Outdoors Indoors Exhibit
A Front End Evaluation Literature Review

Prepared for

OREGON MUSEUM OF SCIENCE AND INDUSTRY

by

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EXECUTIVE SUMMARY

Introduction. The Oregon Museum of Science and Industry (OMSI) is developing *Outdoors Indoors*, an interactive natural science exhibition for young children, ages 3–8, and their families. OMSI contracted with Selinda Research Associates, Inc. (SRA) to complete a literature review as part of the front-end evaluation for the exhibits and related programs. The purpose of this review is to inform and provide direction for the exhibit development process. The primary research question is, "What can we learn from the research and evaluation literature about how to best design and evaluate an exhibit environment about natural science for 3–8-year olds and their families?"

Children's experiences with nature. Today's American children seem to have less direct contact with nature than children of previous generations, but there are increases in their indirect experiences with nature (in museums and zoos) and their vicarious experiences of nature (through TV and the computers). Little is known about parents' role in facilitating and shaping young children's experiences of the natural world; however, evaluation research suggests that parents who don't have much knowledge about nature have a difficult time engaging their children with nature in museums or the out-of-doors. Some of older children's most profound and memorable explorations of nature take place independently of their parents, so there may be value in creating indoor naturalistic environments where children can explore independently without parents being fearful.

Parents' roles in museums. Mothers who visit children's museums perceive themselves as playing many and often conflicting roles during their visits. Roles like learning enhancer, vocabulary supplier, and long-term learning facilitator seem to fit well with most museums' learning goals. However, if parents are going to perform these education roles well, museums also have to help them fulfill their many other roles (including planner, time keeper, visit facilitator, protector, and promoter of independence).

Influencing parents' interactions with their children. Much research remains to be done to determine what constitutes good forms of adult mediation in museums and to develop effective ways for parents to support their children's learning in specific exhibits. Nevertheless, evaluation suggests that providing information designed to guide parents helps them facilitate their children's experiences, and that building in elements that are likely to trigger personal connections makes families more likely to converse about the topic both during and after their visit to the museum. Research also suggests that families' use of museums is shaped by their personal agendas, and these must be taken into account.

Parents and labels. Most museum exhibits communicate with parents through labels, and research suggests that parents read them under a variety of circumstances. Parents often sample fragments of label text at a glance to get an idea what an exhibit is about. They read in slightly greater depth when they are trying to figure out how to use something or what to say to their children about an exhibit. When an exhibit engages their children for longer periods of time, parents sometimes further their own learning by trying to understand what an exhibit is doing and satisfy their curiosity about a subject.

These findings imply that labels must help parents quickly find the information they need to use and talk about the exhibit with their children, and that important themes and concepts need to be reflected at all levels of the label hierarchy.

Learning science within families. Recent research on how children learn science with their families suggests that children from a variety of backgrounds ask questions about the causes of events, and their parents often provide causal explanations in response. Parents usually focus on particular events that catch their preschool-aged children's attention, and they often provide a narrative about that particular experience. Parents' causal explanations are often fragmentary and incomplete, yet seem to be powerful because they focus closely on that particular experience. In museum exhibits, parents help their children notice, collect, and interpret evidence in ways that help them make inferences and generate explanations, and they also connect the museum experience to children's previous experiences in important ways. In addition to communicating information, parents' explanatory behavior also models scientific discovery for their children, shows there is value in knowing about the causes of events, and helps define the domains of knowledge within which a particular event can be explained. Some authors argue that family conversations in museums share many features with hands-on science inquiry practiced in more formal settings, and that "by talking science the family is doing science" (Ash, 2000, p. 2). They also suggest that science exhibits should be designed to stimulate these kinds of parent-child conversations. Perhaps these findings should also affect how explanatory labels are written and how gallery staff engage with children and their families.

Science process skills. Research suggests that children's science process skills are strongly related to their Piagetian developmental level, and it would be inappropriate to expect most younger children to develop and interpret their own hypothesis-testing experiments without a lot of adult support. However, evaluation studies have found that even classic dioramas can inspire museum visitors to engage in basic science process skills, and that combining dioramas with interactives can promote the practice of somewhat higher levels of science process skills.

Inquiry-based learning in exhibits. Most authors consider that the inquiry process starts with exploring the natural world, which leads to a question that is meaningful for the child, and then finding an answer to that question by directly investigating the natural world. Each stage in the inquiry process involves a set of skills that must be learned and that can be greatly improved by practice. Thus, although most authors stress the importance of allowing children to develop their own research questions, some authors suggest using "structured" or "guided" inquiry, especially as an approach for working with learners who have little experience with developing their own questions. Several sources suggest how to recognize when inquiry is taking place within an informal setting, and these findings are synthesized in the recommendations section of the report.

Learning science through play. Although games, fantasy, and repetitive play come closest to what most people think of as child's play, children also engage in playful exploration, productive play, and even problem solving during play, in ways that help them learn new facts and concepts and that mirror the kinds of playful behaviors that scientists say inspire their creativity. Children need to process what they learn if they are going to find its personal meaning and remember it for long periods of time, and fantasy play, role playing, and repetitive play are major ways they can accomplish these goals.

Children's understandings of the natural sciences. Recent research about children's thinking suggests that children's early concepts are not always concrete or perceptually based. Even preschool children are capable of reasoning about subtle and abstract ideas that reflect children's emerging "theories" about the world. Thinking about young children's understandings as "folk knowledge" stresses the shared, cultural aspects of children's understandings. This review suggests key readings about various aspects of children's folk knowledge of the natural sciences.

Making exhibits feel immersive and naturalistic. Immersive exhibits make visitors feel as if they are visiting a particular time or place, and immersive experiences create feelings of immersion without physically recreating an environment. Naturalistic exhibits are designed to look like a natural setting (forest, seashore, cave, etc.) through use of dioramas, murals, backdrops, or more immersive environments. The review lists a range of factors that seem to contribute to visitors' feelings of immersion and to the naturalistic feel of an exhibit. Families seem to behave and react differently in immersive naturalistic settings than in more traditional diorama halls. Although much learning in immersive exhibits seems affective in nature, adding interactive experiences within a naturalistic setting can increase visitors' cognitive learning.

Defining key issues. This review of the literature suggests that the *Outdoors Indoors* team needs to think about:

- The types of experience they want to provide
- Developing age-appropriate environments and activities
- Defining the degree and types of parent/caregiver involvement they want to encourage
- Potential uses and outcomes of including naturalistic and immersive elements in the exhibit

As part of this process, the *Outdoors Indoors* team will need to decide whether this is primarily an exhibit about:

- Helping families learn science processes
- Helping families learn natural science concepts
- Helping children learn how to explore and appreciate the natural world

Once exhibit goals are determined, the team needs to structure learning objectives in ways that will encompass the huge range in developing abilities and understandings among its target audience. We suggest that the use of knowledge hierarchies and nested concepts may aid this process.

Exploring possibilities. Without making specific recommendations, the review suggests some possible ways to raise parents' awareness of their roles in facilitating learning, to encourage children's cognitive and affective development, and to encourage families to explore their own natural environments. It also suggests a range of possible approaches to the evaluation.

Recommendations. This review concludes with specific recommendations about:

- Encouraging caregivers and their children to engage together at the exhibits
- Conveying messages to family groups
- Supporting parents' varied roles
- Balancing parent-child interactions with children's independent use of the exhibits

It also lists behaviors that may indicate that families are having successful inquiry experiences within the *Outdoors Indoors* exhibition.

INTRODUCTION

The Oregon Museum of Science and Industry (OMSI) is developing *Outdoors Indoors*, an interactive natural science exhibition for young children, ages 3–8, and their families. The exhibition will invite visitors to explore a woodland environment where children can develop science process skills and learn natural science concepts. The exhibition will also focus on ways that parents can facilitate their children's science learning.

As described in the National Science Foundation (NSF) grant proposal, the project has five primary goals, four of which are relevant to this review:

1. Offer young children rich opportunities to develop science process skills and gain an understanding of basic concepts in the natural sciences (life science, earth science, and ecology)
2. Raise the awareness of parents of young children about their role in their children's learning and development and the importance of playing an active role
3. Provide parents of young children with the tools and techniques needed to encourage their children's interest in science
4. Encourage families to explore the natural world
5. Help pre-K–3 teachers meet educational goals

OMSI has contracted with Selinda Research Associates, Inc. (SRA) to assist with all stages of the evaluation process for *Outdoors Indoors*. This literature review is part of the front-end evaluation for the exhibits and related programs.

Purpose of This Review

The purpose of this literature review is to inform and provide direction for the exhibit development process. The primary research question is, "What can we learn from the research and evaluation literature about how to best design and evaluate an exhibit environment about natural science for 3–8-year olds and their families?"

To answer this question, the literature review looks at what researchers and evaluators from a variety of disciplines have already learned about: (a) families' experiences in nature, in museums in general, and in immersive and naturalistic exhibits; and (b) children's relationships to, learning about, and understanding of nature and natural processes. The findings can help focus and refine the exhibit planning process, as well as provide supporting evidence for the exhibit design.

Methods

In consultation with the *Outdoors Indoors* team, we developed a topical framework outlining questions to guide the research process (Appendix A). Although the topical framework provided an outline for the report, we have rearranged and sometimes reformulated some of the topics based on our findings. For instance, although we originally thought about the implications of each major section separately, we decided it made more sense to combine them into a "Synthesis" section at the end of the report.

Research methods included:

- Searches of the Selinda Research Library holdings in these areas, which were already extensive, and of databases and files maintained by the senior author (e.g., http://museumdeveloper.net/)
- Consultation of existing literature reviews completed by Selinda Research Associates staff on similar topics
- Searches through the World Wide Web, including the askERIC.org database, online catalogs of public and academic libraries, online visitor studies databases, and more general search engines, like Google.com
- Consultation with Selinda Research Associates staff about unpublished evaluations of exhibits on related topics and other unpublished studies

Our analysis of this literature might best be termed inductive constant comparison (Lincoln & Guba, 1985), whereby each new unit of data is systematically compared with each previous unit. Therefore, ideas and concepts that we found in the literature were elaborated or modified based on findings from newly located sources, which were compared to the previous findings. This approach allowed us to continually identify, develop, and refine categories and interesting themes as they emerged.

Limitations of This Review

We surveyed a wide range of literature and explored in depth only those areas that seemed most relevant to the project. The Selinda Research Library and the senior author's personal library already had copies of most of the key references, and others were available from Chicago-area research libraries or on the Web. However, in a few cases we were not able to obtain original publications in time to include in this review. When necessary, we have cited secondary sources, such as review articles and ERIC abstracts.

It is also important to note that some of the research cited in this review (particularly on children's understandings) was undertaken in school and clinical settings that may not be ideal analogies for what happens with family audiences in a museum setting. For that reason, we have supplemented the published literature with unpublished studies undertaken in informal settings, particularly evaluation studies about museum exhibitions, to the extent possible.

Finally, there were some interesting questions raised during this study that, as far as we can tell, haven't been investigated by child development or educational researchers. Some of these questions emerged from the authors' extensive experiences as evaluators, museum employees, and parents. These areas are noted and briefly discussed in the text.

FAMILIES' EXPERIENCES IN MUSEUMS AND IN NATURE

We will focus on the family and parent-child interactions as we discuss the social context of visits to museums and natural areas. To establish why this is increasingly important, we present data that suggest that, on average, parents seem to be spending more time with their children in the late 1990s compared to the early 1980s. Sandberg & Hofferth (2001) used time-diary data to reach the following conclusions:

- **Children aged 3–12 spent significantly more time with their mothers** in 1997 than in 1981 (an increase of 4 hours a week, or about 15%).
- **Children spent more time with both "working" and "non-working" mothers** in 1997.
- **Children also spent more time with their fathers** in 1997. At least part of this seems to be due to fathers taking more responsibility for childcare while the mother worked.

Why is this so? Hofferth and Sandberg (2000b) noted several trends:

- **Mothers today are better educated than in the past.** Sandberg & Hofferth (2001) cite research showing that better-educated mothers spend more time with their children in educational activities (Leibowitz, 1974), and their own data supported this finding.
- **Women today, on average, have fewer children than in the past.** Other studies have indicated that parents tend to spend less time with each child as the number of children in the family increases (Bryant & Zick, 1996a, cited in Sandberg & Hofferth, 2001).
- **"Working" mothers spend less time doing traditional childcare but more time sharing housework and leisure activities with their children** (Bryant and Zick, 1996b).
- **Many parents adjust their work schedules to minimize the need for daycare.** For two-income, two-parent families with preschoolers, Presser (1989) found that about one-third of parents work different schedules and can share childcare.

If parents are indeed spending more time with their children, then the importance of understanding and supporting their interactions with their children is bound to increase.

How Parents Think about Their Roles in Museums

How do parents think about their roles in museums and in their children's learning and development? Although much of this review focuses on parents' roles as facilitators of learning and shapers of attitudes, what little research there is suggests that parents play a multitude of other roles during a museum visit.

Parents' ideas and feelings about these roles were explored in pioneering work by Dockser (1989, 1990). Dockser videotaped seven mothers and their four-year-old children (all museum members) during a visit to a children's museum. She later viewed the tape with each mother and interviewed them about their perceptions about what had occurred during the visit. Dockser found that the mothers perceived themselves to be playing many different roles during their visits and that these roles often conflicted with one another. Dockser identified thirteen maternal roles in all, including:

- **Planner** of what, they hoped, would be a successful visit
- **Time keeper**, tracking the length and pace of the visit
- **Follower**, rather than leader, because they said their own needs were secondary
- **Visit facilitator**, helping their children manage difficult or inaccessible aspects of the museum
- **Protector** from environmental dangers, physically dangerous encounters with other children, and other children who were disrupting their children's experiences
- **Rule maker, interpreter, and enforcer**, especially for rules related to protection and safety (a job made more difficult when the museum's rules were unclear)
- **Social mediator,** helping their children with their social encounters
- **Learning enhancer,** intervening at opportune times to help their children make sense of things they encountered
- **Vocabulary supplier,** providing words for their children to learn and use during and after the visit
- **Long-term learning facilitator,** helping their children remember and discuss what had happened at the museum once the visit was over
- **Promotor of positive self-esteem and independence** in their children
- **Socializer** with other adults in the museum, which some described as "safe ground" for social interactions
- **Time-out taker,** giving themselves a break or chance to rest from the many demands of motherhood

Dockser noted that the mothers expressed appreciation when the museum's staff stepped in to help with one or more of these roles. She also pointed out that individual mothers didn't perform every role during every visit, and some mothers downplayed the importance of certain roles (e.g., the last two) (Dockser, 1989).

As a result of their conflicting roles, the mothers faced many decisions about how to mediate or intervene with their child's experiences during their visit. The choices they made depended on the behavior and perceived needs of their children, the social climate in the museum, the presence or absence of siblings, interventions by museum staff, the mothers' theories about child rearing and learning, and a variety of issues that the families brought with them to the museum (Dockser, 1989).

Our experience in children's museums and elsewhere suggests that helping parents perform their many non-educational roles can increase the chances that they will be able to facilitate their children's learning. We speculate that *Outdoors Indoors* will be a more successful educational experience if the exhibit is developed in a way that helps parents navigate the many factors that complicate a family visit to a museum.

How Children and Families Explore the Natural World

What is known about how families explore the natural world and how parents interact with their children during these explorations? In particular, how do young children learn about the natural world today, as opposed to when the adults reading this report were young? We attempt to answer those questions in this section.

Changes in Children's Experiences with Nature

Many authors have noted that today's American children seem to have less direct contact with nature than children of previous generations. One reason is that most children today are growing up in what can best be called urban areas—perhaps as many as 90% (Schicker, 1988). But the issue is more complex than that because it is also related to how Americans choose to live their lives. Based on time diaries completed by 2,380 households during the 1997 school year, during the "average" week, the "average" child, 12 years old or less, spent about a half hour engaged in "outdoor activities" like gardening, boating, camping, picnicking, pleasure drives, walking, and hiking (Hofferth & Sandberg, 2000a). As another author states,

> *Many young children, regardless of where they live, spend most of their time in settings and activities that keep them essentially isolated from direct contact with the natural world. Recreation tends to be indoors (e.g., watching TV); transportation tends to be by car or other motor vehicle versus walking; and daycare programs—where many children spend most of their waking hours—tend to be much more oriented toward the classroom than outdoors* (Wilson, 1996).

Kellert (2002) points out that today's children experience nature in three ways:

- **Direct experience** involves actual physical contact with natural settings and nonhuman species.
- **Indirect experience** involves actual physical contact with natural objects or nonhuman species, but in far more restricted, programmed, and managed contexts, such as zoos, aquariums, botanical gardens, arboretums, natural history and science

museums, and nature centers. Another type of indirect experience is with pets, gardens, and other types of natural environments dependent on human intervention.

- **Vicarious, or symbolic, experience** occurs in the absence of actual physical contact with the natural world, such as through television. This type of experience involves representations or depicted scenes of nature that may be realistic or stylized.

