibition, although some used it before or after their visit to *Sugar from the Sun*.

- Because of its educational nature, simple theme, and brief text, many adults perceived the *Sugar from the Sun* to be for children, not for themselves.

RECOMMENDATIONS

Sugar from the Sun Exhibition

To increase the effectiveness of the exhibition at meeting its goals, the researchers recommend that the *Sugar from the Sun* team undertake the following improvements (as staff time and funding become available).

For the short term:

***Sugar from the Sun* identity**. Update the Conservatory signage, maps, brochures, website, and teacher materials to identify both the house and the exhibition as *Sugar from the Sun*.

Improve legibility. Make the existing signage easier to read. Keep the glass signs clean, experiment with reflective background materials and lighting, and do whatever else is possible to increase the legibility for the existing labels.

For the long term:

Redevelop the four entrances. The revised entrance signage should both orient visitors as they enter the exhibition and redirect visitors to see what they missed as they begin the leave the exhibition.

Rethink the design and technologies used in the glass labels. The redesign of these labels needs to address the following problems that are making the labels hard to read: Small font size (of the third level of text), blurring from refraction, heights (some too low), problems with back lighting (wattage too low, not aimed well, absorbed by soil). The *Addressing Misconception* labels (mounted in rocks) will require a different range of solutions than the *Engagement Cue* labels.

Rewrite the text for the *Section Entrance* labels. Although the current labels are concise, they are too vague and provide weak support to the big idea. The following suggestions should be tested during the writing process, critically reviewed, and then tested with visitors.

- **Use these brief texts to introduce the key idea for each section.** For, instance the new *Sunlight* label could say, "Leaves capture the energy of sunlight to make sugar."

- **Be specific**. Avoid broad generalities (like "Sugar is made" and "Air carries many things").

- **Support the big idea**. Avoid off-topic information like, "Sunlight takes thousands of years to be created."

Rewrite the text for the *Engagement Cue* labels. These labels are designed as concept labels, rather than as engagement cues.

- **Put the action first**. For instance, put "Feel the Air" first, so parents will read that to their children.

- **Add a line drawing of the action**. That way, younger children can do the action themselves without parent intervention (for times when their caregivers are busy elsewhere).

- **Use only two levels of text**. The action should replace the current first level (first line) of text. Combine the current first level and third level into a sentence that clearly spells out the concept related to the action.

- **Be specific**. Express the main idea in concrete terms (although it will sometimes be appropriate to harness visitors' imaginations). This specificity may require introducing some new terms. For instance, in the new "Feel the Air" label, use the term "carbon dioxide" in the second level of text (since many adults and children seem to be familiar with this term).

Rewrite the text for the *Addressing Misconception* labels: Although the *Air*, *Water*, and *Sugar* texts were moderately effective (when visitors can read them), they need some tweaking. The *Sunlight* label needs a major rewrite.

- **Be specific**. For instance, the *Water* label could read, "As plants use water to make sugar, they release the oxygen you breathe."

- **Use appropriate terminology**. Because respondents were more familiar with the term carbon dioxide, rewrite the *Air* label. For instance, it could say something like, "Carbon dioxide from air provides the basic building block for sugar. Soil provides nutrients used to make sugar into other chemicals for life."

- **Don't assume visitors know the significance of "green."** Even if green pigments were discussed in another label (which they were not), visitors may not have read it. The *Sunlight* label could be rewritten as, "To capture sunlight and make sugar, plants need a green pigment, called chlorophyll. In some leaves, the green is hidden by darker colors." Notice that this version uses a term that many adults and older children will recognize, but only in an aside at the end of a sentence.

Redevelop the *Central Plaza*. The redeveloped plaza should include at least three major components:

- **Interactive component**. Aimed at children and other active learners, this component should summarize the sugar-making process in a way that children can physically manipulate.

- **Graphical component**. Aimed at visual learners, this component should portray the sugar-making process with a diagram or illustration.

- **Textual explanation**. Aimed at visitors who learned about photosynthesis at school (but probably forgot much of what they learned), the goal is to make these visitors feel that this exhibition is for adults, as well as children. The component should describe the sugar-making process using terms and concepts that these visitors will recognize from their earlier studies, but then take them a step or two beyond what they once learned. For instance, this component might use the terms *photosynthesis*, *carbon dioxide*, *oxygen*, and *chloroplast*. It might link the sugar-making process to the larger world in unexpected ways by, for instance, talking about the impact of photosynthesis global warming.

For future exhibitions at Garfield Park Conservatory:

Effectively apply the findings from formative evaluation studies. Problems noted with the prototype versions of the exhibition were not adequately addressed during the final stages of exhibition development.

Test signage systems in advance. Physical prototypes should be tested in conservatory environments for a month or more to uncover unanticipated problems.

Include a professional label writer or editor in the exhibit development process. Writing effective labels is a skill that requires study, practice, and constant feedback (from critical reviews, editors, and visitors). There are skilled professionals in the Chicago area who will work on a contract basis.

Printed Materials

Develop a *Sugar from the Sun* scavenger hunt. This single-page scavenger hunt activity could focus young visitors' attention on the major sections and concepts of the *Sugar from the Sun* exhibition. It should be handed out free at the door and to tour groups (as the *History* scavenger hunt was handed out during data collection).

For folded handouts, make sure the cover clearly communicates the handout's purpose. It should be clear what the handout is for, and how it should be used (e.g., used in the Conservatory or read later).

Test prototype materials, and then apply the results. Issues with the current *Exhibit Guide* might have been avoided if the lessons from the formative evaluation of the *Universal Guide* had been applied.

Programming

Continue to develop activities that challenge all ages. This can include programs especially for preschoolers (on weekday mornings) as well as older children and adults (such as *Inside Every Leaf…*)

Develop additional formats where knowledgeable staff and volunteers can interact informally with casual visitors. Although much of the current programming focuses on younger visitors, adult visitors have many questions that are going unanswered. Perhaps a group of roving interpreters could fill this role (like roving park naturalists do in many national parks).

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APPENDIX A: KNOWLEDGE HIERARCHIES ABOUT PHOTOSYNTHESIS

Completing the formative evaluation of the *Universal Guide* (Gyllenhaal & Cheng, 2006) advanced the researchers' thinking on a number of issues that were also raised by the front-end literature review (Gyllenhaal, 2002), front-end evaluation (Garibay et al., 2004), and formative evaluation of the *Sugar from the Sun* exhibition (Gyllenhaal et al., 2005). This appendix puts those issues in a larger context by re-visiting the concept of knowledge hierarchies, first introduced to *Sugar from the Sun* project in the formative evaluation report (Garibay et al., 2004). Gyllenhaal & Cheng (2006) developed two knowledge hierarchies dealing with visitors' understanding of first the process of photosynthesis and then the importance of the process for all life on Earth. Understanding the dual roles of sugar is an important aspect of visitors' understanding of the importance of photosynthesis. Those hierarchies are spelled out below (with some editing).

Knowledge Hierarchy about the Process of Photosynthesis

This section describes the range of visitor understanding about photosynthesis using a knowledge hierarchy, adapted from the hierarchy first described in the front-end report (Garibay et al., 2004). A knowledge hierarchy technique (Perry, 1993) can describe the ways in which visitors think about and potentially understand the sorts of topics included in this study. A knowledge hierarchy presents a range of visitor understandings about a certain topic, based on the assumptions that (a) there is an internal knowledge structure inherent in a topic as presented in an educational experience, and (b) this hierarchy is located at the intersection of the developer's and the visitor's organization and understanding of the topic. Thus, a knowledge hierarchy is simply a description of the range of visitors' understandings about a topic within the context of a particular educational experience. It represents, in manageable form, virtually all visitors' understandings about that aspect of the topic. Knowledge hierarchies are a way of helping informal science institutions address the needs and interests of a greater proportion of their multiple audiences, and therefore are an important tool for analyzing and presenting the results of this study.