It's important to note that children's direct experiences of nature don't need to take place in large, undeveloped natural areas like parks. Research, biographical and journalistic investigations, and the senior author's personal experiences point to the value of vacant lots, abandoned canals (Pyle, 2002), and weedy railroad right-of-ways (Kotlowitz, 1992) in children's lives. Of course, even these sorts of environments are threatened by both suburban development and urban infilling (Pyle, 2002), and evidence suggests that both rural and urban children have lost the freedom to roam and the open, unstructured time required to maximize their experiences in such marginally wild areas (Chawla, 1994).

Based on data from many sources, Kellert and other authors have concluded that children today encounter far fewer direct nature experiences than previous generations. On the other hand, indirect experiences of nature may be increasing, as indicated by comparative data from Hofferth & Sandberg (2000b). From 1981 to 1997, children's time spent in school, daycare, and other structured activities increased significantly, and there was a decrease in unstructured play and art activities. Vicarious experiences also seem to be increasingly available to American children. For instance, there are hundreds of hours of nature television available each year (Eagles & Demare, 1999).

Children's Responses to Natural Environments and Natural Objects

What aspects of the exhibit could be inspired by children's responses to natural environments? In a classic paper on what children get from their interactions with natural materials, Chipeniuk (1995) found that children who forage for more kinds of natural things in childhood have a better sense of biodiversity as adults. Chipeniuk defines foraging as seeking out and using natural things. From Chipeniuk's research, we can discern that when dealing with natural materials, children like to search for natural items, touch and use them in some way, and interact with a variety of natural items. In addition, having these opportunities apparently has a long-lasting impact on children's understanding of the natural world. This has implications for the types of natural items and how they are made available in *Outdoors Indoors.*

The literature on object-centered learning also offers some insights to keep in mind when developing a naturalistic exhibit. One key insight is that children do not realize or appreciate the authenticity of objects the same way adults do. Evans *et al.* (2002) distinguish between the authenticity of artifacts and the authenticity of objects of nature. To be authentic, artifactual objects must be original and of intentional origin, while natural objects must be natural and not of intentional origin. Children's understanding of both these senses of authenticity emerges slowly over time through their experiences. Similarly, Rennie *et al.* (2002) explain that the meaning of an object depends not only on the object itself but also on the way it is interpreted by the visitor. For example, a bowl considered to be cheap tableware might have a different significance in the death camps of the Holocaust. Rennie *et* *al*. pose the question of how young children make sense of an object they have not seen before but without providing any clear-cut answers. What this suggests is that the OMSI development team will need to carefully consider how to mediate children's experiences with the naturalistic exhibit environment so children can appropriately interpret the combination of natural and simulated aspects of the environment.

The range, complexity, and varied scale of natural objects in arboreta and botanic gardens (reflected in landscapes, garden areas, and individual plants) are a key part of what captures the imagination of visitors, according to Michener *et al.* (2002). Children in particular respond with excitement to opportunities to put themselves in the environment (for example by engaging in an activity to explore "secret spaces") and not just study it from afar. These findings pose some challenges for the OMSI development team because it will not be possible to replicate the richness of an outdoor environment indoors. However, these findings suggest that to create a naturalistic space that is engaging for children, efforts should be made to provide natural spaces that can be explored, even if they are simulated, and not just activity stations.

Parents' Roles in Children's Explorations

What seems missing from the literature cited so far is discussion of parents' role in facilitating and shaping young children's experiences of the natural world. For instance, the subject index for the otherwise excellent resource, *Children and Nature: Psychological, Sociocultural, and Evolutionary Investigations* (Kahn & Kellert, 2002) includes no entries for "parents" or "families," and the one entry for "father" and two for "mother" refer to only very young children. There seem to be several reasons for this paucity of research into family learning about nature:

- As pointed out earlier, exploring the out-of-doors, with or without parents, seems to be an increasingly uncommon use of children's time.
- Much of the research in rural and suburban settings has focused on children's increasingly independent explorations of the natural world as they grow into and through middle childhood (e.g., Hart, 1979; Sobel, 2002), and this seems to be a time when children increasingly value their time away from adult supervision.
- Evaluations conducted by Selinda Research Associates in several settings suggest that parents who don't have much knowledge about nature seem to have a difficult time knowing how to engage their children with nature in the out-of-doors. Families need help in getting beyond pointing out and naming whatever they recognize and reaching deeper levels of exploration and engagement (C. Garibay, personal communication, Oct. 31, 2003). This suggests that, for many children, parents may not be an important source of positive experiences with nature.

One interesting theme that emerged from the literature was that some of children's most profound and memorable explorations of the natural world involve no interaction with parents. Moore (1990), based on his research about how urban settings can be designed to support children's development, argued that children need to have private places where they can escape to do as they please and be free to physically manipulate the environment. At the same time, he identified a recurring fear among urban parents in Britain that their children will come to harm when on their own. Similarly, Pyle (2002) talked about how children can find "Eden in a vacant lot" and how important these places are to children. In other words, children need to have the opportunity to interact with nature on their own.

Does this finding apply in any sense to museum exhibits? Interestingly, Michael Spock recently wrote about visitors' needs for "alonetime and owntime in museums" (Spock, 2000). Perhaps an indoor naturalistic environment has the potential to create spaces where children can do as they please and wander about a bit without parents being fearful. In addition to allowing children to develop their sense of independence, this would give parents an opportunity to fulfill their roles as "socializers" and "time out takers."

That said, both experience by the authors in children's and science museums and the more recent research on how children learn science within their families (cited later) suggest that parents can play an important role in children's learning in museum settings. In the next section, we discuss ways to think about parental roles in children's learning about nature.

Parents' Interactions with Children in Natural Settings

Our experience and the available literature suggest that parents interact with their children in a variety of ways, depending in part on parental attitudes, behavior, and knowledge and in part on characteristics of the natural setting. Based on Selinda's experience as evaluators we have found two factors that affect parent interactions with children in natural environments (C. Garibay, personal communication, Oct. 31, 2003).

- **Parental knowledge**. First, as discussed earlier, parent interactions are limited by the degree of knowledge the parents have about nature. Parents who do not know much about nature have difficulty engaging their children in natural environments beyond just pointing out and identifying objects.
- **Size of the space**. Second, parents seem to have a more difficult time focusing children's attention and interacting with their children in larger natural spaces. This may be, in part, because parents are concerned about keeping track of their children, especially if they have more than one child who is wandering off to different places at different times. This appears to be less of a problem in smaller and more confined outdoor spaces.

The Brookfield Zoo's Web site offers descriptions of four parenting styles in the context of interactions with the natural world (*Take the Caregiver Challenge*, no date). The site includes a quiz about how a parent might handle different nature situations to determine parenting styles. For example, the first question in the quiz is "It's a hot summer day and a light rain starts to fall." The possible answers for what a parent might do illustrate the different types of parenting styles relating to nature:

- "**Nature leaders**" focus on sharing knowledge about nature and in the quiz question would choose to set up gauges to measure the amount of rainfall.
- "**Play leaders**" like to have fun out in nature with their children and in the quiz question would choose to make leaf boats.

- “**Door openers**” like to step back and give their children opportunities to explore nature on their own and in the quiz question would choose to watch as their children jump in puddles.
- “**Wet blankets**” are most likely caring and concerned about their children’s safety but tend to steer their children clear of the outdoors to avoid wet clothes, germs, sunburns, or scrapes.

While specific research was not cited to support the existence of these parenting styles, the concrete examples demonstrate how parental attitudes can affect the types of interactions they and their children have in the natural world. This does not necessarily suggest that there is one right way for parents to interact with children in the natural world, but that a range of types of activities will appeal to parents with different attitudes about nature. (However, it’s interesting to note that floor staff in Brookfield Zoo’s Hamill Family Play Zoo are termed “Play Partners,” suggesting the importance of that role to zoo personnel.)

Finally, the literature on general parenting styles can suggest some ways that parents may interact with their children in exploring the natural world. Baumrind (1972) described three parenting styles:

- **Authoritative** parents are positively involved with their children and set clear and appropriate limits for their behavior.
- **Authoritarian** parents are not very involved and set high standards that children are expected to follow based on parental authority.
- **Permissive** parents leave children to make their own decisions and regulate their own behavior.

Baumrind concluded that an authoritative parenting style is the most effective at supporting children’s play and learning (Baumrind, 1972). Applying her model, authoritative parents might take their children to visit appropriate natural environments and within those environments let them have some free exploration as well as engage their children in discussing what they encounter there.

Finally, Selinda evaluators have noted in several formative evaluations that parent-child interactions improve significantly when there is information that guides parents. One take-away message might be to gear interpretation primarily for parents and other caregivers, so they can facilitate their children’s experiences (C. Garibay, personal communication, Oct. 31, 2003).

Influencing Parents’ Interactions with Their Children

What have been the outcomes of previous attempts to shape parents’ interactions with their children within and beyond the museum walls? It appears that little has been done to systematically study the outcomes of these efforts. This may be in part because museums in general have not focused much attention on directly influencing parent interactions with their children, much less beyond them. Schauble *et al.* (2002) noted that much remains to be done to determine what constitutes good forms of adult mediation in museums and to develop more effective ways for adults to support children's learning in specific exhibits.

Nevertheless, experience suggests two factors that can help deepen the level of parents' interactions with their children during and after experiencing an exhibit (C. Garibay, personal communication, Oct. 31, 2003).

- First, **providing information designed to guide parents** helps them facilitate their children's experiences. This suggests that it is critical to identify parents' knowledge and comfort level with topics being presented in order to build in the right level of information for parents.
- Second, **building in elements that are likely to trigger personal connections** with what families encounter outside of the museum (such as animals they may see in their neighborhood or fruits they may eat) makes it more likely that families will converse or have other interactions about the topic after they leave the museum (C. Garibay, personal communication, Oct. 31, 2003).

Schauble *et al.* (2002) also researched parent interactions with children in a science museum. Schauble found that, in exhibits with a wide variety of interactive activities and minimal signage containing declarative facts, a number of parents had a tendency to be passive and let their children play. Others, who wanted their children to learn more, adopted strategies such as providing explanations or asking questions. Some wanted the museum to provide more assistance in the form of signage or staff. Museum staff tended to want parents to be more active, to the point of designing some exhibits where an adult would be needed to help operate it. However, the researchers found that sometimes staff ended up having to help children operate the exhibits because some parents did not get involved. At the same time, museum staff also observed cases where they felt the parents were being overcontrolling or didactic.

In a second study of parent-child interaction, Schauble *et al.* (2002) observed how parents and children worked together to conduct a specific experiment (how boat features affect boat speed). Schauble found that parents did a good job helping their children design and run the experiment but did comparatively little to help them interpret the experiment. Because the parents were highly educated and the activity geared towards parent-child interaction, Schauble speculates that parents simply were not aware that their children needed help with interpretation. This suggests parents need help understanding their children's developmental needs at different ages.

Schauble's work suggests that a major challenge in shaping parent-child interactions will be first to decide on the desired level and type of parental involvement and then to design the exhibit to achieve those goals. Within an exhibit, it may be appropriate to provide a variety of opportunities for different types of parent-child interactions. And of course, given the variety of roles that parents play in museums (Dockser, 1989, 1990), developers and designers' ability to shape those interactions will be constrained by a variety of factors.

Finally, Ellenbogen's (2002) ethnographic case study of one family's use of museums suggests that attempts to shape parent-child interactions, both inside and beyond museum walls, must take into account an understanding of parent-child interactions outside museum walls and how the museum fits into a larger educational infrastructure. In her study, she found that the use of the museum depended on personal agendas brought by the family members. For example, because the family did home schooling, one child tended to treat the museum more like a formal, rather than an informal, learning environment.

Do Parents Read Labels?

As we discuss the various ways that OMSI might try to influence parents' behaviors in *Outdoors Indoors*, it occurred to us that we needed to establish that parents, in fact, do read labels and describe some situations where such reading is likely to occur. Some authors have argued that *visitors* read labels (e.g., McManus, 1989, 1990), establishing that visitors can be reading labels even when it looks like they are not, and that visitor groups may have members who take on the role of reader, passing on information to the entire group (McManus, 1990). However, to what extend and in what ways do *parents* read labels despite the many other demands on their time?

We have addressed this question as part of several summative evaluations at science museums this past year, and here are some of our preliminary findings. Given the child-centered nature of most family visits to museums, it's not surprising that most label reading by parents seems related to their roles as learning enhancers, visit facilitators, and vocabulary suppliers.

- Parents often sample fragments of label text **in passing, at a glance, or while still walking**. This can help them figure out what an exhibit is about, which they may then communicate to their children. A well-placed and well-written introductory label may be used in this way by some parents (although labels that are not directly related to a specific exhibit are more often ignored).
- Parents often read labels because they are **trying to figure out how to use something**. For instance, if they can't figure out how to get an interactive to work on their own, parents may turn to the instructions. As a corollary to this, when children are able to make interesting things happen without their parents reading the instructions, then all of the text in the instructions may be ignored.
- Parents read object labels because they want to **identify something or figure out what it is,** so they can communicate that information to their children.
- Parents who are taking on the teacher role often **use labels as they attempt to teach their children about the exhibit**. More specifically, they read labels so they can figure out **what to say to their children** about an exhibit.
- While label panels mounted next to computer interactives are often ignored, we've had some parents tell us they at least sampled this sort of text when they **couldn't figure out what the computer was supposed to do**. (Parents may also sample these labels while waiting for their children to complete an interaction.)

We have been interested to note that, when an exhibit engages their children for longer periods of time, parents will sometimes use their "time out" to further their own learning. For instance, we've seen parents use labels in the following ways.

- Parents sometimes read at least portions of longer label panels when they are **trying to make sense of an exhibit.** For instance, they may have gotten the interactive to work, but they are still wondering what it's doing and why (independently of what they might want to say to their children about the exhibit). This sort of label reading is inspired by interactives that are intellectually engaging and that stimulate curiosity in parents as well as children.

- Parents sometimes read longer labels because they are **curious about the subject matter**. They may want to remind themselves of concepts they learned long ago or to answer more general questions they had been wondering about even before they visited the exhibit. This sort of reading is motivated by what the parents bring with them to the museum—their existing interests and prior experiences.

- Parents sometimes read labels in greater depth while they are **waiting for their children** to complete their interactions with the exhibit. This type of use seems to start as a way of "killing time." Parents at least sample the text from labels they otherwise would have ignored and then keep reading if it engages their interest. In this case, a well-written label may win over some readers who otherwise might not have pursued more information about the exhibit.

Given these findings, here are some important points:

- Given the way parents sample label text, the key to success seems to be to **help parents find the critical information** they need to use and understand the exhibit—and to talk about the exhibit with their children—as quickly as possible.

- Given that some parents may read only the interactive instructions of object labels, it's clear that important themes and concepts in the exhibit need to be reflected at **all levels of the label hierarchy**, from interactive instructions and object labels on up to the main label panel.

- **Well-written labels can make a difference** in learning by parents, as well as children!

CHILDREN'S LEARNING ABOUT THE NATURAL SCIENCES

Learning from a Range of Experiences

We earlier discussed Kellert's three types of experiences of nature: direct, indirect, and vicarious. Given the loss of direct experiences with nature, what can we say about the value of the indirect and vicarious experiences that remain? Kellert (2002) tentatively concluded that the increase in children's indirect and vicarious contact with nature does not exert major or long-term development impacts. Because most indirect experiences are sporadic, atypical, and highly structured, he argued, they do not give children the opportunity to behave spontaneously. Quoting Pyle (1993), he explained that children need places where they are free to "wander off a trail." Indirect experiences are likely to work best, he concluded, when they complement direct encounters in familiar natural environments.

Other authors have noted that, whatever its ultimate value, children's learning from vicarious sources is increasingly important. For instance, studies in the southwestern United States suggest that even rural children are learning more about nature from the media than from experiences in the wild. Nabhan & St. Antoine (1993) interviewed a convenience sample of children in largely rural parts of Arizona, including representatives from two indigenous cultures—O'odham and Yaqui—and Anglo and Hispanic children. Although most of the children said they had direct experience with wildlife, including hunting, plant gathering, or capturing small animals, most of them said they had seen more wild animals on television and in movies than in the wild—including 35% of the O'odham, 60% of the Yaqui, 61% of the Anglos, and 77% of the Hispanic children. Many of these same children said they had never collected bones, insects, rocks, or other natural objects from the surrounding desert (35% of the O'odham, 60% of the Yaqui, 46% of the Anglos, and 44% of the Hispanic children). Nabhan & St. Antoine (1993) also documented many other ways in which these children lacked knowledge of their natural surroundings—especially folk knowledge from their native cultures.

It seems, however, that vicarious experience is at least associated with positive effects. Research by Eagles & DeMare (1999) suggested that reading environmental books or magazines and watching environmental television or movies both correlate with positive attitudes towards the environment. Of course, the problem here is determining causality. Do children read and watch environmentally positive materials because of their pre-existing attitudes, does reading and watching bring about changes in attitudes, or is there some more complex relationship that needs to be better understood?

Finally, much of the research and opinion about the importance of direct experience of nature seems based on studies of adults who are environmentally active (e.g., Tanner, 1998; Chawla, 1998, 1999). The assumption is that, "If we find that certain kinds of early experience were important in shaping adults, perhaps environmental educators can, to the degree feasible, replicate these experiences in the education of the young" (Tanner, 1998, p. 365). However, Gough (1999) argues that youth today are so different from children of earlier generations that "to argue that such intergenerational transfer is meaningful at the end of the 20th century is highly problematic" (1999, p. 386). She supports her arguments by citing numerous studies of the younger generation and describing her own interviews with young environmental activists.

Learning Science within Families

What is known about how children learn science within their families? There has been quite a bit of research published on this topic in just the last few years (Ash, 2000, 2002; Callanan & Jipson, 2001; Crowley & Callanan, 1998; Crowley, Callanan, Jipson, Galco, Topping, & Shrager, 2001; Crowley, Callanan, Tenenbaum, & Allen, 2001; Crowley & Galco, 2001; Crowley & Jacobs, 2002). By using a variety of methods to study conversations between children and parents, researchers have discovered a number of interesting patterns:

- **Questions lead to explanations**. Children from a variety of backgrounds ask questions about the causes of events, and their parents frequently provide explanations in response. Although many of these explanations deal with causal mechanisms or outcomes, others are religious (e.g., "God made it that way"), deal with unexplained essences (e.g., "That's how ducks are made"), or are non-causal (e.g., in response to a question, "How are babies born?" the mother says, "The baby is in my stomach") (Callanan & Jipson, 2001, p. 30).
- **Particular events**. Parents' causal explanations rarely guide their children "directly toward reflective, abstract understandings of science" (Callanan & Jipson, 2001, p. 44). Instead, parents usually focus on particular events that catch their preschool-aged children's attention, and they often provide a narrative about that particular experience (Callanan & Jipson, 2001).
- **Explanatoids**. Parents' causal explanations usually are fragmentary and incomplete (Callanan & Jipson, 2001). Crowley & Galco, (2001) used the term "explanatoids" to "characterize the simple, incomplete, and mundane explanatory talk that parents provide as they engage in collaborative everyday activity with their children," and that "explanatoids are powerful because they are offered when relevant evidence is the focus of joint parent-child attention" (p. 409–410). They hypothesize that explanatoids may help children develop their scientific thinking, although they haven't yet tested this hypothesis (Crowley & Galco, 2001).
- **Use of evidence**. Some studies compared what children did when they used an exhibit alone with what was done when a parent was present (e.g., Crowley & Galco, 2001). The results suggested that parents help their children notice, collect, and interpret evidence in ways that help them make inferences, generate explanations, and construct new theories (Crowley & Galco, 2001).
- **Connections**. In one study of parents' explanations in museums, about a quarter of the explanations connected the museum experience to children's previous experiences, which seems to be a particularly effective way to engage children in science topics (Callanan & Jipson, 2001).

- **Modeling**. In addition to providing explanations about causes, parents' behavior also seems to model various aspects of scientific discovery for their preschool children by "showing them how to formulate questions, find answers, and test predictions" (Callanan & Jipson, 2001, p. 44).
- **Values and domains**. Parents' behavior also shows children that they value knowing about the causes of events and helps children define the domains of knowledge within which a particular event can be explained (Callanan & Jipson, 2001).
- **Negotiated meanings**. Looking at conversations among parents and school-aged children, Ash (2002) found that expertise was more evenly distributed among family members, and that conversations included negotiating shared meanings for whatever was being observed (although parents often played an expert role at least initially).
- **Conversations as inquiry**. Ash (2000, p. 2) argues that the family conversations she has studied in museums shared many features with the hands-on inquiry practiced in more formal settings, and that "by talking science the family is doing science."

The patterns listed above are mostly descriptive in nature. Less is known, so far, about the outcomes of parent-child conversations about science. However, most authors seem to assume that focus on specific events is appropriate for at least preschool children, and that children can gradually accumulate partial explanations to develop a broader understanding about causes of events (Callanan & Jipson, 2001). Some authors have also speculated about the broader role that these sorts of conversations may play in children's development. "Parents who involve children in informal science activities provide an opportunity for children to learn factual scientific information and to practice scientific reasoning, but they also provide an opportunity for children to participate in a culture of learning about science. In terms of future classroom success or later choices about science as a career, the most important outcome of everyday parent-child scientific thinking may be that children develop an early interest in science, value science as a cultural practice, and form an identity as someone who is competent in science" (Crowley, Callanan, Jipson, Galco, Topping, & Shrager, 2001).

One outcome of parent-child conversations that has been studied to some extent is this: When children develop a deep interest in a subject, they and their parents may collaboratively develop what Kevin Crowley has called an "island of expertise" (Crowley & Jacobs, 2002). An island of expertise is an area of relatively deep and rich knowledge that children develop when they are passionately interested in something like dinosaurs, rocks, trains, or turtles. These islands emerge over weeks or months as children talk, read, and learn about their passions. On their islands of expertise, children remember, reason, and explain in more advanced ways than they usually do; even preschoolers can think more like an expert adult. Crowley emphasizes that children build and inhabit their islands with their parents' help through everyday activities. Preschoolers especially need this help, because if nobody reads them books about their interests, explains what they see in videos, or answers their questions, then they will be starved of the information they need to build their islands. (For a popular account of islands of expertise, see Gyllenhaal, 2002).

There also seem to be some potentially negative aspects to parent-child conversations about science:

- **Inaccuracies.** Parents sometimes communicate inaccurate information to their children because (a) their own grasp of the causes of many scientific concepts may be weak or incorrect, (b) they don't feel their children are ready for more scientific explanations, or (c) they have other goals in mind for their museum visit, like stimulating creative thinking rather than communicating accurate facts. Many researchers who study family learning of science minimize the importance of these factual inaccuracies preferring to focus instead on parents' modeling of scientific thinking, meaning-making, and other broader implications of parent-child conversations (Callanan & Jipson, 2001; Crowley & Galco, 2001).
- **Gender biases**. In at least one museum setting, parents of preschoolers provided explanations more often to boys than to girls perhaps unintentionally contributing to a gender gap in children's science literacy (Crowley, Callanan, Tenenbaum, & Allen, 2001).

Despite these problems, some authors have begun thinking about the implications of this research for the design of museum exhibits. Here are some preliminary suggestions:

- **Thematic conversations**. Ash (2002) suggests that, "Good exhibits, then, are the jumping off points for thematic conversations, by providing strong themes that pervade family conversations in engaging ways" (p. 396).
- **Exploring and talking together**. Callanan & Jipson (2001) suggest that, rather than designing exhibits where children are left to explore things on their own, exhibits for young children should be designed to stimulate the kinds of conversations where parents structure and guide their children's interactions with the exhibit in fruitful ways. The authors admit that, although some design solutions seem obvious (such as providing places for parents to sit near the exhibit and providing labels that stimulate natural conversation), more precise questions "about how to improve the quality of interactions await further research and debate" (p. 44).

We're wondering if these findings should also affect how explanatory labels are written and how gallery staff engage with children and their families. However, we aren't aware of research that deals with these issues.

Learning Science within Informal Settings

What is known about how children learn science in informal settings? We review some of the relevant literature in the following section.

Learning Science in Open-Ended and Hands-On Exhibits

How can we facilitate learning in open-ended and hands-on exhibits? For aspects of *Outdoors Indoors* that are intended to offer multiple outcomes, a study by Ault (1995) of the multiple-outcome engineering exhibit at OMSI offers fourteen specific principles to follow. Among these, several seem particularly relevant for encouraging learning by children in a naturalistic exhibit environment:

- Provide multiple chances for visitors to see the same principle at work
- Reflect careful attention to the degree and nature of "cueing" visitor interaction
- Often invoke analogies to the real world when presenting simulations, in part as a way of cueing interaction. Make these analogies or correspondences explicit
- Facilitate young children's rapid and successful engagement before parents can dominate by demonstrating what to do
- Develop a system for the easy, quick, and frequent restocking of materials and sorting out of messes
- Have some examples of "the real thing" to try
- Encourage fantasy play

Learning Science Process Skills

How can we facilitate the development of science process skills in exhibits for young children? The science process skills that were much discussed in science education in the 1970s and beyond are still a core part of much of the literature on inquiry-based learning (Institute for Inquiry, 1996). Most authors recognize a two-level hierarchy of skills (Brotherton & Preece, 1995; Champagne, 1990; Padilla, 1990, 1991; Padilla & Pyle, 1996). These include (adapted from Padilla, 1990):

Basic skills:

- **Observing**—using the senses to gather data
- **Measuring**—describing the dimensions of an object or event
- **Classifying**—grouping or ordering objects or events into categories based on properties or criteria
- **Inferring**—making an "educated guess" about an object or event
- **Predicting**—stating the outcome of a future event based on a pattern of evidence
- **Communicating**—using words or graphic symbols to describe an action, object, or event.

Integrated skills:

- **Controlling variables**— being able to identify variables that can affect an experimental outcome, keeping most constant while manipulating only the independent variable.
- **Defining operationally**—stating how to measure a variable in an experiment.
- **Formulating hypotheses**—stating the expected outcome of an experiment

- **Interpreting data**—organizing data and drawing conclusions from it
- **Experimenting**—being able to conduct an experiment, including asking an appropriate question, using the skills outlined above to design a "fair" experiment, conducting the experiment, and interpreting the results
- **Formulating models**—creating a mental or physical model of a process or event

Research suggests that children's science process skills are strongly related to their Piagetian developmental level (Brotherton & Preece, 1995), and, thus, it would be inappropriate to expect most younger children to, for instance, develop and interpret their own hypothesis-testing experiments without a lot of adult support. Some evidence suggests that even middle-school students need special training to gain competence in basic science process skills (Padilla, 1990). However, with appropriate training, skills such as prediction can be taught to older elementary students (Padilla, 1990).

In a report that will discussed later in greater depth, Perry *et al.* (1995) re-examined interviews collected for a study of visitor responses to classic dioramas at the Chicago Academy of Sciences to find out to what extent visitors talked about using science process skills as they viewed the dioramas. Their findings included the following:

- **Basic skills**. The dioramas were successful at engaging respondents in the basic process skills. "Most respondents clearly used observation, communication, and identification skills when engaging with the dioramas…. In fact, in many ways, the simplicity and ease with which respondents reported being successful at identification and observation are important contributions to the popularity of the dioramas." Although some respondents described engaging in comparing/contrasting, classifying, and possibly analyzing, those skills appeared to be used much less often.
- **Integrated skills**. "There was no evidence of hypothesizing/predicting, experimenting, synthesizing, conceptualizing, evaluating, or applying/transferring." This did not surprise the investigators, because it was hard for them to imagine very many meaningful situations in which casual visitors could use the dioramas alone to engage in, say, experimenting activities.
- **Visitor goals**. There was evidence that "many visitors felt frustrated because they wanted to engage in higher level thinking skills, but were unable to." A number of respondents "indicated that they wanted to take their children beyond observation and identification, but they didn't know how…. The problem with the dioramas was not that most visitors appeared to spend the most time observing and identifying, but that there was little to help them move to higher levels of intellectual processing, even when they knew they wanted to."
- **Developing prerequisite skills**. "In many ways observation and identification can be considered necessary prerequisites to higher order thinking; unless visitors are able to be successful at these levels, they will never be able to move onto the more sophisticated comparing/contrasting, conceptualizing, and synthesizing. The real task of exhibits is to pave the road to the higher level thinking; to enable visitors to

> observe and identify and then compare, contrast, analyze, conceptualize, evaluate, and apply."

Thus, Perry *et al.* (1995) found that even classic dioramas can inspire museum visitors to engage in basic science process skills, and they suggested that it might be possible to help visitors engage in even higher-level skills with proper support. A study at the Milwaukee Public Museum looked at what happened when such support was added in the form of interactives located along the outer margins of dioramas (Korenic, 1995). As will be discussed in greater depth later in this review, Korenic found that dioramas, when combined with interactives, promoted learning of science process skills.

The research also suggests that we can expect younger visitors to need help with even basic science process skills, and older children (and perhaps their adults) will be challenged by the integrated process skills. The literature suggests that the exhibit still can make some major contributions:

- **Preschool and kindergarten children** can practice what might be called pre-science process skills, like one-to-one correspondence, counting, and naming, as well as basic science skills, like observing, measuring, and classifying (Lind, 1998).
- **Children in the primary grades** may be challenged with the other basic skills, like inferring and predicting, and, with appropriate support, some older children may be ready to begin to practice more integrated skills (Padilla, 1990).

Inquiry in Exhibits for Young Children

Although various authors have defined inquiry in slightly different ways, several key concepts emerge consistently from these definitions. Most authors argue that inquiry includes:

1. **Exploring the natural world**, **which leads to a question** that is meaningful for the child and
2. **Finding an answer** to that question **by investigating the natural world directly** (Haury, 1993; Institute for Inquiry, 1996; Windschitl & Butterner, 2000).

As one source puts it, "Inquiry, as it relates to science education, should mirror as closely as possible the enterprise of doing real science" (Institute for Inquiry, 1996). In order to closely mirror the activities of real scientists, some authors stress that inquiry should go beyond asking questions and finding answers. The final stage of an inquiry should involve:

3. **Arguing the validity** of a answer in front of an audience (Windschitl & Butterner, 2000).

Each stage in the inquiry process involves a set of skills that must be learned and that can be greatly improved by practice. "Because inquiry is a concert of so many intellectual sub-skills, students can move from novice to expert inquirers only through repeated, teacher-supported inquiry opportunities" (Windschitl & Butterner, 2000).

Thus, although most authors stress the importance of allowing children to develop their own research questions, some authors suggest using **"structured" or "guided" inquiry**, especially as an approach for working with learners who have little experience with developing their own questions. This means that the teacher constrains the inquiry by providing the question and the means for finding a particular answer to it (Haury, 1993; Windschitl & Butterner, 2000).

How can we recognize when inquiry is taking place within an informal setting, especially a museum exhibit? The Exploratorium's Institute for Inquiry provides a number of online resources that can help in this process. For instance, the following description of inquiry includes a number of clues that could be used to recognize when inquiry is taking place (Institute for Inquiry, 1996):

- *The inquiry process is driven by one's own curiosity, wonder, interest, or passion to understand an observation or solve a problem.*
- *The process begins by the learner noticing something that intrigues, surprises, or stimulates a question. What is observed often does not make sense in relationship to the learner's previous experience or current understanding.*
- *Action is then taken through continued observing, raising questions, making predictions, testing hypotheses, and creating theories and conceptual models. The learner must find their own idiosyncratic pathway through this process; it is hardly ever a linear progression but rather more of a back and forth or cyclical series of events.*
- *As the process unfolds more observations and questions emerge, giving occasion for deeper interaction and relationship with the phenomena—and greater potential for further development of understanding.*
- *Along the way, the inquirer is collecting and recording data, making representations of results and explanations, and drawing upon other resources such as books, videos, and colleagues.*
- *Making meaning from the experience requires intermittent reflection, conversations and comparison of findings with others, interpretation of data and observations, and applying new conceptions to other contexts as one attempts to construct new mental frameworks of the world.*

A paper from the Vermont Elementary Science Project, also on the Institute for Inquiry Web site, lists a range of clues that an observer can use to recognize when inquiry is taking place (Vermont Elementary Science Project, 1995). When children are doing inquiry-based science, an observer will see that they:

- *View themselves as scientists in the process of learning*
- *Accept an "invitation to learn" and readily engage in the exploration process*
- *Plan and carry out investigations. Communicate using a variety of methods*
- *Propose explanations and solutions and build a store of concepts*
- *Raise questions*
- *Use observation*
- *Critique their science practices*

The full paper includes examples for each of these points that can help the observer determine if the criteria are being met (Vermont Elementary Science Project, 1995).

Learning Science through Play

In the literature on play in museums, we discovered a taxonomy or classification of play developed by Hutt (1981) and adapted to a museum setting by Rennie & McClafferty (2002). We adapted this taxonomy a bit further to better describe the range of play behaviors we might expect to see in an exhibit like *Outdoors Indoors* (Figure 1). Although games and ludic behaviors (like fantasy and repetitive play) come closest to what most people think of as children's play, Figure 1 also identifies a range of what Hutt called epistemic behaviors, which look and feel like play but result in the acquiring of information about the environment.

Rennie & McClafferty (2002) are probably correct in their claim that children's epistemic behaviors in museums are more apt to result in learning of new facts and concepts. However, we want to be careful not to dismiss the value of ludic play. Children need to process what they learn if they are going to find its personal meaning and remember it for long periods of time, and ludic play is a major way they accomplish that goal.