The structure of knowledge hierarchies tends to follow a certain pattern, covering a full range of how visitors think about a topic by increasing levels of sophistication (adapted from Perry, Garibay, & Gyllenhaal, 1998). Hierarchies usually begin at Level Zero (visitors who "don't know and don't care" about the topic), are anchored at Level Three (a *basic* understanding of the topic), and range up to Level Five or above, to account for the advanced levels of knowledge typical of visitors who bring professional knowledge and experience to the topic.

The following hierarchy is about visitors' understanding of the "how" of photosynthesis. It is adapted from a hierarchy included in the front-end report (Garibay et al., 2004).

Level Zero: **"Don't know and don't care."** Visitors at this level often have not thought much about plants making sugar and have not developed any particular interest in it. They sometimes can be motivated to become curious about the topic, but they have not thought about it much on their own. The youngest Conservatory visitors and some adults started at this level.

Level One: **"Don't know, but I was wondering."** These visitors have formed questions about the topic in their minds, but they have not yet developed answers to their questions. Some children and adults reached this level through exposure to the prototype exhibition or *Guide*.

Level Two: **Incomplete and/or incorrect understanding: Know only "what plants need" or believe "plants get their food from the soil."** These visitors are interested enough in the topic that they have formed some understanding of it, but their ideas are unsophisticated, largely incomplete, and sometimes incorrect in important ways. An incomplete understanding might involve knowing that plants need things like sun, water, and/or air, but not realizing that these components contribute to the production of sugar—or not realizing that it takes all three components to complete the process. This is an appropriate level of understanding for many preschool children, and if the *Guide* or exhibition helps move a preschooler from Level Zero to this level, it has accomplished something important. An incorrect Level-Two understanding might involve thinking of the *soil* as the ultimate source of plants' food. If the *Guide* or exhibition provides these visitors with a new way to think about how plants get their energy and building materials, then it will have accomplished something important, even if the older, incorrect view of plants has not been completed rooted out.

Level Three: **Basic understanding: Plants have a process by which they use sun, water, and air to produce sugar.** These visitors had a fairly accurate *basic* understanding of the topic, although they were fuzzy or sometimes incorrect on the details. Some children and adults reached this level at the Conservatory through experiences with the prototype exhibition or *Guide*. In other cases, visitors arrived at their *Sugar from the Sun* experience already at this level and felt they had been reminded of things they already knew. Some of these Level-Three visitors had studied photosynthesis in school and had once been at Level Four or above. However, many years after graduation, these visitors recalled only some of the knowledge that typified a higher-level understanding (e.g., they knew the word "photosynthesis," or they remembered that plants made oxygen, but did not link that to the production of sugar). Also, visitors sometimes misused what they remembered from school (e.g., one referred to the *production* of sugar as the "Krebs Cycle").

Level Four: **Advanced understanding: Plants have a process, called "photosynthesis," by which they make sugar. The sun's energy drives the process, combining water and carbon dioxide to produce sugar and oxygen**. Visitors who came to their *Sugar from the Sun* experiences at this level sometimes had a particularly strong interest in plants, background in high school- or college-level biology courses, or direct experience working in science education or some aspect of science. These visitors were often appreciative of the Conservatory's efforts to present this subject to the public (especially to children), and they sometimes expressed their appreciation at being reminded of things they had not been thinking about during their walks through the Conservatory. However, Level-Four

visitors were sometimes confused because some aspects of photosynthesis that they expected to see were not present in the *Guide* or exhibition. For instance, they often wondered why oxygen was not mentioned in the texts that they read.

Level Five: **Sophisticated understanding: A more complete understanding of photosynthesis, including an accurate understanding of the chemical processes involved**. This level included visitors who had studied the photosynthesis extensively in school or have chosen a career related to the chemistry, biology, or ecology of life. With their stronger backgrounds in physics and chemistry, these visitors were less intimidated by the more complex aspects of the process and related material cycles. Like Level-Four visitors, some of these respondents also wondered about aspects of the photosynthetic process that were not discussed in the *Guide* or exhibition, including carbon dioxide, oxygen, and chlorophyll. Level-Five visitors also appreciated the Conservatory's efforts, but they sometimes wondered why they seemed incomplete.

Knowledge Hierarchy about the Importance of Photosynthesis

Although the *Sugar from the Sun* prototype exhibition and *Guide* focused on the concept of *sugar as energy* for plants and other living things, a persistent subtheme throughout the project has been that sugar is also a material that can be stored or used to make things like leaves, stems, and flowers. Thinking of *sugar as energy* seemed to work well for many visitors, because it fit well with the folk understanding of energy, e.g., people can eat sugar for a quick burst of energy. It also fit well with the project's emphasis on sunlight as a component in making sugar. Visitors found it relatively easy to feel and think about the Sun as the ultimate source of the energy found in sugar. However, by *only* portraying sugar as energy, some claims made by the *Guide* and exhibition went unexplained. For example, how can all those plant parts be made from sugar, yet none of them taste sweet? Readers probably know the answer, but the *Guide* glossed over that point, leaving some visitors confused.

Thinking about *sugar as matter* can be a bit frightening for an informal science educator, because that comes really close to the steep and deadly slope called "biochemistry." There are many indications that younger (and some older) visitors had trouble with even the most basic idea of transformation of sugar into something else. For instance, when the *Universal Guide* (or prototype exhibit labels) said that a plant part was "made from sugar," some visitors started talking as if it was made *of* sugar—which did not make sense, because they knew that leaves, stems, and so forth did not taste sweet. Also, some respondents expressed skepticism because they did not think that plants (and animals) were made "completely" from sugar. Although *sugar as matter* concepts present some challenges for the team, we can also think of something visitors know about sugar that may serve as a starting point—eating too much sugar makes you fat. That's because people, like plants, can transform sugar into other kinds of stuff.

The following knowledge hierarchy explores the idea of putting both roles of sugar—matter and energy—on a more equal footing in the final versions of the *Universal Guide* and exhibition. In a sense, this hierarchy also is about the "why should I care?" aspect of photosynthesis. It is based

on data from both this study and the formative evaluation of the *Sugar from the Sun* exhibition (Gyllenhaal et al., 2005).

Level Zero: **"Don't know and don't care."** Visitors at this level often had not thought much about the topic of plants making sugar (photosynthesis) and had not developed any particular interest in it. It included many young children and some adults.

Level One: **"Don't know, but I was wondering."** These visitors had formed questions about the importance of plants making sugar, but had not yet found the answers. Most importantly, when these visitors discovered that the exhibition or *Guide* included information about how plants make sugar, they asked, "So what?" or, "Why should I care?"

Level Two: **Incomplete and/or incorrect understanding: "I know life would be impossible without plants, but I don't really know why."** Visitors on this level recognized that plants are important, and they sometimes had developed an explanation for why they were important. However, their ideas were unsophisticated, largely incomplete, and sometimes incorrect in important ways. For instance, some visitors expressed an anthropocentric view of the importance of photosynthesis – as in, "plants produce food for people" – neglecting the fact that plants, themselves, use the sugar they produce for their own energy and growth. Other visitors recognized that plants are important because they produce oxygen – a correct but incomplete understanding.

Level Three: **Basic understanding: The sugar produced by plants <u>both</u> provides energy and is the basic building block for life on Earth.** This version of a basic understanding gives equal emphasis to both *sugar as energy* and *sugar as matter*. Based on the prototype *Guide* or exhibition, some visitors approached this level, but few (if any) reached it using the prototype interpretive strategies. A clear statement of this idea could provide a useful perspective on the importance of plants even for visitors who placed high on the *Knowledge hierarchy about the process of photosynthesis*.

Level Four: **Advanced understanding: The sugar produced by plants is both the ultimate energy source for most life on Earth and the basic building block for the chemicals found in all green plants and for almost all animals.** This version of a Level Four understanding adds some qualifications that may seem nitpicking, but that represent a more complete and accurate understanding of the basic idea. Visitors on the level might know that some of the chemicals derived from sugar include complex carbohydrates, proteins, and fats.