Role playing, in particular, seems like a type of ludic play that is well suited to an exhibit about the natural world. As LaVilla-Havelinn (1990) noted, "In a world increasingly dominated by 'spectator play,' role playing that engages all the senses is crucial. The child must experience the texture, time, sound, voice, and feel of another role." (p. 12). LaVilla-Havelin went on to list five types of role playing that children's museums in particular seem to encourage and then discussed each in depth:

- Role playing with props and objects that define the role and interaction
- Role playing within settings and environments that define the role
- Role playing in familiar situations, sometimes involving intergenerational role reversals
- Role playing to develop empathy with a specific culture
- Role playing that is pure fantasy (LaVilla-Havelin, 1990)

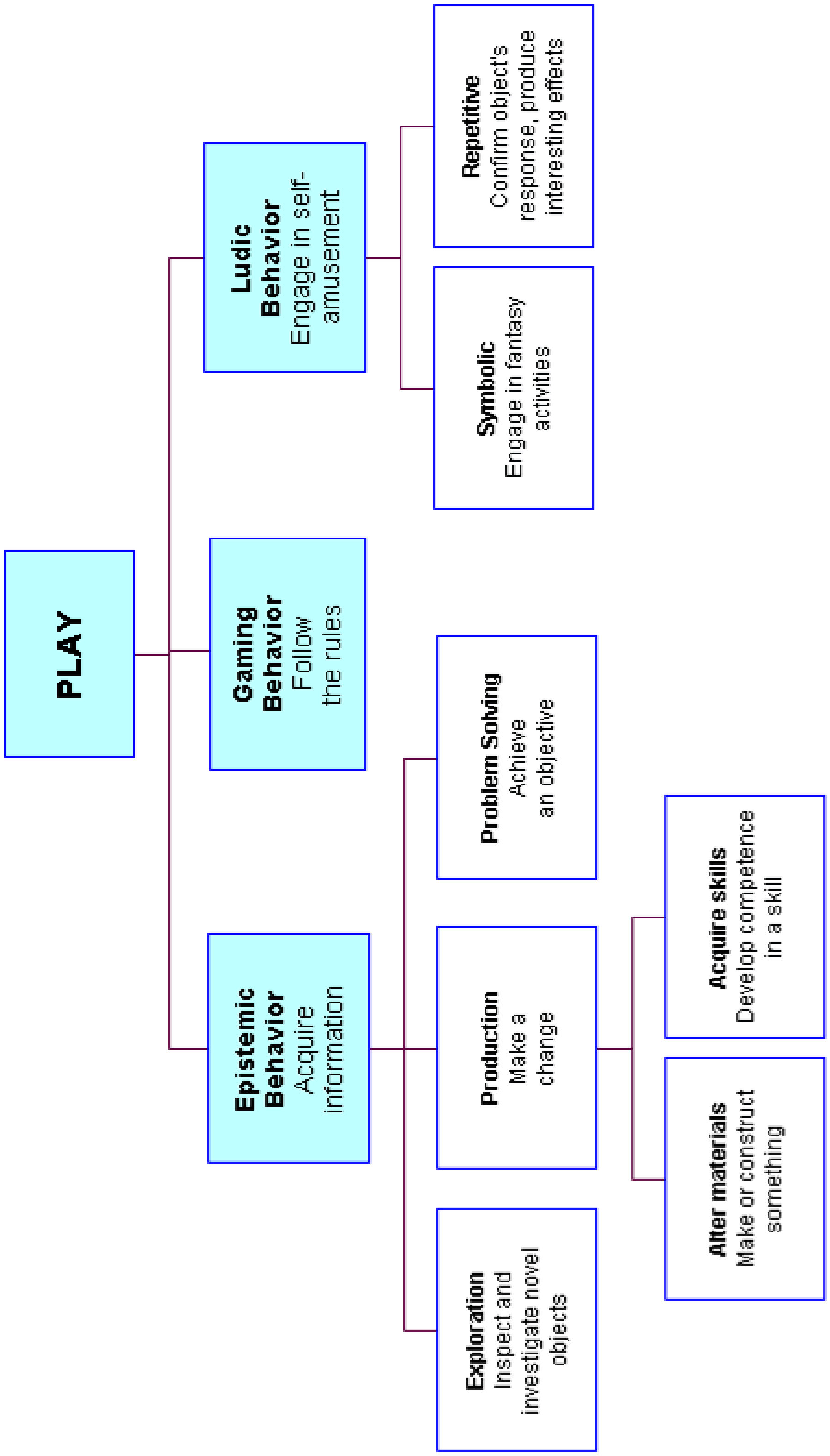

Figure 1. How young visitors play in museum exhibits. Adapted from Hutt's taxonomy of play (1981) and based on a figure in Rennie & McClafferty (2002).

We can imagine all five types of role playing contributing to children's science-related learning in *Outdoors Indoors*. For instance:

- Children might role play with scientific tools, as well as use them in "real" investigations. They may imagine with magnifiers and microscopes, as well as see with them.
- Children might play the role of field scientists as they investigate within the simulated habitats. As they do, aspects of the simulated habitat may guide the subjects they investigate.
- Because field scientists are adults, there will be intergenerational role reversal. We're concerned, however, that the unfamiliarity of scientific field work may constrain or stereotype children's play—perhaps suggesting that the exhibit should provide models of scientific behavior that may inspire new features in their play.
- Children's role playing may contribute to a developing empathy for an identification with scientific culture—or it may also help them develop empathy for living things if they take on those roles. Also, several authors discuss the psychological value of taking on the role of animals—both those the children favor and those they fear (Sobel, 1996).
- Finally, children may use the simulated habitats as jumping off points for fantasies that are beyond *our* imaginations.

Given Hutt's taxonomy (Figure 1), it seems quite natural to consider epistemic play and scientific inquiry to be complementary aspects of problem solving (Severide & Pizzini, 1984). "Scientists often solve problems most effectively and innovatively when they pursue solutions in a spirit of play…. The playful approach encourages people to bring all their experience to bear on the problem—it fosters the openness and awareness that lead to insight" (Severide & Pizzini, 1984, p. 58). That certainly seems like an appropriate style of play for *Outdoors Indoors*!

CHILDREN'S UNDERSTANDING OF THE NATURAL SCIENCES

What is known about children's understanding of the content areas being considered for the exhibits? In an earlier section we discussed how children and their families explore and learn about the natural world. In this section, we discuss the results of that learning.

Recent research is challenging what we thought we knew about young children's thinking in science and other domains (Gelman, 1999). Even young children have developed concepts about the world, and, surprisingly, these early concepts are not necessarily concrete or perceptually based. Even preschool children are capable of reasoning about subtle and abstract ideas. These concepts, in turn, reflect children's emerging "theories" about the world, which vary in their accuracy and are rarely complete (Gelman, 1999).

It's also worth noting that children can be more conceptually sophisticated in some subject areas than others (Gelman, 1999). Even young children may develop "islands of expertise" that allow them to think and reason about dinosaurs, trains, or some other narrowly defined subject in ways that seem well beyond their years (Crowley & Jacobs, 2002).

However, most authors we've read seem most impressed about the ways that children misunderstand the natural world. When children's concepts differ from those of scientists, some use terms like misconceptions, preconceptions, naive conceptions, naive theories, alternative conceptions, or alternative frameworks (Blosser, 1987). Although many authors seem to want to "fix" these alternative ways of thinking, others urge us to respect the thought that goes into children's conceptions of the world. Many children aren't just wrong—they are intelligently wrong (Ault, 1984). Regardless of how one thinks about children's alternative ways of thinking, experience shows that they persist. Perhaps it's best to think of what kids know as prior knowledge. Right or wrong, it's the starting point for future learning (Roschelle, 1995).

Children's Thinking about the Natural World

How do young children think about the natural world? One way to address this question is to look at children's overall relationships or attitudes towards nature. For instance, Kellert (1985) defined nine types of relationships or attitudes that children develop towards animals. He found that children's most common attitude towards animals was **humanistic**, a category for children who show a "primary interest and strong affection for individual animals, primarily pets." Other common attitudes among children are, in order of frequency:

- **Naturalistic**, "primary interest and affection for wildlife and the outdoors"
- **Negativistic**, "primary orientation an active avoidance of animals due to indifference, dislike, or fear" (the naturalistic and negativistic attitudes were negatively correlated)
- **Moralistic**, "primary concern for the right and wrong treatment of animals, with strong opposition to exploitation or cruelty toward animals"

- **Utilitarian**, "primary concern for the practical and material value of animals or the animal's habitat" (Kellert, 1985)

Kellert (1985) found that less common attitudes included the **dominionistic**, "primary interest in the mastery on control of animals typically in sporting situations," and **aesthetic**, "primary interest in the artistic and symbolic characteristics of animals." The least common attitudes were the **ecologistic**, "primary concern for the environment as a system, for interrelationships between wildlife species and natural habitats," and **scientistic**, "primary interest in the physical attributes and biological functioning of animals."

Naturalistic, dominionistic, and utilitarian attitudes were more common among younger children, while the naturalistic, moralistic, and ecologistic attitudes all showed sharp increases between eighth and eleventh grades. Based on Kellert's earlier studies, adults and children shared similar frequencies for the humanistic, negativistic, and moralistic attitudes. However, the naturalistic attitude was much more common in children, and the utilitarian view was much more common among adults (Kellert, 1985).

Related research, undertaken to develop the Hamill Family Play Zoo at Brookfield Zoo, found that children of different ages have different ways of thinking about animals' needs (Anonymous, 2001). Four- to six-year-old children tended to focus on human-oriented needs, such as a house or toys. Seven- to eleven-year olds shifted to an animal's point of view, including needs such as food, water, and companion animals. Not until children reach the ages of twelve to fourteen did they focus more on the elements of an ecosystem. Based on this, the Hamill Family Play Zoo developed age-appropriate activities, such as opportunities for younger children to pretend to be an animal or for older children to think more about animal needs by acting as a veterinarian.

Other studies also tested and extended Kellert's work, including Eagles & DeMare (1999), who adapted Kellert's attitude categories and scales for a study about children's environmental attitudes. They modified the statements in Kellert's instrument so that they referred to the environment rather than to animals or wildlife and then measured sixth graders' ecologistic and moralistic attitudes before and after a weeklong resident camp experience. Overall, the authors found that three factors showed significant associations with their measures of positive environmental attitudes:

- Talking about the environment at home
- Reading environmental books or magazines
- Watching environmental television or movies

Three factors did not show a statistically significant association with positive attitudes:

- Attending the weeklong summer camp
- Camping out with their family
- Talking about the environment in class at school

Although this sort of study doesn't really address causal mechanisms, the authors pointed out that the key influences were long-term and continuous and suggested that the media reinforce and deepen children's developing attitudes towards the environment (Eagles & Demare, 1999). It's also significant that the three really important factors most likely take place at home, including "talking about the environment at home," presumably with their parents.

Children's Understanding of the Proposed Content Areas

One of our favorite ways to think of young children's understanding of science is to talk about the development of "folk knowledge." This term stresses the shared, cultural aspects of children's understandings. Within a given culture, many children are going to understand things in the same way, and, as they grow, their understanding is going to become more similar to adults in that culture (Mintzes, 1989). Thus recent authors have written about children's **folkbiology** (Coley, Solomon, & Shafto, 2002), a term which is also applied to the ways that people in non-Western cultures think about the natural world (Medin & Atran, 1999). The theories of folkbiology are "informal, often intuitive ways of explaining the *what* and the *why* of the world. Folk theories play a central organizing role in determining how children (or adults for that matter) understand new facts" (Coley *et al.*, 2002). For instance, Tull (1991 and 1992) portrayed children's understandings about plants as, in essence, folk knowledge, gained from interactions with their peers and parents as well as other adults. Despite the fact that these children had studied many plant-related concepts in school, their ideas were frequently at odds with their science textbooks.

Due to time constraints, the rest of this section is organized, more or less, as a classified and annotated bibliography of the literature on children's understandings of the natural science topics proposed for *Outdoors Indoors*. For each topic, we suggest one key reading that reviews what is known in a relatively clear and succinct manner, plus one or two other papers that may be of interest to the developer and evaluator of the exhibits on that topic. When possible, we also provide a link to a more complete bibliography on the topic maintained on the senior author's MuseumDeveloper.net Web site.

Understanding the Life Sciences

General biology. Perhaps the best reference we have found for getting an overall feel for children's understanding of biology is the following:

Coley, J. D., Solomon, G. E. A., & Shafto, P. (2002). The development of folkbiology: A cognitive science perspective on children's understanding of the biological world. In P. H. Kahn, Jr. & S. R. Kellert (Eds.), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 65–91). Cambridge, MA: MIT Press.

In fact, the entire book is useful; however, we will provide in the packet we send *Outdoors Indoors* developers next week a copy of this article.

The following link includes a more complete listing of articles dealing with children's (and sometimes older folks') understandings of various aspects of the biological science:
http://www.museumdeveloper.net/understanding/underbio.htm

Living things, characteristics of life, and needs of organisms. There are many articles that cover this topic, and none of them is a clear best choice for our purposes. For the moment, we'll recommend the following article and include a copy in the packet:

Inagaki, K., & Hatano, G. (1996). Young children's recognition of commonalities between animals and plants. *Child Development, 67*(6), 2823–2840.

The Coley *et al.* (2002) article includes a short discussion of children's thinking about animism starting on page 67:

Coley, J. D., Solomon, G. E. A., & Shafto, P. (2002). The development of folkbiology: A cognitive science perspective on children's understanding of the biological world. In P. H. Kahn, Jr. & S. R. Kellert (Eds.), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 65–91). Cambridge, MA: MIT Press.

The following link includes a more complete listing of articles dealing with children's (and sometimes older folks') understandings of various aspects of this subject:
http://www.museumdeveloper.net/understanding/underbioclass.htm

Classification and identification of living things and their remains. The Coley *et al.* (2002) article includes a short discussion of children's classifications of living things starting on page 78:

Coley, J. D., Solomon, G. E. A., & Shafto, P. (2002). The development of folkbiology: A cognitive science perspective on children's understanding of the biological world. In P. H. Kahn, Jr. & S. R. Kellert (Eds.), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 65–91). Cambridge, MA: MIT Press.

Although some environmental educators want to de-emphasize identification and classification in children's learning about nature, here's something to think about when deciding how big of a role identification might play in *Outdoors Indoors*. Stein (2001) described two ways that people, including families and children, can explore the natural world—by experiencing nature and by naming pieces of it. To Stein, "words without experience" and "nameless experience" are both insufficient to help people acquire respect for nature. Simply being able to name natural objects, especially with broad category terms such as bush or tree, leaves the landscape a "green blur." At the same time, one needs names for things in order to be able to make connections, ask questions, and be thoughtful about nature. This suggests that an exhibit about the natural world needs to provide opportunities both for interacting with natural elements as well as learning how to talk about them.

Organisms' structures. We didn't find appropriate articles about how children think about the internal and external structures on non-human animals and plants

The following paper investigates children's understandings of their own internal organs:

Reiss, M. J., & Tunnicliffe, S. D. (2001). Students' understanding of human organs and organ systems. *Research in Science Education, 31*, 383–399.

Life cycles and reproduction. The Coley *et al.* (2002) article includes a short discussion of children's understanding of inheritance starting on page 73 and another section on growth and natural change beginning on page 77:

Coley, J. D., Solomon, G. E. A., & Shafto, P. (2002). The development of folkbiology: A cognitive science perspective on children's understanding of the biological world. In P. H. Kahn, Jr. & S. R. Kellert (Eds.), *Children and nature: Psychological, sociocultural, and evolutionary investigations* (pp. 65–91). Cambridge, MA: MIT Press.

Understanding the Earth Sciences

We recommend the following article because it nicely describes two of the biggest obstacles to children's understanding of earth history: Recognizing that incredible huge changes have reshaped Earth over geologic time and understanding the nature and meaning of bedrock.

Ault, C. R., Jr. (1984). The everyday perspective and exceedingly unobvious meaning. *Journal of Geological Education, 32*(2), 89–91.

The following link includes a more complete listing of articles dealing with children's (and sometimes older folks') understandings of various aspects of the earth sciences:
http://www.museumdeveloper.net/understanding/underprehistproc.htm

Streams, rivers, and erosion. This article is a good place to start learning about children's understanding of streams and rivers:

Dove, J. E., Everett, L. A., & Preece, P. F. W. (1999). Exploring a hydrological concept through children's drawings. *International Journal of Science Education, 21*(5), 485–497.

The following link includes a few more articles dealing with children's thinking about rivers:
http://www.museumdeveloper.net/understanding/underprehistproc.htm#Rivers

We didn't find an appropriate article about children's understanding of erosion.

The water cycle. The classic paper is by Bar:

Bar, V. (1989). Children's views about the water cycle. *Science Education, 73*(4), 481–500.

Here is a link to other articles about the water cycle and ground water:
http://www.museumdeveloper.net/understanding/underprehistproc.htm#WaterCycle

Rocks. This paper is a good starting point (although 6th grade children are beyond the upper end of the age range for the exhibit):

Ford, D. J. (2003). Sixth graders' conceptions of rocks in their local environment. *Journal of Geoscience Education, 51*(4), 373–377.

Here is a link to other articles about the rocks and related topics:
http://www.museumdeveloper.net/understanding/underprehistproc.htm#Rocks

Understanding the Ecological Sciences

Unfortunately, most of the literature that we have found so far on this topic investigates the understandings of children over the age of 10.

Here's one ecological topic that has been investigated with younger children:

Habitats and their inhabitants. Here's a really interesting investigation of children's understandings of forests and their life using a sample of 40 first-grade children from urban areas of Nebraska and New Jersey:

Strommen, E. (1995). Lions and tigers and bears, oh my! Children's conceptions of forests and their inhabitants. *Journal of Research in Science Teaching, 32*, 683–698.