Level Five: **Biochemical understanding: Plants use nutrients from the soil to transform sugar into the biochemicals needed for life. Most living things get their energy by recombining oxygen with sugar—breaking it back down in water and carbon dioxide**. This expression of a Level Five understanding gets at details of the chemistry of photosynthesis and identifies the proper role for soil (as a

source for mineral nutrients rather than “food”). Visitors on this level probably would include science and education professionals who had studied photosynthesis extensively in school or had chosen a career related to plant biology or biochemistry. They would need to reconcile their advanced understanding with what they saw in the exhibition.

Level Six: **Systemic understanding: A more complete understanding of how the cycling of materials (e.g., carbon, oxygen, and nutrients) relates to photosynthesis**. This takes a more holistic or ecological view of photosynthesis, linking it to critical Earth processes like the carbon cycle. This view might be held by professionals and advanced students in ecology and biogeochemistry. Again, they would need to reconcile their advanced understanding with what they saw in the exhibition.

APPENDIX B: PHOTOGRAPHS OF THE EXHIBITION AND PROGRAMMING

The following photographs were taken by Eric D. Gyllenhaal, March through June, 2008.

Figure B-1. Overview of the *Sugar from the Sun* exhibition entrance, viewed from the *Palm House*. The entrance to the *Air* section is on the left.

Figure B-2. Overview of the *Water* (left) and *Air* (right) sections, viewed from the *Central Plaza*.

Figure B-3. Overview of the *Sugar* (left) and *Sunlight* (right) sections, viewed from the *Central Plaza*.

Figure B-4. Entrance to *Air* section from the Palm House.

Figure B-5. Pathway through the *Air* section.

Figure B-6. Vanilla orchid vines hanging around a side platform in the *Air* section.

Figure B-7. Viewing platform in the *Air* section.

Figure B-8. Entrance to the *Water* section from the *Palm House* on a clear day

Figure B-9. Entrance to *Water* on a rainy day, when the vents were closed.

Figure B-10. Rock and waterfalls in the *Water* section.

Figure B-11. Mangrove pool in the *Water* section.

Figure B-12. Overview of the *Sunlight* section, viewed from the *Children's Garden*. Note trellis over pathway and dark-pigmented leaves on either side of path.

Figure B-13. Closer view of iron-work trellis and hanging plants in *Sunlight*.

Figure B-14. Cross path from *Sugar* to *Sunlight*.

Figure B-15. Entrance to *Sugar* section, from the *Children's Garden*.

Figure B-16. Side path through banana plantation in *Sugar* section.

Figure B-17. Fruiting banana plant in *Sugar* section.

Figure B-18. Pineapple plants in *Sugar* section.

Figure B-19. *Central Plaza*, where four leaf-shaped *Synthesis* labels were embedded in the concrete floor.

Figure B-20. Sugar *Synthesis* label in the *Central Plaza* floor. The text reads, “When sunlight, air and water meet inside a leaf, sugar happens.”

Figure B-21. Artificial fruits and leaves included as part of the concrete floor.

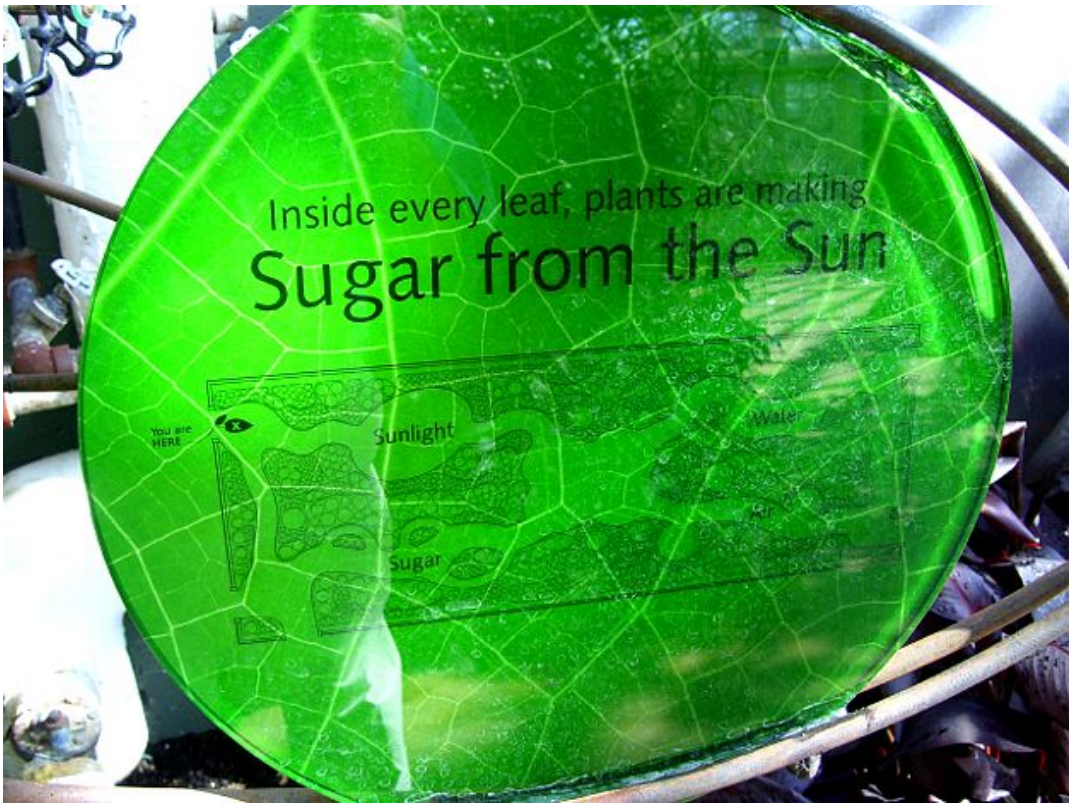

Figure B-22. *Exhibit Entrance/Orientation* label, located at the entrance to each section. Note "You are HERE" in upper left corner of map (for the *Sunlight* section). Fig. B-4 shows the label in context.

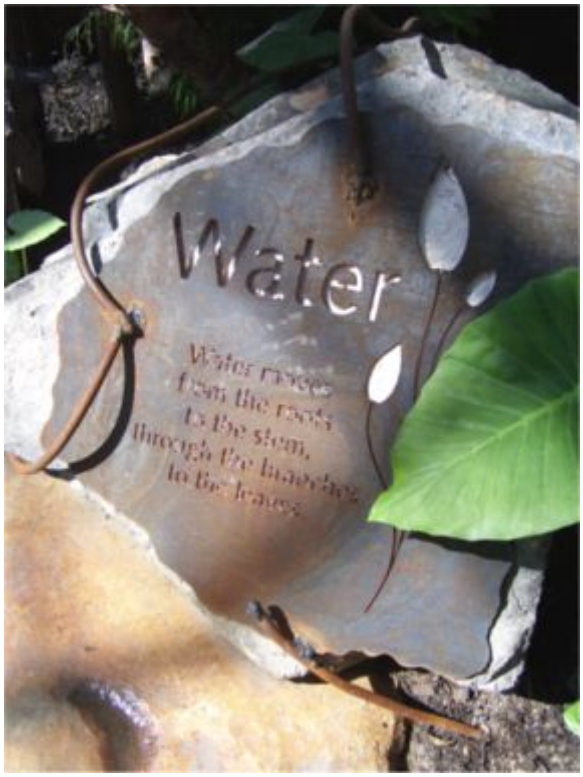

Figure B-23. *Section Entrance* label at entrance to *Water* section.

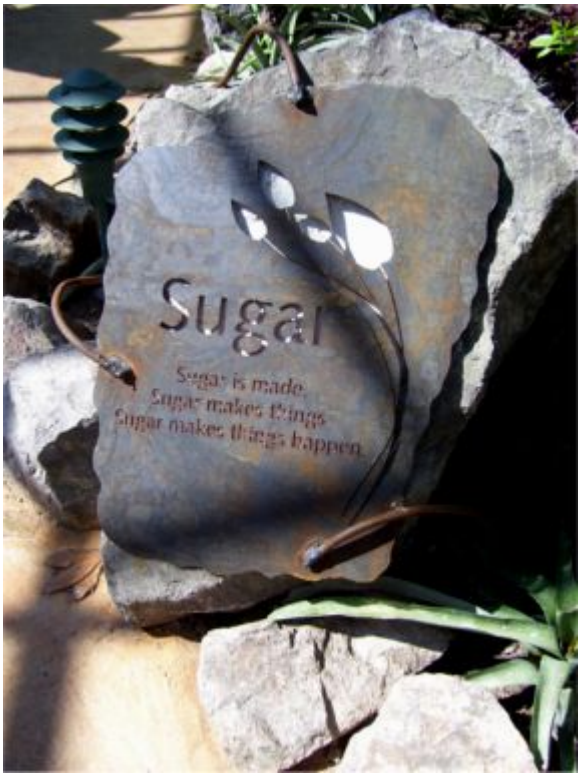

Figure B-24. *Section Entrance* label at entrance to *Sugar* section.

Figure B-25. *Engagement Cue* label, bronze with larger raised and smaller etched text, within the *Water* section. The plaque-like label is embedded within a rock beside the waterfall.

Figure B-26. *Engagement Cue* label, circular glass label iron rebar support, in *Air*.

Figure B-27. Small lamp used to backlight the *Engagement Cue* glass labels.

Figure B-28. *Addressing Misconception* label, backlit circular glass with a solid rock support.

Figure B-29. Example of a *Plant Identification* label.

Figure B-30. *Sugar from the Sun* brochure, showing folded brochure (in center) and front and back sides (above and below, respectively). Note photosynthesis equation and exhibition map on front side.

Figure B-31. New exhibition rack card, showing both sides.

Figure B-32. *Hunting for History* scavenger hunt sheet with stickers.

Figure B-33. Front desk brochure rack, with exhibit brochure (center) and scavenger hunt.

Figure B-34. New rack card, displayed at Conservatory entrance.

Figure B-35. Children's Garden brochure rack, with old rack card and programming brochure.

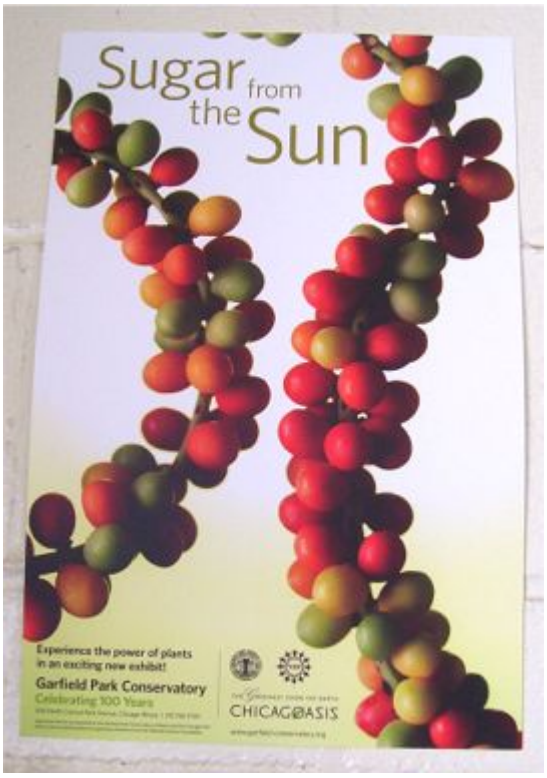

Figure B-36. Poster for *Sugar from the Sun* opening.

Figure B-37. *Sugar from the Sun* signage mounted over the main Conservatory entrance.

Figure B-38. Conservatory map in main lobby (refers to “Sweet House”).

Figure B-39. Directional signage located just inside the entrance to the *Palm House*.

Figure B-40. Prototype *Explore the Power of the Sun* cart activity, set up in *Sugar from the Sun.*

Figure B-41. Closer view of solar powered toys and magnifier at *Explore the Power of the Sun* cart activity.

Figure B-42. Prototype *Inside Every Leaf…* cart activity (with microscopes and light table), set up in *Sugar from the Sun*.

Figure B-43. Prototype *Water* and *Air* cart activities for preschoolers, set up in *Sugar from the Sun*.

APPENDIX C: TEXTS FOR INTERPRETIVE LABELS

Sugar from the Sun: Exhibit Interpretive Messages

Air and Water Sections

AIR	WATER
A1 Exhibit Entrance / Orientation Map	**B1** Exhibit Entrance / Orientation Map
Inside every leaf, plants are making **Sugar from the Sun**	Inside every leaf, plants are making **Sugar from the Sun**
A2 Section Entrance Message	**B2** Section Entrance Message
Air Air carries many things in many forms to many places.	**Water** Water moves from the roots to the stem, through the branches to the leaves.
A3 Engagement Cue 1	**B3** Engagement Cue 1
Air is moving Look for blowing leaves From moving air, every leaf is taking material it needs to build sugar.	**Water is moving** Feel the flowing water. Plants are moving water through every leaf around you.
A4 Engagement Cue 2	**B4** Engagement Cue 2
Air takes up space Notice the air around you Inside the space of each leaf, plants are using a tiny part of air in the big job of making sugar.	**Water is changing** Follow the water as it flows, drips, and pools. Inside every leaf, plants are changing water so that it can be used to make sugar.
A5 Engagement Cue 3	**B5** Engagement Cue 3
Air has substance Feel the air touching you Every part of every plant around you was built from material in the air.	**Water is all around you** Find water everywhere. Right now, inside every leaf, plants are using a small part of water in the big job of making sugar.
A6 Addressing Misconception Message	**B6** Addressing Misconception Message
What about the soil? Although plants do get nutrients from the soil, they take carbon, the basic building block for growth, from the air.	**Breathing water?** As plants change water within their leaves, they release a large part of it into the air as the oxygen you breathe.
A7 Central Plaza / Syntheis Message	**B7** Central Plaza / Syntheis Message
Leaves take what they need from the air.	**Leaves use sunlight to split water into its basic elements.**

Sugar from the Sun: Exhibit Interpretive Messages

Sunlight and Sugar Sections

SUNLIGHT

A1 Exhibit Entrance / Orientation Map

Inside every leaf, plants are making
Sugar from the Sun

A2 Section Entrance Message

Sunlight

Sunlight takes thousands of years to be created, about eight minutes to reach Earth and a fraction of a second to be captured and used by plants.

A3 Engagement Cue 1

Sunlight is being captured
Notice light in the leaves above.

Right now, every leaf around you is capturing sunlight.

A4 Engagement Cue 2

Sunlight is making things happen
Look closely at any leaf.

Right now, inside that leaf, sunlight is changing small parts of air and water into sugar.

A5 Engagement Cue 3

Sunlight is energy
Look all around you.

Inside every leaf, plants are using energy from the sun to make sugar.

A6 Addressing Misconception Message

Where is the green?

Many leaves are missing some green or hiding it behind darker colors, but plants need green color to capture sunlight and make sugar.

A7 Central Plaza / Syntheis Message

Leaves capture energy from the sun.

SUGAR

B1 Exhibit Entrance / Orientation Map

Inside every leaf, plants are making
Sugar from the Sun

B2 Section Entrance Message

Sugar

Sugar is made.
Sugar makes things.
Sugar makes things happen.

B3 Engagement Cue 1

Sugar is everywhere
Notice stems, roots, flowers & fruits.

Every leaf around you is making sugar and sending it to other parts of the plant.

B4 Engagement Cue 2

Sugar is energy
Look for bananas, papayas, and oranges ripening around you.

Just like you, plants are using energy from sugar to grow and change.

B5 Engagement Cue 3

Sugar is building plants
Look for small banana plants.
Look for big banana plants.

Right now, all around you, plants are using the sugar made in their leaves to build larger and stronger bodies.