This paper may also be useful. It looks at older British children's perceptions of what lived in two familiar natural habitats, ponds and woodlands:

Lock, R., Kaye, D., & Mason, H. (1995). Pupil perceptions of local habitats. *School Science Review, 76*, 57–60.

The following link includes a very short list of articles dealing with children's (and sometimes older folks') understandings of various aspects of the ecological sciences:
http://www.museumdeveloper.net/understanding/underenvironecol.htm

FAMILIES' EXPERIENCES IN NATURALISTIC EXHIBIT SPACES

Making Exhibits Feel Naturalistic and Immersive

What does it take to make an exhibit environment feel immersive and naturalistic for the target audience? The available literature provides few solid answers to this question, particularly for children ages 3–8. However, from the existing literature, we can do some educated thinking about factors that need to be kept in mind. By carefully choosing and pursuing certain factors during the development of *Outdoors Indoors*, and then evaluating the effect of those factors at various stages, this exhibit can ultimately contribute to what is known about making exhibit environments immersive and naturalistic for young children and their families.

At the outset, it will be important for the exhibit team to agree upon what they are trying to accomplish by creating an immersive and naturalistic environment, both so that appropriate steps can be taken to achieve those goals and so that it will be possible to measure the exhibit's success in meeting those goals. Does the team hope to attract and hold visitors by making a memorable and enjoyable experience, to enhance certain types of learning, or to stimulate particular types of behaviors? The literature suggests some ideas about the ability of immersive experiences to meet each of these goals.

Immersive Exhibits

Definition. The term "immersion" is used in different ways by different authors, and some otherwise knowledgeable museum professionals don't recognize the term (Gilbert, 2000). Bitgood (1990) defined "simulated immersion" as "the degree to which an exhibit effectively involves, absorbs, engrosses, or creates for visitors the experience of a particular time and place." Examples of this type of experience include walk-through caves in museums (Koran *et al.*, 1983), historical recreations in Greenfield Village in Michigan (Bitgood, 1990), and the "landscape immersion" exhibits created in many zoos over the last few decades (Hyson, 2001). Based on surveys and interviews with museum professionals, Gilbert (2000) recognized two distinct types of immersive exhibits:

- **Immersive environments**: Re-created realistic settings intended to make visitors feel as if they are visiting a particular time or place. These environments put the visitor into the story, "changing the exhibit from a static representation viewed from a single ideal station, into a holistic enveloping experience which the visitor can actively explore."
- **Immersive experiences**: Creating a situation and experience distinct from merely the physical re-creation of the environment.

Note that the first definition focuses on what the museum creates and the second on what the visitor experiences. By creating a setting that simulates natural woodlands or other natural habitats with activities that enable visitors to learn science process skills, it appears that *Outdoors Indoors* seeks to create both an immersive environment and an immersive experience.

Factors. Bitgood (1990) gives the following list of factors that may contribute to simulated immersion when used in various combinations. This list focuses mostly on the physical aspects of the experience in Falk and Dierking's model:

- Use of physical space
- Provision of environmental feedback
- Inclusion of multi-sensory stimulation
- Use of authenticity or object realism
- Use of "real time" or "dramatic time"
- Social involvement
- Use of text to prompt mental imagery to encourage visitors to feel immersed
- Artistic portrayal
- Lighting effects

In analyzing the use of physical space, Bitgood also found that exhibits with features that totally surround the visitor are not necessarily more immersive than a three dimensional object within a realistic background, such as a diorama. However, he indicated the question needs further study. Bitgood also found the evidence to be inconclusive about the effect of the presence of objects not found in the natural environment. For example, he noted there was no data to compare feelings of immersion in exhibitions with and without labels but reasoned that well designed labels do not necessarily have to interfere with immersion (Bitgood, 1990).

Two other studies looked closely at the physical aspects of the immersion experience. Harvey *et al.* (1998) investigated visitors' experiences of immersion and psychological flow in a newly renovated exhibit of large mounted mammals at what was then called the Denver Museum of Natural History. Their analysis demonstrated that the factors most responsible for visitors' feelings of flow and immersion were the interactive components, multisensory stimulation, and dynamic displays (e.g., videos of the animals in action). It's interesting that two of these components—the interactives and videos—seem somewhat at odds with the idea of re-creating an environment exactly. Perhaps that indicates that immersion is created by the visitors' reactions to the exhibit rather than by the exhibits themselves.

Jones & Wageman (2000) found that a number of factors influenced visitors' recognition of and immersion in exhibits that simulate particular human-built places, such as a microchip "clean room" and an operating room. Environmental features, such as flooring and lighting, helped visitors recognize these areas as different from the rest of the exhibit hall. The inclusion of real environmental elements from the actual places and authentic details helped create feelings of immersion. Including interpretive materials in these exhibits seemed to have a minimal impact on visitors' feeling of immersion, however, including exhibit cases did seem to disrupt the experience (Jones & Wageman, 2000).

Psotka (1995) analyzed how the feeling of immersion can be produced in synthetic environments. His analysis is important because it emphasizes the more personal aspects of the experience, especially the roles of imagination and individual differences in susceptibility to immersive experiences:

> *Immersion seems to be facilitated by the ability to control attention and focus on the new VR [Virtual Reality] to the exclusion of the real world. Being able to see parts of one's own body, even in cartoon form, adds to the experience. It also depends on the use of good visual imagination. There is a great range of individual differences in the experience of immersion in VR environments. The technological limitations are largely responsible, but temperamental differences among individuals result in different reactions to these limitations.* (Psotka, 1995, p. 409)

Some of these ideas—control of attention, exclusion of the real world, the roles of imagination and individual differences—may also be applicable to understanding immersion in the *Outdoors Indoors* environment. We speculate that because many children are used to living in imaginative worlds of their own creation they will be willing subjects for immersive experiences created by the museum.

The evaluators will continue to investigate the published and unpublished literature on factors that contribute to the immersive experience. The exhibit team and evaluators should work together to investigate visitors' immersive experiences in a simulated outdoor setting during front-end and formative evaluation.

Naturalistic Exhibits

Definition. The terms "natural" and "naturalistic" mean different things to different people. Hyson (2001) points out that the sorts of zoo exhibits that professionals and visitors recognize as "natural" have changed over the last century, and Spirn (1997) makes a similar point for gardens and landscapes. For purposes of this literature review, we propose the following working definition of a "naturalistic" exhibit: an exhibit designed to look like a natural setting (forest, seashore, cave, etc.) through use of dioramas, murals, backdrops, or more immersive environments.

Factors. Two evaluation studies about the success of dioramas can help us infer what factors might make an exhibit feel naturalistic. Perry *et al.* (1995) analyzed the reasons behind why the dioramas at the Chicago Academy of Sciences were so popular among visitors. From their findings, we can discern some elements that may have contributed to making the dioramas feel naturalistic:

- Identifiable animals and plants, especially large ones
- Scenes, such as of sand dunes or the prairie
- Details and realism
- Multiple layers
- Lighting and atmosphere
- Connections to specific familiar places such as the Great Lakes

Note that the physical aspects of the experience are the focus of this list, but the concept of familiarity implies that there is also a more personal aspect to the experience. For example, Perry *et al.* (1995) noted that the dioramas at the Chicago Academy of Sciences evoked a deep connection because they were specific to the area where visitors lived (for example, depicting Chicago or Great Lakes wildlife and prairie).

Korenic (1995) evaluated visitor responses to an exhibit at the Milwaukee Public Museum that combined dioramas with interactives intended to engage visitors in using science tools and processes. Korenic found that when looking at dioramas, visitors tended to be attracted to:

- The large size of an object
- Bright colors
- An unusual object
- Familiar objects
- Objects within lines of sight
- Recognizable objects though not commonly seen

Korenic found that intangible concepts such as food webs, animal social behavior, or decomposition processes were less likely to be named as an attracting feature. While Korenic was not investigating what made the dioramas "naturalistic," it may be useful to refer to these findings in considering elements to include in a naturalistic exhibit. In particular, the size and familiarity of objects are two factors that emerged as being significant to visitors in both Perry's and Korenic's studies, implying that it's important to take into account what would seem large and familiar to a 3–8-year old.

In addition, Korenic found during formative testing that the use of common names and vocabulary rather than scientific jargon and the use of familiar animals to demonstrate science tools or a concept were the most effective techniques for promoting understanding of the diorama and use of science process skills and tools. From this, we can infer that use of familiar ways of representing the natural world may contribute to both the naturalistic feel and educational effectiveness of the exhibit.

Exhibits that Seem Immersive and Naturalistic

The available literature does not specifically discuss how to make an environment feel *both* immersive and naturalistic. However, we can draw upon some of the literature to hypothesize about ways to do so.

One thread that emerges from the literature is that creating a sense of physically moving through a natural environment may be one way to make a naturalistic environment also feel immersive. Perry *et al.* (1995) reported how visitors described the experience of walking through the dioramas at the Chicago Academy of Sciences, which took up an entire floor, as being like a nature walk. As one visitor put it, "It was like I was in the big fat middle of it!…It seems like I'm walking 100 yards into the diorama…a forest path with footprints." An echo of this idea can be found in the discussion of "visual momentum" in Harvey *et al.* (1993). At the Denver Museum of Natural History, he found the presence of "visual momentum" in the form of consistent diagrams that demonstrated the relationship between dioramas and created graceful transitions between them.

Roberts (1997) does not directly discuss immersive and naturalistic environments. However, her work suggests some ways of thinking about how to create such exhibits. First, she identifies what she calls a culture of simulation, one in which appeal is found in simulations of realistic experiences. An interpretation of her discussion about the culture of simulation suggests that to create a realistic experience, three parts of an exhibit need to be considered: 1) the object, (2) signage or other "markers" that indicate how to interpret the objects, and 3) the context in which the objects are exhibited. According to Roberts, these elements can be combined in different ways to simulate a realistic experience. Traditionally, museums have focused on displaying authentic objects. However, Roberts posits that even if an object is not authentic, it can be part of a realistic experience if it is presented in the proper context. For example, for an exhibit about Linnaeus at the Chicago Botanic Garden, they could not procure the actual microscope Linnaeus used, but they were able to obtain an authentic 18th century microscope and present it with a label that says it is a microscope "like the one" Linnaeus used.

In summary, the literature on immersive and naturalistic exhibits focused mainly on the physical aspects of the experience, with a bit of discussion of the more personal aspects of immersion. There was some mention of the social aspects of the exhibits, such as conversation about what was seen in the exhibits or sharing personal experiences (Perry *et al.,* 1995; Schaefer *et al.,* 2002). However, the ways in which the immersive aspects of the exhibit may further these social aspects were not discussed. It seems to us that this may be extremely important, especially in the context of family groups. Based on our "unpublished" experiences as evaluators, educators, and parents, two aspects of the social experience seem particularly important to consider: the interactions of children with their parents and the interactions of children with their peers (both siblings and members of other groups). Parents can play a big role in shaping their children's experiences of the immersive environments with verbal cues, teaching moments, and fantasy play based on labels and their quick read of the physical aspects of the environment. Children's interactions with each other—particularly their joint fantasy play—can determine how they experience the environments. Will they explore the cave as scientists or as pirates in search of buried treasure? Will they search the woods for birds and insects or flee from imaginary bears and monsters? The literature provides few if any clues on how to influence families' interactions within such environments, but the social aspects of the exhibits could be a focus for the later stages of the evaluation.

How Families Behave in Naturalistic Exhibits

What is known about how parents/caregivers and children behave in naturalistic exhibit environments? Studies of two different naturalistic exhibits suggest that behavior will be different in naturalistic compared to non-naturalistic spaces. However, they also suggest that behavior within naturalistic spaces will vary depending on the type of space.

Schaefer *et al.* (2002) observed the following types of behaviors in the Underground Experience area of *Underground Adventure* at The Field Museum (where visitors pretend to get shrunk and then enter an environment that simulates being underground with larger than life-size bugs):

- Reading labels

- Talking to other group members
- Standing and looking
- Touching
- Climbing
- Pushing buttons
- Sitting and relaxing
- Running through walkway
- Sitting on video monitors
- Dancing to music

Of these, touching (water droplets or texture on the walls) and climbing (in cicadas) seem to be the most directly attributable to naturalistic features in the exhibit. More playful behaviors, such as running, sitting on monitors, and dancing, arguably were encouraged by the naturalistic space. In contrast, for example, the Mud Room area of the Underground Experience is a more conventional space with counters, chairs, and computer monitors. There, observed behaviors were also more conventional, such as sitting, standing, looking, and pointing in front of interactives. These findings suggest that a naturalistic space might make children in particular less inhibited, leading to behaviors that are more varied, more physically active, or more typical of the outdoors.

Perry *et al.* (1995) noted that the dioramas at the Chicago Academy of Sciences provided ample opportunity for play, such as making up games around the exhibit, hunting for things in the dioramas, and identifying animals and plants. Respondents also participated in imaginative play, such as fantasizing that they were on safari.

Neither of these reports discussed the exhibit elements that may have contributed to the more playful and imaginative aspects of children's behavior in these spaces. However, our "unpublished" experiences as evaluators, educators, and parents—including experiences in the exhibits described in these reports—suggest that the more immersive aspects of both types of exhibits can lend themselves to imaginative play. In addition, Sykes' (1992) study of how children relate to exhibits at the Please Touch Museum found that exhibits with familiar components tended to draw children in, make them feel relaxed and comfortable, and lead to more pretend play. In contrast, exhibits with novel components tended to excite and challenge children and were more likely to convey new information. Extending this reasoning to the natural world, it seems likely that children would react in a similar way to familiar and novel natural environments. Developers of *Outdoors Indoors* will want to think about ways to influence children's play in ways that will help support the goals of the exhibit.

In a study of another type of naturalistic space, dioramas at the Milwaukee Public Museum, Korenic (1995) found an entirely different type of behavior. Visitors tended to look from afar or look while walking (a behavior Korenic calls browsing) and to talk. The contrast to behaviors found in the Underground Experience is not surprising given the differences in the spaces. While the Underground Experience was designed to put visitors inside the naturalistic space, traditional dioramas are designed for visitors to look at from outside the naturalistic space. It should be noted that when interactives were added to the dioramas at the Milwaukee Public Museum, manipulation, or touching, became the most commonly observed behavior. Taken together with Schaefer's findings, this indicates that certain behaviors, such as touching, can be encouraged in a naturalistic environment given the right combination of features.

Families' Affective Responses to Naturalistic Exhibits

What is known about parents'/caregivers' and children's affective responses to naturalistic exhibit environments? In particular, what makes a space seem comfortable and safe to explore for both children and the adults who care for them? The existing literature indicates that affective responses to naturalistic spaces may be either positive or negative. The responses depend both on the type of environment created and the perceptions of the visitor (which is, of course, more part of the personal context than the physical context of the exhibit).

In the Underground Experience, Schaefer *et al.* (2002) found that most young children under the age of five experienced fear. Elements that contributed to the fear included the oversized animals and darkness. For families with children who could not overcome their fear, this was a negative affective response that prevented them from enjoying the exhibit. However, among elementary/preteen age children, Schaefer noted that there was a positive side to the fear. These older children had a scary but fun feeling that intrigued them enough to go back into the exhibit area, and they were later proud of overcoming their fears.

Interestingly, for some children, the fear was associated with wondering whether the experience was real. In other words, the simulation was so strong that they wondered if they had really been shrunk and were really underground. Adults were observed touching or inviting the children to touch the bugs, roots, and soil so they could see that it wasn't real. This raises an interesting contradiction for those seeking to create a realistic experience through naturalistic and immersive exhibits. These findings suggest that achieving a realistic experience also has the potential for creating negative affective responses among some young visitors.

Some adult visitors also experienced a very different response related to the authenticity of *Underground Adventure*. Some visitors described the experience as "fake" and said they felt like they were in an "inexpensive" version of Disney (Schaefer *et al.*, 2002; C. Garibay, personal communication, Oct. 31, 2003). We wonder if visitors' immersion in the exhibit undermined the very properties that help more traditional dioramas maintain their illusion of reality.

The research we found on more traditional dioramas generally found positive affective responses on the part of visitors. In a study of how visitors interpreted the dioramas at the Milwaukee Public Museum, Korenic found they provided a reflective experience for visitors over the age of twelve, evoking feelings such as imagining, reminiscing, valuing, or appreciating. They had this effect, according to Korenic, because they transported visitors to another place. Other factors that contributed to these affective responses, according to Korenic, included that the dioramas were located in peaceful places with carpeting, subdued lighting, and low visitor traffic. Perry *et al.* (1995) found similar affective responses to the dioramas at the Chicago Academy of Sciences. For example, visitors reported that the dioramas provided a restorative experience, an opportunity for escape and relaxation. Some visitors also appreciated the dioramas as works of art because of their detail and realism.

Finally, for those visitors who interpreted the dioramas as representing the past, they experienced a sense of loss and responsibility for the land's destruction.

Finally, both the research literature (Wandersee, 1979; Wandersee & Schussler, 2001) and Selinda's experience as evaluators (C. Garibay, personal communication, Oct. 31, 2003) suggest another facet of affective response to the natural world that may be relevant to consider. Families, and children in particular, often are especially attracted to animals, more so than plants. This presents a challenge regarding how to help families see some of the more interesting aspects of plants.

Family Learning in Naturalistic Exhibits

What is known about how parents/caregivers and children learn within naturalistic exhibit environments? The existing literature suggests some different kinds of learning that can take place in naturalistic exhibit environments. For example, visitors may learn in cognitive, sensory, or affective ways, depending on how the exhibit is set up. The literature also suggests that visitors may tend to engage in one of these modes of learning as the primary mode for a particular exhibit.

Korenic (1995) found that dioramas, when combined with interactives, could be used to promote learning of cognitive skills. Visitors who used interactives in conjunction with the dioramas showed better understanding of science processes and tools than those who viewed the dioramas alone. Interactives that were placed nearby and that prompted visitors to look at and use parts of the dioramas seemed to work the best. The combination, for example, of seeing science tools in context in the diorama and being able to touch and manipulate actual tools in an interactive was particularly effective. Also, as noted above, Korenic found that the use of familiar vocabulary and animals provided a cognitive entry point to the learning experience for visitors. However, Korenic found that with interactives there was a decrease in the number of visitors who treated the diorama as a "reflective experience." In other words, Korenic concluded cognitive improvement came at the expense of affective response. Korenic's study seems particularly relevant given OMSI's similar goal of improving children's science process skills.

Naturalistic exhibit environments may be able to promote learning through affective responses, particularly if they are also immersive. Bitgood (1990) contends that learning associated with immersion is more experience driven than information driven. Instead of emphasizing the acquisition of facts and concepts, an immersive exhibit seeks to provide a more pervasive understanding of the subject, including feelings such as experiencing another time or place, curiosity, or excitement. While Bitgood does not specifically discuss learning in naturalistic environments, it is not hard to imagine that a naturalistic environment has the potential to evoke emotional responses. Note that Bitgood, like Korenic, tends to view affective learning as a way of learning "instead of" cognitive, information learning, although he does not specifically conclude that one way is in conflict with the other.

Naturalistic exhibit environments may also be able to facilitate learning through the senses. Stoinski (no date) cited some limited evidence that suggests zoo visits are linked to increased interest in and understanding of conservation. In particular, two studies found that visits to naturalistic gorilla exhibits compared to traditional exhibits increased interest in conservation issues, in particular the need for habitat preservation. Other studies also found a pro-conservation shift in attitude after exposure to live animal demonstrations. Several studies have tied this interest in conservation issues to conservation action, Stoinski reported. While Stoinski does not discuss the possible reasons for this effect, it seems reasonable to infer that simply seeing and watching the behavior of real animals in a habitat setting was one way that visitors gained an interest in conservation issues. Perry (2002) identified a type of learning called "wrap-around learning" that develops through the senses, often in immersive experiences. It results in a physical understanding but also has a sensory and holistic component to it, according to Perry. For example, a story time about an imaginary fishing trip turned into a wrap-around learning experience when it culminated in cleaning, cooking and eating some fish. Naturalistic environments have the potential to engage multiple senses such as touch (for example, animal fur or leaf textures), hearing (for example, animal sounds) and smell (for example, plant scents).

How Families Orient within Naturalistic Exhibits

Another question in the topical framework was, what is known about how parents/caregivers and children orient themselves within naturalistic exhibit environments? We have found very little literature that specifically addresses this question. However, it may be useful to attempt to think about orientation both in terms of cognitive and physical orientation to environments and then investigate what is known about those two issues.

Several studies in museums suggest that, to orient themselves cognitively in a naturalistic exhibit environment, visitors need to know the extent to which what they are looking at is "real." This helps them establish a conceptual framework for interpreting and applying what they see in the exhibit.

While it will be obvious to most adults that the overall setting of an indoor simulated naturalistic environment is not "real," previous studies suggest that visitors will wonder whether individual elements are real. In a study with visitors to the Field Museum of Natural History, many wondered about the authenticity of the objects on display or assumed they were real unless the museum indicated they were replicas. However, when asked to estimate the overall number of replicas versus real elements in the museum's exhibits, most visitors overestimated the number of replicas because it seemed unrealistic to them to think that "such good stuff" could be real (Gyllenhaal, Perry, & Forland, 1996; Perry & Forland, 1995). As previously noted, the inherent authenticity of exhibit elements as well as how they are presented by the museum will determine visitors' understanding of what is real.

If the exhibit includes both living and preserved specimens, experience indicates this will add a challenge to children's interpretations of what is real. Observations of young visitors to zoos and museums suggest that the meaning of the term "real" changes with the context. When a zoo animal failed to move, children asked whether or not it was real, suggesting that, in this case, "real" meant the same as "alive." When children looked at preserved animals in a museum, they interpreted a "real" animal as one that was once alive but is now dead (Tunnicliffe, 1996). Perhaps the question, "Is it real?" can help younger children develop their understanding of what it means to be alive. The difference between how young children and adults perceive and understand what is real is further discussed in the next section of the review.

To begin thinking about how visitors may orient themselves physically within a naturalistic exhibit environment, we can borrow some concepts from Kevin Lynch's work on how people orient themselves within cities. To understand a city's layout, people create mental maps, according to Lynch, that contain five key elements—paths (means of travel, such as roads or trails), edges (other lines such as seashores), districts (distinct sections), nodes (areas of concentration such as a busy intersection) and landmarks (objects that aid wayfinding). Some of these elements could be included in a naturalistic exhibit environment to help visitors find their way around the exhibit (such as with a "nature trail") and find each other (for example, by meeting at a "landmark"). However, it is worth noting that, for young children in particular, part of the appeal of a natural environment lies in having the opportunity to wander freely and discover "secret spaces" (Michener, *et al.,* 2002). Because part of the idea of a naturalistic exhibit is to create a contrast from city space, care should be taken in extending Lynch's principles. For example, some parts of the exhibit may remain "pathless."

Finally, an element that will affect both cognitive and physical orientation is the extent to which the exhibit simulates or refers to actual specific places rather than just a generic outdoor environment. At the Chicago Academy of Sciences, Perry *et al.* (1995) found that visitors found dioramas to be particularly compelling when they depicted places that were known or familiar to visitors. This may have implications for how the traveling version of the OMSI exhibit is developed.

EXTENSION AND SYNTHESIS

In this section, we tie together the findings from the earlier sections of the review before making preliminary recommendations about how to proceed with the project. Here are two important points that readers should keep in mind as they read this section.

- **We introduce some new concepts**. As we pulled together the many threads introduced earlier in the report, we found that we needed to introduce some new concepts and approaches to thinking about learning in exhibits, ones that cut across the categories that were originally defined in the topical framework. For instance, we discuss the PISEC criteria for family-friendly exhibits here because they have implications for all aspects of family interactions in a museum, including family learning about science and family experiences within naturalistic exhibits. Similarly, the applicability of knowledge hierarchies to evaluating family learning should be more obvious now that we looked at the broad range of research on family learning about science in museum settings.

- **The literature is often suggestive but rarely prescriptive**. For instance, some of the most promising lines of research in describing and understanding how families learn about science are only a few years old. The researchers are only beginning to suggest general guidelines for exhibit development, but they can't prescribe specific approaches to achieve specific learning objectives in museum settings. Although we can and do cite guidelines that should increase family interactions around exhibit units (e.g., the PISEC criteria for family friendly exhibits), we can't say up front, for instance, how different label formats will affect different types of learning for families with different ages of children. However, once label text is drafted, we can test for those sorts of effects during formative evaluation. Despite the extensive findings discussed in this review, iterative prototyping and formative evaluation will still be the key to developing a successful exhibition.

Defining the Key Issues

Based on a synthesis of the literature cited in this review, what appear to be the key issues that will need to be addressed during the design and development of *Outdoors Indoors*? Here is our list, which the exhibit development team should feel free to expand on:

- **Types of experience provided**. Given that the proposed *Outdoors Indoors* exhibit will combine elements of indirect and vicarious experiences, two lessons can be drawn from the literature: the importance of building in opportunities for spontaneous or playful behavior and for relating the exhibit experience to opportunities for direct nature experiences.

- **Age-appropriate environments and activities.** Within the target age range of 3–8, there will be significant differences in cognitive and affective responses to exhibit elements.

- **Degree and types of adult involvement**. Parents will have a range of levels of knowledge about nature and be interested in participating in different types of activities (for example, experimental vs. playful activities) to varying degrees, and the exhibit will need to accommodate these different interests. Based on other settings designed to serve children, floor staff may need to facilitate involvement by both parents and children in some of the exhibit interactives. We make more specific recommendations in the final section of the report.

- **Use of naturalistic and immersive elements**. One key decision that the team will need to consider is the degree of naturalism and immersion desired for the space. For example, will efforts be made to create a realistic level of simulation or a feeling of being surrounded by nature? Or will the exhibit simply suggest a natural environment through props? What kind and how many real, as opposed to simulated, objects will be placed in the setting? Given that these types of elements will likely be relatively expensive to create, their intended effect should be carefully considered in deciding upon the degree of naturalism and immersion to create. A central challenge for a naturalists exhibit will be how best to use an environment that is inherently an indirect experience of nature to achieve the desired cognitive goals. These decisions should be coordinated with the goals of the exhibit and the answers to the many other questions posed (and sometimes answered) in this synthesis.

Clarifying the Goals and Objectives of the Project

It is critical for the *Outdoors Indoors* team to select and articulate its primary goals for different aspects of the exhibit. For example, should the exhibit promote cognitive, affective, or sensory learning as its primary goal? The team may want to consider whether it is desirable and realistic to promote different goals in different parts of the space. This will enable the team to develop exhibit components with an eye toward achieving particular results. At the same time, the team should use the research to anticipate the potential effects of proposed exhibit components, including unintended consequences such as negative emotional responses. As noted above, this articulation of goals will also enable effective evaluation of the exhibit's success.

The *Outdoors Indoors* team will need to decide whether this is primarily an exhibit about:

- **helping families learn science processes**,
- **helping families learn natural science concepts,** or,
- **helping children learn how to explore and appreciate** the natural world.

From the NSF proposal, it seems the first two goals are the main focus of the project but, as we've talked about the exhibit with OMSI staff, it seemed like the third goal was also of some importance. Our concern is that it seems that one set of approaches may be more appropriate if the intention is to encourage exploration of the natural world, and another if the intention is to help children learn science processes, and a third may be more appropriate for learning specific concepts within natural science domains. We are not certain how well these different approaches can all be incorporated into the same relatively small exhibition.

For example, one theme that seems to emerge from this review is that children see nature as a place to play, and young children develop a greater appreciation of nature if they have the opportunity to explore freely on their own. However, it seems likely that parent participation would be necessary if children are going to learn about science. How can the exhibit team find an appropriate balance between children exploring on their own and children engaging in adult-mediated experiences? That question remains to be answered, and the answer will depend to a large extent on the goals of the exhibit.

Structuring Goals and Objectives for the Project

Here's an idea to consider when structuring the goals and objectives for visitor learning of natural science facts and concepts within the exhibits. The 3–8 years age range for the exhibit encompasses a huge range in developing abilities and understandings of the natural world, and that range is even larger when we consider that parents will also be learning in the exhibit. Perhaps the general goal for the exhibit units might be, "Everyone should learn something appropriate to their developmental stage, previous background, and degree of interest." However, to give more structure to the objectives for specific exhibit units, we might want to think in terms of two concepts: knowledge hierarchies and nested concepts.

Describe learning within a hierarchy of understanding, like the Knowledge Hierarchy described by Perry (1993) or the Learning Levels used by Borun *et al.* (1998). For instance, Table 1 presents a knowledge hierarchy developed for an exhibition about soil. A knowledge hierarchy presents a range of visitor understandings about a certain topic, but it is more than just the range of things that visitors know about the topic, and it is more than just the range of things that exhibit developers hope to communicate. A knowledge hierarchy emerges as the data, in this case visitor interviews, are analyzed *within the context* of the conceptual information that might be included in the exhibition. The hierarchy is based on the assumption that inherent in each exhibit is an internal knowledge structure, located at the intersection of the exhibit developer's and the visitor's organization and understanding of the topic (Perry, 1993). The knowledge hierarchy usually describes five or six levels of understanding, which characterize the full range of how visitors think about a topic, generally by increasing levels of sophistication. As such, knowledge hierarchies are a way of helping us understand and address the needs and interests of a greater proportion of our complex audiences (Perry, Garibay, & Gyllenhaal, 1998).

Selinda Research Associates has found that it is reasonable to expect visitors to move up one level of a hierarchy in a well-designed exhibit. The key is to determine which level visitors are starting on, so the exhibit can focus on the conceptual leap that will be most appropriate for the museum's audience. Starting with a general hierarchy like the one depicted in Table 1, the evaluators developed more specific hierarchies about individual topics related to soil.

Table 1. Knowledge hierarchy representing visitors' understandings about soil, developed as part of the front-end evaluation for an exhibit at the Field Museum of Natural History (Perry, Garibay, & Gyllenhaal, 1998).

Level 0:	"Don't know and don't care." Visitors at this level had not thought much about the soil and hadn't developed any particular interest in it. Visitors at this level *can* develop a curiosity about soil, it's just that they haven't thought about it much on their own, prior to the interview. (The interview itself was often able to get them interested in certain topics.)
Level 1:	"Don't know, but I was wondering." These visitors had formed questions about the soil in their minds, but they hadn't yet developed answers to their questions. (They sometimes began to work out their own answers during the interview.)
Level 2:	These visitors were interested enough in the soil that they had formed some understanding of it, but their ideas were unsophisticated, largely incomplete, and sometimes incorrect in important ways.
Level 3:	These visitors had a fairly accurate *basic* understanding of the soil, although they were fuzzy or sometimes incorrect on the details.
Level 4:	These visitors had a more sophisticated and accurate understanding of the soil and could often articulate detailed information about one or more aspects of soil systems. These visitors often had a background in college-level science or direct experience working with the soil.
Level 5:	These visitors had a very sophisticated understanding of the soil and included people who had studied soil extensively or had chosen a soil-related career.

For instance, by looking more closely at visitor understandings of soil's role in ecosystems, evaluators discovered that most visitors had a basic understanding of the concepts (Level 3) and were ready to understand the various relationships between soil and other living things. Looking at a hierarchy of visitor understandings about how soils change over time, evaluators found that most visitors were at level 2 or lower. Most visitors did not appear particularly interested in the whole concept of soil changing over time; some seemed to resist the idea that soil changed naturally over time; and some visitors attributed changes to the negative impact of human activities. This implied that exhibit developers needed to concentrate on visitors' awareness and interest in soil changes, rather than focusing on concepts about how soil changes over time (Perry, Garibay, & Gyllenhaal, 1998).

Although the hierarchy in Table 1 was developed for a front-end evaluation, Selinda staff have also used knowledge hierarchies for formative and summative evaluations. Once specific learning goals for *Outdoors Indoors* have been developed, we can use the literature on how children understand the topics of the exhibits to begin to get an understanding of what the hierarchy of understanding might look like and develop tentative knowledge hierarchies for individual exhibits. This understanding then could be tested and expanded during the formative evaluations of the exhibit units.

Develop exhibits that reveal "nested concepts." As Selinda staff have completed summative evaluations over the last year or so, they have noted a number of interactive exhibits that seem to help visitors on different levels of a knowledge hierarchy all move up a level through exposure to the same rich experience. Understandings gained or deepened by visitors who are on the lower levels of a hierarchy are prerequisites for developing higher-level understandings (Garibay & Gyllenhaal, 2003). Developing a higher-level understanding is enabled by nested concepts.

One example of an exhibit with rich, nested concepts was an interactive exhibit about cold fronts at a science museum. By activating the interactive, visitors first filled a clear chamber with warm fog and then released a wedge-shaped body of cold air that pushed the fog up and out of the way. Preschools and their parents often focused on the fog and its properties. Older children and their parents already understood what fog was, so they more often talked about the interaction of the cold and warm air and what that implied about the physics of air ("warm air rises"). Some adults and teens, who already understood fog and the interactions of cold and warm air, recognized that the interactive was a working model of cold fronts discussed on the TV weather report, and they talked about their experience on this more advanced level (Garibay & Gyllenhaal, 2003).

Of course, a water table or sand box is also a rich conceptual environment with opportunities for multiple outcomes. The interesting thing about the cold front interactive was that:

- The possibilities for conceptual learning were more constrained within the goals of the exhibit.
- Each level of understanding was a prerequisite for the next higher level.
- The nested concepts fit well with the range of understandings (or knowledge hierarchy) for the audience for the exhibit.

To the extent that *Outdoors Indoors* will try to help its family audience learn about natural science concepts, one goal could be to develop interactives with nested concepts accessible to family members of different ages.

Implications for *Outdoors Indoors* Exhibits and Programs

What are the implications of this research for *Outdoors Indoors*? We discuss a few of them in this section and in some cases make more specific recommendations in the final section of the report.

Raising Parents' Awareness of Their Roles in Facilitating Learning

What are the best ways to raise parental awareness of the importance of playing an active role in their young children's learning? We will use this section to give some examples of what other institutions have done in this regard, but we will resist the temptation to make more specific recommendations—they would depend greatly on decisions that have yet to be made about the goals and design of the exhibition.