B6 Addressing Misconception Message

If all leaves make sugar, why aren't all leaves sweet?

All green leaves make sugar, but not all forms of sugar taste sweet.

B7 Central Plaza / Syntheis Message

When sunlight, air, and water meet inside a leaf, sugar happens.

APPENDIX D: TOPICAL FRAMEWORK

Topical Framework for the
Summative Evaluation
of the Garfield Park Conservatory
***Sugar from the Sun* Exhibition**

Selinda Research Associates, Inc.
March 24, 2008

A topical framework is a list of issues or topics we will explore during the summative evaluation. It is phrased as a series of questions we will try to answer by observing and talking with visitors as they explore the *Sugar from the Sun* exhibition and associated programming. (Note: These are questions we will *answer* during the study, not the questions we will ask visitors.)

Research Question

As visitors engage with the immersive environments and interpretive messages in the Sugar from the Sun *exhibition, in what ways and to what extent do their experiences contribute to achieving the project's goals* (listed at the end of the framework)?

Topical Framework Questions

Overall Description of the Exhibition and Associated Programs

How was the exhibition organized, and what did it look/sound/feel like?

- What did the exhibition look/sound like as visitors approached it?
- What were the major areas of the exhibition, how were they delineated, and what individual exhibits did they include? What sorts of plantings, pathways, rock and iron work, water, graphics, and label texts were included in each section of the exhibition, and how did they interrelate?

How were the Demonstration Cart and Children's Garden programming organized, and what were the demonstrations and activities like?

- How were the individual demonstrations and activities organized? What materials were available, and how did staff facilitators use them? How long did they take to complete, and what happened during an activity?
- Who were the facilitators, and what were their backgrounds and training?
- How often/long were the activities scheduled each week? Where were they located within the exhibitions?
- What kinds of specimens, equipment, expendables, and graphics were part of the demonstrations and activities?
- Which exhibit(s) did the demonstrations and activities relate to, and how were they referenced?

What were the Exhibit *and* Universal Guides *like, and how were they distributed?*

How were the *Guides* designed? What topics did they include, and how were these topics explained and illustrated?

Where, when, and how were the *Guides* made available to visitors?

Visitor Engagement

In what ways and to what extent were visitors engaged within the Sugar from the Sun *exhibition?*

What sorts of physical, social, intellectual, and emotional engagements did we see, and how did these compare with the intended engagements?

How did visitors engage physically?

How did visitors move through (navigate) the exhibition? Which sections, if any, did they visit more than once, linger in, or skip entirely? How did visitors orient themselves within the exhibition – how did they decide where to go next? To what extent did they use the signs at the entrances, map in the *Exhibit Guide*, and/or visual cues within the exhibition? What other factors seemed to influence visitors' movement through the exhibition? To what extent did visitors leave the exhibition and then return later that same say?

To what extent was there walking (slowly or quickly), standing, sitting, looking, reading, pointing, touching, manipulating, and other forms of physical engagement? In what ways and to what extent did visitors engage with various components of the exhibition (e.g., plantings, objects, sound, water, lighting, and graphics/labels)?

Which texts did visitors read, and at what point in their engagement with each exhibit section did they read them?

How did visitors engage emotionally?

To what extent was there interest, surprise, satisfaction, excitement, passion, enjoyment, frustration, confusion, intimidation, and other forms of emotional engagement? In what ways and to what extent did various aspects of the exhibition and programming contribute to visitors' emotional engagement?

How did visitors engage intellectually?

In what ways did visitors think about, process, make connections, and make meaning of their experiences? To what extent were visitors being thoughtful and reflective? In what ways did the different aspects of the exhibition and programming contribute to visitors' intellectual engagements?

How did visitors engage socially?

When and with whom did visitors engage? In what ways and to what extent did social engagements facilitate and contribute to visitors' learning and enjoyment? To what extent were there teaching/learning interactions? To what extent were there appropriate directing attention, asking questions, explaining phenomena, and other ways of guiding the learning process? Who was leading these teaching/learning interactions?

In what ways, and to what extent, did visitors interact with the GPC facilitators, and what role did these play in visitors' overall experiences? How sophisticated were their

dialogues? How easily did facilitators adapt to the interests and abilities of their audiences?

Design of Exhibits and Programming

How effective were the designs of the exhibits and programs?

What did visitors engage with *first* – the exhibition, *Guides*, or programming? What seemed to draw them into the exhibition and launch them into their engagement? Did the design encourage visitors to spend time in every section of the exhibition? What entry or launch points to the exhibition were most effective, and for whom?

In what ways and to what extent did the various exhibit components and program elements enhance visitors' understanding of the messages? What did visitors say was clear/unclear about the exhibits/programs? Did any components detract from the message or cause visitors to become confused or frustrated?

To what extent was physical accessibility an issue (e.g., for older and disabled visitors)?

What aspects of the exhibits and programs were most appreciated by members of the various target audiences and by others in their groups? Which aspects were least appreciated, or least useful to them?

What were visitors' perceptions and feelings about their overall exhibit experience?

What did the exhibition *feel* like to visitors? For instance, did it feel like a teaching room, an ornamental room, a children's space, just another part of the Conservatory, or some combination of places?

In what ways and to what extent did visitors see this exhibition as different from the other rooms in the Conservatory, or from other plant displays they had visited at other conservatories and public gardens? To what extent did visitors respond differently to this space, compared with other displays of living plants? To what extent did visitors realize that this space was designed with an educational purpose at its core?

Did the interpretation work in tandem with the environment in a seamless and natural way – did visitors respond *both* emotionally and intellectually to the space? In what ways and to what extent did visitors merge their emotional and intellectual responses to the topic of the exhibition and, if so, at what point did those responses link up? Did visitors respond differently to this exhibition than most people remember responding to the classroom teaching of photosynthesis?

Did visitors have experiences that went beyond or were outside of the stated goals of the exhibition? If so, in what ways and where did these experiences take place? (For instance, were they responding to the rock and iron work, the plants as individual entities, horticultural practices, and if so, what exactly were those responses?)

Visitor Interest and Knowledge

What were visitors' interests in and attitudes toward the content of the exhibition and programs?

How did visitors describe their interests in and attitudes toward the plant processes described in the exhibition? What piqued visitors' curiosity and stimulated their interests? To what extent and in what ways did the plantings, interpretation, and programs get visitors more excited about these topics and interested in learning more about them?

How did the exhibits and programs support, contribute to, and influence visitors' interests in plant processes – or did the exhibits and programs fail to support or dampen visitors'

interest and curiosity? What evidence was there that visitors changed their attitudes toward plants and plant processes through their experience in the exhibition?

In what ways and to what extent did the exhibition fit with visitors' own agendas for their conservatory visits? Were they satisfied that their agendas had been met, and/or were they willing to move beyond their original intentions to include different sorts of experiences?

What had visitors heard or found out about the exhibition before they arrived, from family, friends, marketing materials, press coverage, etc.? In what ways and to what extent did that share their experiences with the exhibition?

Did visitors come back to see the exhibition again (either during the same visit, or at a later time), and if so, how did their experiences evolve? Did they come back especially to see this exhibition, or did something else motivate their return to the Conservatory?

How did their visit to SFTS integrate in with the rest of their visit to the Conservatory? What did it contribute to their overall conservatory experience?

What messages were visitors walking away with?

What words did visitors use as they talked about exhibits and programs?

What messages about the sugar-making process came across to visitors? Which messages *stuck* with them as they left and explored other parts of the Conservatory?

How did visitors make sense of the sections that they visited? To what extent and in what ways did visitors understand the concepts presented in the exhibits and programs? Were there significant misconceptions about or alternative understandings of these concepts?

In what ways and to what extent did visitors gain knowledge, correct misconceptions, or deepen their understanding of plants and plant processes? For visitors who engaged with the exhibit texts, what did they take away content-wise? What evidence was there that visitors progressed along various knowledge hierarchies related to *Sugar from the Sun*?