One way to raise parental awareness of the importance of their involvement in their children's learning might be to share some of what is known about the influence of parental involvement on their children's development. In particular, parents can be educated about how their participation in nature activities affects how their children perceive and understand nature throughout their lives.

Experiences by children's museums suggest that this information needs to be shared in a way that is credible, understandable, and easy to access. For example, children's museums have found several ways to share information with parents (Beaumont, 2002), including to:

- **Mount labels where parents can read them as their children interact with the exhibits**. Some children's museums found that parents didn't stop and read such labels for very long and, therefore, took down the graphics panels and instead provided take-home handouts. However, the Children's Museum in Indianapolis redeveloped their original set of labeling for parents, which they characterized as too long and academic. They found labels could be successful if the messages were simply and clearly stated in a few words and in a conversational style (Beaumont, 2002). One approach to structuring these labels would be to include two kinds of information in every label:
    - **What's happening**. Describe what parents are probably going to see their children doing at the exhibit.
    - **What it means**. Explain how these behaviors contribute to children's development (L. Beaumont, personal communication, November 7, 2003).

  As to where these labels could be located, the senior author's recent experience evaluating science museum labels suggests that parents are more apt to read labels at exhibits where their children can be engaged for long periods of time without much need for supervision and help.

- **Construct a family resource room** with books, pamphlets, and other materials for parents (Beaumont, 2002). Experiences with similar resource centers in science museums suggest that they can serve a variety of other purposes as well, including (a) a reference library for staff and volunteer training; (b) an area for pre-school children to rest, play, and unwind; and (c) a place for parents and grandparents to rest their weary feet. If such an area is developed for *Outdoors Indoors*, it will be important to (a) make sure sitting caregivers still have a clear view of any of their children who are still in the exhibits, (b) include small interactives or toys that can occupy infants and toddlers as their parents read or rest, and (c) allow enough space for children and adults to use the space together (Gyllenhaal, 1998). From the *Outdoors Indoors* grant proposal, we understand that visitors to OMSI's *Busytown* exhibit don't take time to read materials in the exhibit. Perhaps providing an appropriate reading space might increase parental reading.

- **Provide handouts throughout the exhibit near areas where parents may wait or linger**. At one children's museum, handouts, in contrast to graphic panels that used to be displayed on the walls, were easy for parents to take home and were written with simple, easy to understand messages (Beaumont, 2002). Unfortunately, there were no follow-up studies to find out to what extent parents actually used the information at home.

- **Find subtle ways to communicate expectations to parents**. For example, at one children's museum's water table, there were aprons for children that say, "Play with me," and adult aprons for parents that said, "I came to play." At the train table, staff noticed that when children stood around the outside of the table their parents could only see the backs of their heads and not their faces. Parents were missing their children's reactions and excitement, which would have invited parents to respond. So the museum installed pop-up holes near the center of the table, where children stand and work with the trains at their own height. This also allowed the child to face the parent on the outside of the train table and have conversations as they played (Beaumont, 2002).

One or more of these approaches may be appropriate for *Outdoors Indoors*. Unfortunately, we have not yet discovered any formal evaluations of these approaches, so we can't say how well they achieve their goals in various contexts.

Finally, we might ask, what exactly should OMSI be telling parents about how to interact with their children? That, of course, could be the subject of an entire book. However, as a starting point, here is some advice from Eheart & Leavitt (1985) (cited in Beaumont, 2002). They found that parents' responsiveness was the key to supporting the play of toddlers and used that as the basis for the following recommendations:

- **Observe** your children's play
- Take advantage of **opportune moments** for expanding their play in deeper or new directions
- **Encourage** your children to explore and experiment with materials in their own ways with the least amount of direction
- **Allow** your children to be as independent as they are able
- **Avoid interrupting** your children's play unless absolutely necessary, in which case, adequate warning should be given

- **Let your children know you are interested** in what they do by **encouraging them to talk** about their play
- **Be available** to your children for assistance when needed

Or, perhaps, parents would benefit from being exposed to the concept of "scaffolding," a term that Jerome Bruner and others have used to refer to a particular kind of assistance and support that adults can provide to children (Wood, Bruner, & Ross, 1976, cited in Beaumont, 2002). Bruner defined scaffolding as the way in which adults help a child as he or she is solving a problem or mastering a task by performing or directing the parts of the task that are beyond the child's capability. Adults can provide either physical or verbal assistance, and Bruner suggests that they do so by following definite steps:

1. **Recruitment:** Is the child interested? If so, invite them to participate in the task. Can the child be successful even without adult help?
2. **Demonstrate solutions:** Model or demonstrate a possible solution that may be more appropriate than the one the child has chosen.
3. **Simplify the task:** Break the task down into smaller tasks that the child can readily accomplish on his or her own.
4. **Maintain child's participation:** Encourage the child to be persistent. Keep them focused on the goal.
5. **Provide feedback:** Show the child what their mistakes are, what they are doing well, and what they still need to do.
6. **Monitor and control** the child's frustration (Wood, Bruner, & Ross, 1976, cited in Beaumont, 2002).

Of course, museum staff and volunteers also could provide scaffolding for young visitors, model scaffolding for parents, or even scaffold for parents who are trying to learn a new task. Since so many of the steps require one-on-one feedback from an adult, the exhibit itself cannot provide scaffolding in Bruner's sense. However, exhibit labels might advise parents on how they can help scaffold their children's learning within the exhibit.

OMSI has an opportunity to break new ground in this area, particularly if the attempts to influence parents' interactions with their children are tested and improved during formative evaluation and then evaluated in greater depth during the summative evaluation.

Encouraging Cognitive Development

What are the best ways to help young children learn facts and concepts, develop science process skills, and engage in inquiry? In this subsection we give some general guidelines to consider, based on discussions in other sections of the literature review. In the recommendations section, we give some more specific suggestions about how to facilitate and recognize when families are doing inquiry within the exhibit.

As we consider these questions, we can recall that, although naturalistic and immersive environments seem especially well suited to creating affective responses, studies of dioramas have demonstrated that they can also be used to support cognitive development when activities are carefully combined with naturalistic and immersive elements.

With regard to inquiry and science process skills, the research cited in this report suggests that:

- The team needs to focus on science process skills that are most appropriate to the **age range** of children coming to the exhibit.
- The team needs to focus on science process skills that are most appropriate to the **topics** covered by the exhibits.
- Younger children and even adults will need support with many science process skills.

Perhaps the learning of inquiry and process skills could be enhanced in the following ways:

- **Encourage children to role-play as scientists** within the exhibit.
- **Provide a space for in-depth investigations** within the exhibit. These could be modeled, in part, on the Hands-On Labs located in several OMSI science exhibits. However, it might be useful to investigate the possibilities for a more open setting like the counter-top Activity Station in the Science Museum of Minnesota's Experiment Gallery. A smaller version of this used to travel with the *Traveling Experiment Gallery* (Gyllenhaal, 1998).

Encouraging Affective Development

Since we don't know how important affective goals will be to the exhibit team, we won't make specific recommendations in this area. However, here are some guidelines about how to help families encourage their children's emotional development, which were gleaned from what zoos around the country are doing. For example, the goal of the Hamill Family Play Zoo at the Brookfield Zoo is to help children develop a caring attitude toward nature; it focuses on communicating at an emotional level rather than specific science concepts or encouraging specific action. While much of the Hamill Family Play Zoo does not attempt to create a naturalistic setting indoors, it does seek to teach about nature in a primarily indoor space, so it may offer some applicable lessons.

Mikenas (2001) reported that, in developing the Hamill Family Play Zoo, they found one key was to help adults understand the importance of nature experiences for their children's development and to provide suggestions on how to easily provide these experiences for children at home. In addition, Mikenas found the following factors to be important:

- **Promote experience** with a special adult (through the presence of trained staff or volunteers)
- **Start with the familiar**
- Provide opportunities to **practice caregiving**
- Provide opportunities for **authentic experiences**
- Allow for **spontaneous interactions, play, and learning**

- Create opportunities for **extraordinary moments** and offer the creation of memories

Again, some of these approaches might be appropriate for *Outdoors Indoors*, depending on the primary goals for the exhibit.

Encouraging Families to Explore the Natural World

What are the best ways to encourage families with young children to explore the natural world? The existing literature does not offer definitive answers to this complex question. However, some guidance can be gleaned from the literature discussed above and from those whose work is devoted to encouraging young children's exploration of nature. We will cite this literature here but defer making more specific recommendations until we have a better understanding of the exhibit team's goals and resources in this area.

To encourage young children to explore the natural world, not only when they are young but also throughout their lives, several guidelines have been suggested:

- **Aim to instill a love of nature.** Sobel (no date) argued that for young children especially, it is important to first help them develop a love of nature before overwhelming them with messages about global environmental problems.
- **Start with and connect to familiar environments**. The importance of familiarity is stressed in several places within this review. Make sure to provide connections to local/regional environments where families may spend time. For example, this may even include backyards and information about local/regional plants. Efforts should be made to introduce children to vocabulary, skills, and concepts that can be applied in their real world. This means careful thought will have to be given to whether portions of the exhibit can be tailored for different regions in the traveling exhibit version.
- **Provide age-appropriate activities**. For instance, for children approximately ages four to seven or eight, Sobel (no date) contends that they first need to develop emotional empathy for creatures of the natural world.
- **Provide opportunities for unstructured exploration.** The Brookfield Zoo, on its Web site, noted the importance of giving young children the opportunity to play freely in local natural environments. As noted in previous sections, this includes providing some opportunities for children to explore independently without direct parental participation (*The Need for Nature Play*, 2001). This not only facilitates children developing independent connections with nature but also allows parents to play one of their desired roles, that of "time-out taker" who gets to use the museum as an opportunity to take a "timeout" from parental demands.
- **Involve children in nature in stages.** Cornell (no date) proposed a Flow Learning™ model as a way to structure and develop activities to get children involved with nature. The four stages of the model are: Awaken Enthusiasm, Focus Attention, Direct Experience, and Share Inspiration. (For details, visit their Web site: http://www.sharingnature.com/FlowLearning.html#Read)

At the same time, Sobel and the Brookfield Zoo have noted that the involvement of an adult who teaches respect for nature is also an important component of children developing a love of nature. The literature previously discussed suggests that some parents need assistance with playing such a role. To help parents help their children explore the natural world, several guidelines can be considered:

- **Provide interpretation that gives parents the knowledge they need to help their children better understand and appreciate nature**. To do so, museums need to first understand parents' knowledge and comfort level with nature topics so they can build in the right level of information (C. Garibay, personal communication, Oct. 31, 2003).
- **Provide ideas for activities that involve both parents and children**. See, for example, Nature Activities (no date) on the Brookfield Zoo Web site.
- **Educate parents about what constitutes age-appropriate activities for their children** (L. Beaumont, personal communication, 2003; Schauble, 2002).
- **Provide or guide parents towards natural environments where they feel their children can explore safely** (C. Garibay, personal communication, Oct. 31, 2003; Moore, 1990).

The *Outdoors Indoors* grant proposal mentions that the project will include a "take-home family activity guide to reinforce exhibition content and encourage parents to take their children outdoors to extend the learning process." Selinda Research Associates has evaluated similar materials developed for somewhat different settings (Garibay, 2001; Garibay *et al.*, 1999). The senior author of those studies made the following recommendations (C. Garibay, personal communication, Nov. 4, 2003):

- **Be realistic about what families are willing and able to accomplish.** Families are busy and don't necessarily have a lot of free time. Even though they are at home, families won't necessarily take the time to do activities that are longer (e.g., an hour) or those that require extended times for follow up (e.g., checking in on an experiment every few days). Our formative evaluations found these put a burden on parents, who weren't always happy about the extent of time things took.
- **Don't try to do too much with incorporating various school-related skill sets**. For instance, we found that well-intentioned but overly structured initial activities incorporating math and reading skills often detracted from the point of the activity. For example, children wanted to cut open fruit and vegetables they were given for an activity rather than start by writing out the names of all the fruit and vegetables on a worksheet.
- **Provide a variety of short activities, each of which can be done in one sitting**. Families in our study tended to do one activity and then were ready to move on to something completely different, like dinner, watching TV, and so forth. They liked the idea of having a variety of activities that they could spread out over a couple of weeks.
- **Families will engage in extended activities only if they are really compelling**. More often, children lost interest in longer activities, and, when they were getting

ready to do part two of an activity a few days later, they had often forgotten the point of the activity. (Planting seeds where something actually sprouts might be an exception, because there's something cool that happens to reinvigorate kids' interest in the activity.)

- **Relevance and application to children's everyday world was, as noted many times in this review, very important**. The activities that worked best at home were things that children could relate to their everyday world.

- **Parents preferred activities that they could do with *all* their children, regardless of age or ability**. The activities that worked best were ones that each child could engage with on his or her own level. Even if younger children didn't get a lot of scientific content out of an activity, parents wanted to involve them in some aspect of it. It was also easier for parents to help older children if their younger ones were kept busy.

- **Parents need guidance, particularly if it is a topic they don't know a lot about**. We found that being clear about both the messages and logistics of activities was important. This included:
    a. Goal of the activity
    b. Some summary statement/info on what kids were supposed to learn
    c. Time the activity took
    d. List of everything that was needed
    e. Age range for which activity was suited

- **However, parents can feel overwhelmed by too much information.** Resist the impulse to give them too much background information. With whatever you do write, use the "inverted pyramid" style, covering the most critical information first and adding details later in the text.

- **Develop activities that use simple and easily obtained materials**. In general, the more time it takes to get everything a family needs for an activity, the less likely it is families will do it.

Implications for the *Outdoors Indoors* Evaluation

What are the implications of this research for the later stages of the evaluation of *Outdoors Indoors*? We are just beginning to explore this question, and we hope to discuss it with the *Outdoors Indoors* exhibit team before we take our answers too far. We regard the following suggestions as a starting point for this discussion.

Indicators of Success

What does prior research suggest are appropriate predictors of success and criteria for measuring engagement and learning for this target audience and in this context?

An approach that Selinda Research Associates has used successfully is to collect data on three types of visitor engagement with an exhibit: physical, social, and intellectual. These are usually recorded during unobtrusive observations of visitors conducted within a protocol developed in consultation with the client.

Thinking about visitor learning of facts and concepts, if the objectives of individual exhibit units are expressed in hierarchical form, then we could also gauge what visitors learn from the exhibits within that framework. How we investigate learning will depend on the age of the visitor. It will most likely require a combination of observations and interviews.

As we plan how to evaluate learning of science process and inquiry skills, we might use the previously mentioned descriptions of science process skills and how to recognize that inquiry is taking place. We could develop:

- **Exhibit development guidelines**. The project team may want to assemble a list of guidelines that exhibit developers and designers can use as they plan individual exhibit units.
- **Heuristic evaluation tool**. The evaluators and exhibit team could work together to develop a tool that staff can use to evaluate designs and early prototypes *before* they go out on the floor.
- **Evaluation protocols for formative and summative evaluations**. These protocols could be developed as the evaluators make plans for the formative evaluation of exhibit prototypes and the summative evaluation of the finished exhibit.

These could then be applied at appropriate times through the exhibit development process. We take a first stab at this approach in the recommendations section, but, once again, we need to know more about specific goals and objectives for the project before we can go much further.

Prototype Testing

What are the best ways to test exhibit prototypes with this audience (parents and children ages 3–8)? Ideally the exhibit prototypes will be tested in an OMSI exhibit space using a rapid-prototyping process so that results from the formative evaluation can immediately inform design/development decisions. Research questions could include:

- Can visitors use this component successfully?
- What seems to work well?
- What doesn't work as well?
- What are visitors taking away from this experience?
- How can this component be improved so that more visitors will be able to be more successful?

Selinda Research Associates has had success answering these sorts of questions using a combination of unobtrusive and participant observations combined with intercept interviews of the participants. Based on the observations and interviews, we can begin to get an idea of what visitors would be likely to learn from the exhibits within the framework of the learning hierarchies defined for each exhibit.

Testing Naturalistic Elements with Families

One important question that is yet to be answered is how much effort will it take to produce appropriate feelings of naturalistic immersion in the target audiences? Two ways to answer this question would be:

- Assemble a simulated forest or other natural environment using cheap, easily obtained materials and then bring in families, so we can observe how children interact with the environment.
- Conduct a study of visitors at a museum that already has an environment at a desired level of detail, so we can study its impact on visitors' experiences.

The evaluators need to discuss this issue with the *Outdoors Indoors* team to determine if either of these approaches would work.

RECOMMENDATIONS

Encourage Caregivers and Children to Engage Together

What are the best ways to engage parents/caregivers and young children in exhibits together, and how might this vary with the ages of the children? This has been studied extensively in museum settings, and much of this research was summarized by the PISEC group, as described by Borun *et al.* (1998). They described "seven characteristics of family friendly exhibits" based on evaluating and modifying four exhibits at four institutions.