To what extent were visitors' understandings shaped by the order in which they visited the four sections/central space, or by their use/non-use of the *Exhibit Guide*? In what ways did visitors think and feel about the plan of the room, and in what ways and to what extent did they coordinate the room's layout with the concepts in the exhibition? How did visitors "map the space in their minds" – to what extent did they recognize the four components and put them all together, making sense of them as a whole? Did visitors construct a linear narrative from this non-linear space, and if so what narrative did they construct?

What kinds of questions did visitors ask within the exhibition and during programs? Did the exhibits and programs answer questions visitors came with or developed during their visit? What unanswered questions did visitors have when they left the exhibition and programs?

Visitor Enjoyment

How did visitors appear to be enjoying themselves?

To what extent and in what ways was this an enjoyable experience for visitors? In what ways and to what extent did visitors feel challenged, motivated, curious, and playful? What did they enjoy the most? The least?

What did they appear to be frustrated by and/or unhappy with? In what ways and to what extent did visitors feel satisfied and/or unsatisfied with their *Sugar from the Sun* experience?

In what ways and to what extent were visitors comfortable with the exhibits and programs, with exhibit amenities, and with approaching GPC staff and volunteers?

Visitor Use of the* Guides *and Programming

When, where, and in what ways did visitors use the Guides*?*

Who picked up the *Guides*, where did they pick them up, and what did they do with them when they first obtained them? Who used the *Guides* within the exhibition? What factors seemed to play a role facilitating their use within the exhibition?

How did visitors use the *Guides*? In what ways and to what extent did the *Guides* play a role in visitors' experiences of the exhibition? What relationships did visitors see or draw between the *Guides* and the exhibition? How did the visitor experience differ when they use the *Exhibit Guide*? What did visitors take away from their experiences with the *Guides*?

In what ways were visitors involved in the cart demonstrations and Children's Garden activities?

Who self-selected to participate during the demonstrations and activities? Who declined to participate? What factors seemed to play a role in their decisions?

What did visitors do during the demonstrations and activities? How did they attend and react to the activities? What did visitors take away from their experiences with *Sugar from the Sun* programming?

In what ways and to what extent did the programming play a role in visitors' experiences of the exhibition? What relationships did visitors see or draw between the demonstrations/activities and the exhibition?

Achieving the Project Goals

Which goals did the Sugar from the Sun *project achieve?*

In what ways and to what extent did the *Sugar from the Sun* exhibits and programs achieve their stated goals? Which exhibit components and programming elements contributed to achieving the goals, and in what ways did they do so?

For whom did the exhibit and program experiences seem to work particularly well?

Who did the exhibition work well for? Who was most engaged? Who had the most fun? Who learned the most? For which audience members were the goals achieved, and why?

What audience characteristics, group compositions, ages, pre-existing interests, and previous experiences seemed to facilitate a good experience and/or achieving the project goals? For which audiences was the exhibition not as successful?

Big Idea and Goals for the *Sugar from the Sun* Exhibition

The big idea for the project is:

> *Through an amazing and complex process hidden within their leaves, plants use sunlight energy to make sugar energy from water and air.*

The project has five major visitor goals:

1. Visitors will respond physically by pointing, touching, smelling, listening and looking up, down and all around.

2. Visitors will gain a heightened awareness and deeper appreciation for the beauty and variety of plants.

3. Visitors will engage in multi-sensory experiences that spark emotional responses: imagination, wonder, and playfulness; feelings of being transported to another place; awe and amazement; mystery and intrigue.

4. Visitors will understand that inside their leaves, plants are using sunlight, air and water to make sugar.

5. Visitors will have social interactions and discussions that inspire them to ask questions about the role of plants in their lives and environment.

APPENDIX E: SAMPLE DATA COLLECTION PROTOCOLS

Brief Overview of the Summative Evaluation Process
March 18, 2008

Step 1. Post signs.
Make sure signs are posted at each entrance to the exhibition where you will be conducting observations and interviews.

Step 2. Select respondent(s).
Use purposive sampling of intact visitor groups. Record why you selected each group.

Step 3. Observe respondent(s) using the exhibits.

Step 4. Invite respondent(s) to participate in an interview.
If they say no, write up observations and then go back to step 2.

Step 5. Introduce respondent(s) to the interview process.
Include all pertinent information.

Step 6. Interview the respondent(s) and take notes.
Use Interview protocol. Ask probing questions as necessary/appropriate.

Step 7. Invite respondents to talk again by phone later.
If they accept, have them complete a follow-up survey form.

Step 8. Thank respondent(s) and give them a gift.
Be generous in your appreciation.

Step 9. Complete your observation and interview notes.
Fill in and flesh out any missing items.

Step 10. Complete debrief for this observation/interview.
Do this BEFORE your next observation and interview.

Step 11. Enter respondent information on the Respondent Data Sheet.

Step 12. Go back to Step 2 and begin another round of data collection.

***Sugar from the Sun* at the Garfield Park Conservatory**
Detailed Overview of the Summative Evaluation Process

March 18, 2008

Step 1. Post signs.
Make sure signs are posted at each end of the exhibition where you will be conducting observations and interviews.

Step 2. Select respondent(s).
Throughout the course of the observations and interviews, it's important to try to observe and interview a *range* of visitors. When selecting respondents you want to make sure you are conscious of whom you choose to speak with. Look for intact social groups that show, in aggregate, a range in these variables:

- Age (anyone under 18 must have permission from parent guardian to be interviewed; we cannot collect contact information for anyone under 18 years)
- Gender
- Social group configuration
- Ethnicity
- Presence of a disability
- Other interesting characteristics or group dynamics

It's human nature to pick people who look like us. Two ways to make sure you're selecting a broad range is:

- Write down: Why am I selecting this respondent?
- Choose a visitor group that is completely different from the previous group you talked to (unless you have a specific reason for selecting a similar group).

Make note of the group characteristics on the top of the first page of the Observation Form.

We want to make a special effort to include visitors with disabilities or other physical limitations in the sample. At some point, we also need to consider whether we have observed enough visitors at each of the exhibit units. We may, at that point, need to choose visitor groups on the basis of which exhibit units they stop at.

Step 3. Observe respondent(s).
Observe the following, listening for natural conversations:

- Physical engagements are all the physical things visitors do at an exhibit, for example, sitting, standing, looking, reading, pointing, touching, and so forth. This also includes how long visitors spend at the various parts of the exhibition.

- Intellectual engagements are all the ways in which visitors engage cognitively with an exhibit, including thinking about, processing, and making meaning of their experiences. In what ways do visitors seem to be thinking about and making connections with what they already know and have experienced?

- Social engagements are all the ways in which visitors engage with each other within the context of the exhibit, including verbal exchanges as well as body language. This could include directing attention, asking a question, coming up with an explanation together, reading a label out loud. We are interested in how visitors engage with each other, the types of teaching/learning and meaning-making interactions they participate in, and what they talk about and how they talk about it.

- Emotional engagements are all the ways that visitors engage emotionally with the exhibit; examples include surprise, delight, awe, satisfaction, feelings of competence, intimidation, and frustration. By looking at emotional engagements, we can get a feel for visitors' primary emotional connections with the exhibit materials, as well as look at the role of play in developing and maintaining interest (and learning).

Step 4. Invite respondent(s) to participate in an interview
Approach them from the front if possible (rather than, say, "sneaking up" behind them). Invite respondents to participate in an interview. The important points are:

- Introduce yourself by name.
- Describe what you are doing
- Ask for their help, but let them know it's completely voluntary and anonymous
- Tell them how long it will take.

If they say yes:

- Make sure they understand why the interview is important
- Let them know they can say anything about the exhibit/program without hurting your feelings.
- Reinforce that it's confidential
- There are no right or wrong answers, and we are not testing them—if something doesn't work for them, then we need to fix the exhibit.
- They should let us know if we are taking too much time, and we will stop.

Step 5. Introduce respondent(s) to the interview process.
Important points to make:

- [see interview form]

Step 6. Interview the respondent(s) and take notes.
Use Interview protocol. Ask probing questions as necessary/appropriate.

Use the Interview protocol and take detailed notes. The questions on this form should help focus the discussion so you can quickly get the information you're looking for. Write visitors' answers directly on the protocol form, or in a separate notebook. Either way, you will eventually use your notes to help you write up a debrief.

Feel free to ask probing questions to elicit further information. Probes are questions that aren't listed on the Interview Form, such as:

"I noticed that you _____. Can you tell me about that?" (Use this kind of question when you want to focus in on something a visitor did, read, or talked with to someone else in his or her group.)

Probes also can be used either to:

- Clarify something *or*
- Better understand something a visitor is saying. e.g., when you have an initial response to a question that is incomplete, you can probe by asking further questions.

Step 7. Invite respondents to talk again by phone later.
If they accept, have them complete a follow-up survey form.

Step 8. Thank respondent(s) and give them a gift.
Be generous in your appreciation. Let them know how much you appreciate their help and that you have a small gift from GPC as a thank you for their participation.

Step 9. Complete your observation and interview notes.
Immediately after the interview, take time to read through and complete your observation and interview notes. Fill in any missing items in your notes and clarify anything that seems confusing. Perhaps the observations and interview left you with some questions; if so, write them down.

Step 10 A and B. Complete debrief for this observation/interview.
Do this BEFORE your next observation and interview. Go back to your laptop and complete both pages of the Debrief form. In the first part, be as specific as possible in giving specific examples, and noting how the exhibit facilitated specific engagements. With time, you'll develop your own criteria for rating the engagements, and that's fine. The ratings are designed to get you thinking, rather than to "measure and compare" engagements between exhibits. However, do try to be consistent in your ratings.

In the second part, you are trying to analyze and make meaning of the observation and interview. Use the questions on the Debrief form to guide your write-up, but don't feel confined by them. Try to look at what went on from a variety of perspectives.

Do this BEFORE your next observation and interview.

Step 11. Enter respondent information on the Respondent Data Sheet.
Complete a row on the Respondent Data Sheet (a separate file, entitled:
< SFS5 Respondent Data Sheet v_ >
This allows us to keep an accurate tally on respondents we've talked with and observed. It also enables us to keep track of the diversity of our respondent pool, and think about ways to increase that diversity.

Step 12. Go back to Step 2 and begin another round of data collection.
Repeat until the unit works effectively with all groups in the target age ranges.

SFS5 Remedial/Summative Observation Protocol
Step 3. Observe respondent(s) using the prototype and take notes.

Date: _____ Obs # _____ Initials: _____

Start Time: _____AM/PM End Time: _____AM/PM

Group Type

1 alone
2 two adults
3 several adults
4 tour group
5 adults with children
6 camp/school group

Group Size / Ages:

Members? Y N

Ethnic Category:

___ H/L-F = Hispanic or Latino female
___ H/L-M = Hispanic or Latino male
___ N-F = Not Hispanic or Latino female
___ N-M = Not Hispanic or Latino male

Racial Categories:

___ A-F = Asian female
___ A-M = Asian male
___ B-F = Black or African American female
___ B-M = Black or African American male
___ W-F = White female
___ W-M = White male
___ AI-F = American Indian or Alaskan Native female
___ AI-M = American Indian or Alaskan Native male

Why did you select this respondent group?

NOTES: (add more on the back if necessary—or use a separate notebook)

Sugar from the Sun at the Garfield Park Conservatory
Step 4. Invite Respondents to Participate in Interview

Step 4. Invite respondent(s) to participate in the study.
The introductory statements might go something like this:

Hi, I'm _____, and I'm working with Garfield Park Conservatory to help them figure how this new exhibit is working. We are talking to visitors about the new exhibit, and I was wondering if I could talk with you for a few minutes. It's completely voluntary – you don't have to participate. It will take about __ minutes to participate in the study. Would you be willing to participate?

[If yes.]

Everything you say is confidential, and you don't have to give your name unless you really want to. There are no right or wrong answers, because we want to find out what you think about the exhibit. We need you to tell us what you really think so we can make sure it works for the people who come here. We're finding out about how well the exhibit works, not testing you. If something about the exhibit isn't working for you, then we need to fix the exhibit.

By the way, we don't work for the science center. We are testing this for the science center, so you can say anything you want to about the exhibit—you don't have to worry about hurting our feelings.

We want to find out as much as we can by talking with you, but if we end up taking too much time, we can stop the interview at any time—just let us know you want to stop.

.

Step 5-8. SFS5 Summative Interview Protocol
Date: _____ Obs # _____

Introduction: We'll ask you some questions:

- no right or wrong answers
- trying out the exhibit, not testing you
- stop at any time
- [chit chat to get visitors relaxed]

1. Have you ever visited GPC before? Y N
   What about this exhibit? Y N

   Who else is here with you today?
   What ages are the children who are with you today?
   May I ask where you're from?

2. I noticed that you were _____.

   Can you tell me more about what you were doing and thinking? [What got you thinking about that?]

3. When you finished using this exhibit, what things were going through your mind?

   What unanswered questions did you have?

4. What is something new [that you think your child found out at this exhibit that they didn't know before]?

   What did you find out?

   [If appropriate] How would you explain this to somebody else?

5. Can you tell me about any special interest or expertise in this area?

6. Rate this exhibit from 1-10 (1 is the worst and 10 is the best) compared to other exhibits you've seen in science centers. Why did you give it this rating?

7. That's all the questions I have. Do you have any questions for me?

Step 7. Invite respondents to talk again by phone later.
If they accept, have them complete a follow-up survey form.

Step 8. Thank respondent(s) and give them a gift.
Thank you very much for your time. Here's a small token of our appreciation.

Step 10A. Complete Debrief
***SFS5* Summative Engagements Debrief**
Date: _____ Obs # _____

For each item, rate the overall quality of the group's engagement relative to the team's intentions on a scale of 0 to 4. (4 highest level, 0 is no engagement). Explain why you gave that rating, give specific examples, and note how the exhibit facilitated these engagements.

Physical Engagements: 4 3 2 1 0

Intellectual Engagements: 4 3 2 1 0

Social Engagements: 4 3 2 1 0

Emotional Engagements: 4 3 2 1 0

Step 10B. *SFS5* Summative Debrief (continued)

Answer these questions as part of your written debrief:

1. What was special about this observation/interview?

2. What aspects of the exhibition/programming attracted visitors' interest and seemed to stimulate their curiosity?

3. Which aspects of the exhibition did visitors particularly enjoy using? Which exhibits didn't seem like very much fun, and why?

4. In what ways were people playing in the exhibition? In what ways, if any, did that contribute to their making sense of, and understanding, the exhibits?

5. What aspects of the exhibition stimulated meaningful conversations? What were those conversations about, and who were they with? To what extent were they personal narratives? To what extent did they involve ethical or controversial issues?

6. What sorts of teaching/learning interactions did you see? What aspects of the prototype seemed to stimulate or support these sorts of interactions?

7. In what ways did the respondents seem to connect to the exhibit material and ideas in a personal way (beyond likes and dislikes)?

8. To what overall extent did this group achieve the team's goals?

9. To what extent, and in what ways, did this group understand the intended messages?

10. What three things did you learn from this respondent group? What did you find out that you didn't know before?

11. Did the observation/interview raise any new questions?

12. What about the exhibit ion seems to be working well, and why? What is not working as well?

13. How might the exhibition be revised to make it more effective for this group?

14. What larger lessons did you learn that apply to remediating the exhibition or planning future exhibitions at GPC?

APPENDIX F: DESCRIPTION OF RESPONDENTS

Summary by Data Collection Method

February 28 through June 15, 2008

Type of Data Method	Individuals	Groups
NON-SCHOOL/SMALLER GROUPS		
Unobtrusive observation only	45	15
Observation and interview	63	27
Depth observation with interview	5	3
Participant observation with interview	30	10
Subtotals:	*143*	*55*
SCHOOL/LARGER GROUPS		
Unobtrusive observation only	1400*	36*
TOTALS:	***1543***	***91***

* Approximate count

Descriptions of Non-School Respondent Groups Observed and Interviewed in the Exhibition

			Group Composition				Ethnicity				Racial Categories							
Date	#	Total	AF	AM	CF ages	CM ages	H/L-F	H/L-M	N-F	N-M	A-F	A-M	B-F	B-M	W-F	W-M	Type	Prog.
0228	1eg	1				12				1						1	DO	
0228	1dp	2	1	1					1	1					1	1	DO	
0318	1	4	1	1	2	4			2	2					2	2	Ob	
0318	2	2	1	1			1	1							1	1	Ob	
0318	3	3	1			2, 7			1	2					1	2	ObI	
0318	4	2	1			7			1	1	1	1					ObI	
0320	1	3	2			5	2	1							2	1	Ob(I)	
0320	2	6	2		x, x, x	11, x	4	2							4	2	Ob	Morning
0320	4	3	1		12	9							2	1	2	1	ObI	
0320	6	2	1	1					1	1					1	1	ObI	
0320	7	4	1	1		5, 6			1	3			1	3			ObI	Inside, Challenge
0320	8	2	1			10			2				2				ObI	Challenge
0320	9	2		1		10		2								2	ObI	Challenge
0320	10	3	3					3							3		ObI	
0322	1	1		1						1						1	ObI	Inside
0322	2	2	1	1					1	1					1	1	(I)	
0322	3	2	1	1					1	1					1	1	ObI	Inside
0322	4	2	2						2						2		ObI	

NON-SCHOOL GROUPS, continued

Date	#	Total	Group Composition				Ethnicity					Racial Categories					Type	Prog.
			AF	AM	CF ages	CM ages	H/L-F	H/L-M	N-F	N-M	A-F	A-M	B-F	B-M	W-F	W-M		
0324	1	2		1		~11				2						2	ObI	
0324	2	2	2						2						2		ObI	
0325	1	3		1	2, 4				2	1					2	1	Ob	
0325	2	7	1	1	~3, 6	~ 15, 10, 10		2	3	2					3	2	ObI	
0325	3	2	2						2						2		ObI	
0325	4	2	2						4						2		ObI	
0325	5	2	1			~1			1	1					1	1	Ob	
0407	1	1	1						1						1		ObI	Morning
0407	2	2	1			3			1	1					1	1	ObI	Morning
0407	3	3	1		2	4			2	1					2	1	ObI	Morning
0407	4	2	1		2				2						2		ObI	Morning
0407	5	2	1			4			1	1					1	1	Ob	Morning
0407	6	1								1				1			ObI	
0427	1	2	1			1			1	1					1	1	DO	
0504	1	2	1	1					1	1					1	1	ObI	Inside
0504	2	2	2				2								2		ObI	Inside
0504	3	4	2	2					2	2					2	2	ObI/ PO	Inside
0504	4	2	2						2						2		ObI	Inside
0504	5	2	1	1					1	1					1	1	ObI	Inside
0528	5	10	3	2	3	3											Ob	
0530	10																Ob	
0531	1	5		2	9	2, 3			1	4					1	4	Ob	
0531	2	2	1	1					1	1					1	1	Ob	
0531	3	2	1			10			1	1					1	1	Ob	
0531	4	3	1	1		5			1	2					1	2	ObI/ PO	
0531	5	2	1	1	6 or 7				2	1					2	1	ObI/ PO	Power of Sun
0601	1	3	3						3						3		ObI/ PO	Power of Sun
0601	2	5	1	1	9, 8, 5				4	1			4	1			Ob	Power of Sun
0601	3	4		1	7, 4	2			2	2			2	2			Ob	Power of Sun
0601	4	3	1	1		8			1	2					1	2	Ob	Power of Sun
0601	5	3	1	1	14				2	1					2	1	Ob	Power of Sun
0601	6	2		1		8		2								2	Ob	Power of Sun
0601	7	3	2	1					2	1	2					1	Ob	Power of Sun
0614	1	3	1		8	13			2	1			2	1			PO	Power of Sun

NON-SCHOOL GROUPS, continued

Date	#	Total	Group Composition				Ethnicity				Racial Categories						Type	Prog.
			AF	AM	CF ages	CM ages	H/L-F	H/L-M	N-F	N-M	A-F	A-M	B-F	B-M	W-F	W-M		
0614	2	3	1	2					1	2					1	2	PO	Power of Sun
0614	3	1		1						1						1	PO	Power of Sun
0615	1	3	1	1	6				2	1					2	1	Ob	Power of Sun
0615	2	3	1	1	13				2	1					2	1	PO	Power of Sun
0615	3	4	2	2					2	2					2	2	PO	Power of Sun
0615	4	4	1	1	5	8			2	2	2	1				1	PO	Power of Sun

KEY
Date = MM/DD
# = Interview number
Total = Total number in group
Group composition:
- AF = Number of adult females in group
- AM = Number of adult males in group
- CF = Ages/grades of female children in group
- CM = Ages/grades of male children in group

Ethnicity (if left blank, no members of that group were identified as Hispanic/Latina or Latino):
- H/L-F = Number of Hispanic/Latina females in group
- H/L-M = Number of Hispanic/Latino males in group
- N-F = Number of Non-Hispanic/Latina females in group
- N-M = Number of Non-Hispanic/Latino males in group

Racial categories (no visitors of American Indian descent were identified during the study:
- A-F = Number of Asian or Asian American visitors in group
- A-M = Number of Asian or Asian American females in group
- B-F = Number of Black/African females in group
- B-M = Number of Black/African males in group
- W-F = Number of White/Caucasian females in group
- W-M = Number of White/Caucasian males in group

Type = Type of observation or interview
- Ob = Observation only
- ObI = Observation and Intercept Interview (the I is in parentheses when the interview was very brief)
- I = Depth Interview only
- PO = Participant Observation
- DO = Depth Observation

Prog. = Name of program participated in
- [blank] = did not participate
- Morning = Morning Glories (preschool activities in the Children's Garden)
- Sugar = Prototype *Sugar Challenge* activity (guess which objects were made from sugar)
- Inside = Prototype *Inside Every Leaf…* activity (with microscopes)
- Power of Sun = Prototype *Explore the Power of the Sun* activity (with solar-powered toys)

Descriptions of School/Other Groups Observed in the Exhibition
(Totals and group compositions are generally estimates.)

Date	#	Total	Group Composition		Grade Levels
			Students	Adults	
0320	3	20	10	10	Pre-Kindergarten (part of larger group)
0320	5	10	5	5	Pre-Kindergarten (part of larger group)
0501	1	45	35	10	4th-5th
0501	2	45	35	10	4th-5th
0501	3	12	10	2	Secondary
0501	4	40	30	10	K
0501	5	80	60	20	K-1st
0501	6	70	35	15	1st
0501	7	35	30	5	1st
0501	8	15		15	Adults
0501	9	10	9	1	Secondary
0501	10	12	12		College
0501	11	50	42	8	2nd
0501	12	100	90	10	8th
0502	1	30	28	2	7th
0502	2	45	40	5	4th-5th
0502	3	45	40	5	4th-5th
0502	4	40	30	10	Pre-Kindergarten
0502	5	15		15	Adults
0528	1	20	18	2	8th
0528	2	65	50	15	Kindergarten
0528	3	75	60	15	1st & 2nd
0528	4	12	10	2	Secondary
0528	5	10	8	2	Pre-Kindergarten
0530	1	25	16	9	Pre-Kindergarten
0530	2	6	5	1	Secondary
0530	3	180	155	25	1st
0530	4	8	6	2	1st
0530	5	60	46	14	Kindergarten
0530	6	24	22	2	Kindergarten
0530	7	70	60	10	5th – 6th
0530	8	28	24	4	2nd – 3rd
0530	9	76	60	16	2nd