- **Multi-sided**: family can cluster around exhibit
- **Multi-user**: interaction allows for several sets of hands (or bodies)
- **Accessible**: comfortably used by children and adults
- **Multi-outcome**: observation and interaction are sufficiently complex to foster group discussion
- **Multi-modal**: appeals to different learning styles and levels of knowledge
- **Readable**: text is arranged in easily understood segments [realizing that parents will do most of the reading]
- **Relevant**: provides cognitive links to visitors' existing knowledge and experience

These seven characteristics are intended to be generalizable to other informal learning institutions, such as aquaria, zoos, science, and natural history museums. Borun *et al.* also pointed out that these criteria are not meant to replace exhibit characteristics related to specific cognitive and affective objectives but rather are an additional set of exhibit criteria.

We recommend that the exhibit team carefully consider each of the seven criteria as they develop individual exhibits. It may not be possible, or even necessary, to achieve all of these characteristics in all parts of a naturalistic exhibit environment. However, they should serve as a critical point of reference during development because Borun *et al.* have carefully conceived these characteristics based on concrete, well-documented testing with families. OMSI may want to refer to specifics of the different exhibits that were tested, particularly in planning prototypes and formative evaluation.

Conveying Messages to Family Groups

From the preceding review and discussion, it seems obvious that **parents are going to mediate almost all communication** between the exhibit and the family group. Although a few six- through eight-year olds (and older children) may read labels when they need to figure out what something is or how it works, more often parents (or other caregivers) will take on the roles of learning enhancer, visit facilitator, and vocabulary supplier for their group.

Whatever messages developers want to communicate to families will need to be:

- **Easy for parents to find** (rather than buried within a lot of text or sequestered on a label that's far from where families are interacting with the exhibit)
- **Easy for parents to read** (text is short, to the point, and chunked in ways that facilitate scanning)
- **Communicating something important to parents who only glance at the headline** (suggesting the need to avoid cute titles and puns and inside jokes in label headers)
- **Reflected at all levels of the label hierarchy** (because parents may only read interactive instructions and object labels at that particular exhibit)

Supporting Parents' Varied Roles

To support the full range of parental roles, *Outdoors Indoors* will need to help parents meet the full range of physical, emotional, and intellectual needs of families. By helping parents fulfill all their roles, *Outdoors Indoors* can increase the chances that parents will have the time and energy they need to support their children's learning.

Note that our recommendations fall into at least four broad categories:

- **Gallery architecture** (larger scale features)
- **Exhibit design** (of individual exhibits)
- **Signage**
- **Interactions with gallery staff**, which imply **careful recruitment and training** of paid and volunteer staff

Because *Outdoors Indoors* is a traveling exhibition, OMSI staff may need to work closely with the host institutions to make sure as many needs as possible can be met.

What follows are recommendations for each of the roles outlined by Dockser (1989, 1990) based on our experiences as evaluators and parents.

- **Planner:** Clearly communicate at the entrance what the exhibit is about and how much time families should plan to spend there.
- **Timekeeper:** Put one or more clearly visible clocks in the exhibit (so parents don't have to fumble for a watch or ask other parents for the time).
- **Follower:** A wide-open exhibit area, with clear sightlines, will make it easier for parents to keep track of their children. An exhibit entrance with a parent-operated gate will help parents feel less nervous if they temporarily lose track of a child.
- **Visit facilitator:** Dockser (1989) defines this role as "helping their children manage difficult or inaccessible aspects of the museum." The best support might be to limit the number of difficult or inaccessible aspects in the exhibit. However, an exhibit

that tries to serve a target audience as broad as three to eight years of age is bound to have some aspects that work well for eight-year olds but present difficulties for three- and four-year olds, both with exhibits that inspire physical play (like climbing) and intellectual engagement. Perhaps the only advice we can give is to 1) keep in mind that parents will have to deal with this issue and 2) provide options that younger children can be directed to, which will serve some of the same needs (e.g., low things to climb as well as tall things).

- **Protector:** Dockser (1989) pointed out that parents need to protect their children from both environmental dangers (which can be minimized by careful design) and physically dangerous or disruptive encounters with other children. A design approach to the second type of danger might be to include two or more copies of elements that may be particularly popular. A programmatic approach would be to train gallery staff to intervene in appropriate ways so that parents don't feel the need to control the behavior of other people's children.

- **Rule maker, interpreter, and enforcer:** Dockser (1989) found that parents didn't always know what the rules and expectations were in some museum situations. This might be a particular problem if the rules for *Outdoors Indoors* differ in important ways from the usual rules and expectations established by a host institution. This problem might be addressed through careful and sensitive use of signage and through careful and sensitive training and supervision of gallery staff. If the volunteers at a host institution are used to doing things a certain way, they may need special training to help them adapt to the *Outdoors Indoors* way of doing things.

- **Social mediator:** To some extent this role might be supported by establishing clear guidelines for social behavior in the exhibit (such as limiting time on an interactive) and by encouraging gallery staff to enforce these guidelines in appropriate ways. However, interactions with gallery staff are, themselves, an aspect of the experience that some children will want to have mediated by their parents. Gallery staff will need to be trained in appropriate ways to approach and interact with young children—as well as to recognize situations where they should not approach or should withdraw from an interaction.

- **Learning enhancer:** This type of support is discussed in the next section.

- **Vocabulary supplier:** This can be supported by paying careful attention to labeling, especially at the lower levels of a label hierarchy.

- **Long-term learning facilitator:** This is also discussed in the following section.

- **Promoter of positive self-esteem and independence:** This can be supported by designing exhibits that can be used successfully by all ages (because children often blame themselves when they can't succeed) and by designing interactives that don't malfunction very often and that are easily repaired when they do (because visitors can't always tell when an exhibit is not working, and children sometimes blame themselves when they can't get an exhibit to work).

- **Socializer:** Designers can support this role by including several adult-sized chairs (or a long bench) near exhibit areas where children are apt to engage in extended, independent play.

- **Time-out taker:** Although there is plenty of research supporting the value of parent-child interactions within museums, exhibit developers and gallery staff need to realize that parents sometimes need a break. When parents just need to rest, the gallery architecture can help meet that need by (1) providing seating that is close to individual exhibits where children may need some support but not actually part of the exhibit (so parents can rest until their help is needed) and by (2) providing seating in positions that give a clear overview of the exhibit area. During gallery staff training, paid and volunteer staff should be reminded that they are rarely in a position to pass judgment on a parent who chooses to take some time for themselves rather than engaging with their children at an exhibit.

  Developers should also realize that, once their children's needs are met, some parents may take time to look after their own needs as learners. At times like this, they may be interested in learning more about the subject matter of the exhibit (from labels, pamphlets, or books), or they may be interested in learning more about their children (in ways described in the Synthesis section).

Because Dockser (1989, 1990) limited her study to mothers accompanying a single four-year-old child to the museum, she did not devote much attention to the needs of mothers with infants and toddlers or to the needs of parents with several children spread over a broad age range. Here are some suggestions to help meet the needs of parents who take on these roles:

- **Infant areas**. Provide multiple areas where parents can place and amuse their infants close to where their older children are playing.

- **Restrooms**. Provide restrooms close to or, better yet, inside the exhibition area (with changing tables in both men's and women's rooms).

- **Nursing area**. Provide a semi-private nursing area inside the exhibition with both features to amuse older children and a clear view of the rest of the exhibit. Make sure gallery staff are trained to support the needs of nursing mothers by keeping an extra eye out for their children and by deflecting possible objections by other visitors (which may vary according to the host institution).

- **Strollers**. Provide places to park strollers both at the exhibit entrance and (for those with sleeping children in their strollers) at strategic locations within the exhibit.

Supporting Parents' Roles as Science Partners and Mentors

The earlier section entitled Learning Science Within Families demonstrates many of the things that parents do to support their children's learning about science processes and science concepts. Some of these are listed in Table 2. *Outdoors Indoors* exhibits should be designed, and labels written, in ways that will support these sorts of parental behaviors.

Balancing Parent-Child Interactions and Child Independence

Perhaps the key here is to realize that parents are ultimately in the best position to decide on an appropriate level of interaction with their child. For a given child at a given point in time, fostering independence may be a much more important goal than any learning goal set by the exhibit team, and parents are the only people who are going to be in a position to make that choice. Perhaps the best roles that the exhibit team could play in this process would be these:

- **Provide interpretation, aimed at parents, that helps them appreciate the value of the things they already do**. See the section on Learning Science Within Families and Table 2 for ideas about what this interpretation might emphasize.
- **Design rich exhibit experiences that can be used either with parental support or independently by the child**. Perhaps an ideal situation would be to develop exhibits that both encourage joint epistemic play by parents and children but also allow for independent ludic play by children once they understand the potential of the exhibit. (These terms were defined in the section entitled Learning Science Through Play.)

Behaviors that May Serve as Indicators of Success

Of course, indicators of success for *Outdoors Indoors* can't be finalized until the goals and objectives are more clearly defined. However, assuming the exhibit team wants to encourage inquiry in the exhibit, we have made a first stab at listing behaviors that the evaluators might look for that would indicate inquiry is taking place (Table 3). Note that this table is based in part on the sorts of naturally occurring parent-child interactions that are listed in Table 2 and in part on the descriptions of inquiry in more formal settings described in the section of the report entitled Inquiry in Exhibits for Young Children. Following Ash (2000), we contend that "by talking science the family is doing science" (p. 2), and that the most important behaviors will be overheard as snatches of naturally occurring conversation at the exhibits. We would recommend using Table 3 as a starting point to be tested and revised as part of the formative evaluation of exhibit components.

Table 2. Things parents do that appear to support their children's learning about science. (Based on Callanan & Jipson, 2001; Crowley & Callanan, 1998; Crowley, Callanan, Jipson, Galco, Topping, & Shrager, 2001; Crowley & Galco, 2001; Crowley & Jacobs, 2002.)

- **Provide explanations**. Answer their children's causal questions with explanations that deal with causal mechanisms or outcomes.
- **Focus on the particular**. Focus on particular events that catch their children's attention, providing a narrative about that particular experience.
- **Give "explanatoids**." Give explanations that, although simple and incomplete, are very relevant to whatever the child is focusing on.
- **Focus on evidence**. Help children notice, collect, and interpret evidence in ways that help them make inferences, generate explanations, and construct new theories.
- **Make connections**. Help children connect the museum experience to the children's previous experiences.
- **Model discovery**. Model various aspects of scientific discovery for their children by showing them how to formulate questions, find answers, and test predictions.
- **Show their values**. Show their children that they value knowing about the causes of events.
- **Define domains of knowledge**. Help their children define the domains of knowledge within which a particular event can be explained.
- **Support developing expertise**. Help children talk, read, and learn about their passionate interests, thereby developing collaborative "islands of expertise."

Table 3. Behaviors that might indicate that families are engaging in inquiry in *Outdoors Indoors*. Following Ash (2002), conversation is considered a vital part of the inquiry process. Note that this list has not yet been tested in an exhibit setting. (Based in part on Ash, 2000, 2002; Institute for Inquiry, 1996; Vermont Elementary Science Project, 1995, as well as the references listed for Table 2.)

- **Observations**. Children and parents stop and attend an exhibit, making observations and communicating them to others in their group.
- **Domains**. Based on conversations, it's clear the family is dealing with this experience within the domain of science (or perhaps in another domain that also uses inquiry as a process).
- **Questions**. Children ask questions on their own about what they see and do at the exhibit.
- **Responses**. Children respond to questions that their parents ask with closer observations or with words.
- **Explanations**. Parents or children propose explanations for what they see and do.
- **Evaluation**. Parents or children evaluate their explanations through conversation and argument.
- **Testing**. Parents or children try to test their explanations based on what they can observe and do at the exhibit.
- **Evidence**. Parents and children talk about the evidence for or against a particular explanation.
- **Connections**. Parents or children discuss their experiences or evaluate their explanations based on other experiences they have had, connecting what they do in the museum to other aspects of their lives.
- **Roles**. Children talk about themselves as investigators, detectives, discoverers, or scientists, or parents point out that they are taking on those roles.
- **Better answers**. Children and parents talk about how well they were able to answer a particular question and what they might need to produce an even better answer.

As exhibit development proceeds and the goals and objectives of the project become clearer, we can develop other lists and evaluation protocols based on the research and evaluation results included in this review. As things currently stand, this would be more appropriately done during formative evaluation than as part of the front-end evaluation.

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APPENDIX 1. Topical Framework for the Literature Review

Topical Framework for the *Outdoors Indoors* Literature Review
Draft 3
10/10/03
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I. Families' Experiences in Museums

We will focus on this aspect of the social context of museum visits.

A. What is known about how families learn in museums and similar informal education institutions?

B. What is known about how families explore the natural world, and how parents interact with their kids during these explorations?

C. How do parents think about their roles in museums and in their children's learning and development?

D. What have been the outcomes of previous attempts to shape parent's interactions with their children within and beyond the museum walls?

E. What are the implications of this research for *Outdoors Indoors*?

1. What are the best ways to engage parents/caregivers and young children in exhibits together, and how might this vary with the ages of the children?

2. What are the best ways to raise parental awareness of the importance of playing an active role in their young children's learning?

3. What are the best ways to give parents the tools and techniques they need to encourage their children's interest in science?

4. What are the best ways to encourage families with young children to explore the natural world?

F. What are the implications of this research for the later stages of the evaluation of *Outdoors Indoors*?

1. What does prior research suggest are appropriate predictors of success and criteria for measuring:
   a. Learning for this target audience and in this context?

b. Engagement and interest among this target audience and in this context?

2. What are the best ways to test exhibit prototypes with this audience (parents and kids ages 3–8)? What are appropriate contexts? What are appropriate methods?

II. Children's Learning about the Natural Sciences

We will focus on this aspect of the personal context of museum visits.

A. What is known about how children learn science within their families?

B. What is known about how children learn science in informal settings?

1. How can we facilitate learning in open-ended and hands-on exhibits?
2. How can we facilitate inquiry in exhibits for young children?
3. How can we facilitate the development of science process skills in exhibits for young children?
4. How can we facilitate learning through play?

C. What is known about what children understand and how children learn within the content areas being considered for the exhibits?

1. How do young children learn about the natural world today?
2. How do young children think about the natural world?

Note: For the following content areas, we will recommend and provide copies of key papers rather than discussing the literature in depth in the review.

3. Content area: Life sciences
   a. Living things and the characteristics of life
   b. Needs of organisms (e.g., plant growth in different conditions)
   c. Organisms' structures (e.g., bird beaks, tree leaves, and bark) and their functions (e.g., animal movement and senses, flying seeds)
   d. Life cycles and reproduction (simple genetics)
   e. Identification and classification of living things and their remains (e.g., leaves, skulls, insects, sounds, etc.)

4. Content area: Earth science
   a. Streams, rivers, erosion
   b. Water cycle
   c. Rock comparisons

5. Content area: Ecology
   a. Habitats: Steam, forest, tree, soil, cave, meadow

b. Organisms within habitats
c. Dependence of animals on plants (e.g., food chains and webs)
d. Interconnections between living things and their environments
e. Organisms change their environments (e.g., bird nests)
f. Humans and their natural and constructed environments
g. Humans as stewards of the natural environment

D. What are the implications of this research for *Outdoors Indoors*?

1. What are the best ways to help young children develop science process skills?

2. What are the best ways to help young children develop an understanding of basic concepts in the natural sciences, including ecology?

3. What are the best ways to give parents the tools and techniques they need to encourage their children's learning in these areas of science?

E. What are the implications of this research for the later stages of the evaluation of *Outdoors Indoors*?

1. What does prior research suggest are appropriate predictors of success and criteria for measuring learning *within these content areas* for this target audience and in this context?

III. Families' Experiences in Naturalistic Exhibit Spaces

We will focus on this aspect of the physical context of museum visits.

A. What does it take to make an exhibit environment feel *immersive and naturalistic* for the target audience?

B. What is known about how parents/caregivers and children *behave* in naturalistic exhibit environments?

C. What is known about parents'/caregivers' and children's *affective responses* to naturalistic exhibit environments? In particular, what makes a space seem comfortable and safe to explore for both children and the adults who care for them?

D. What is known about how parents/caregivers and children *learn* within naturalistic exhibit environments?

E. What is known about how parents/caregivers and children *orient themselves* within exhibit naturalistic environments (e.g., research on spatial layouts and cognitive maps)?

F. What other aspects of the exhibit could be inspired by children's responses to natural environments (e.g., types and uses of natural materials, etc.)?

G. What are the implications of this research for *Outdoors Indoors*?

1. What are the best ways to help families with young children to explore *Outdoors Indoors* in ways that will encourage their development?

2. How can the exhibits help families feel appropriate ranges and balances of affective responses within the exhibit (e.g., excitement, fear, safety, challenge, accomplishment, etc.)

3. What are appropriate ways to help families orient themselves within the exhibit, both physically and conceptually?

4. What are cost effective ways to create the illusion of being in particular environments for the target audience (e.g., through the use of models and other reproductions, backdrops, lighting, sounds, etc.)?

H. What are the implications of this research for the later stages of the evaluation of *Outdoors Indoors*?

1. What does prior research suggest are appropriate predictors of success and criteria for measuring children's *behavioral, affective, and cognitive responses* to these sorts of exhibit environments?

2. What are the best ways to test *naturalistic* exhibit elements with this audience (parents and kids ages 3–8)? What are appropriate contexts? What are appropriate methods?

IV. Synthesis

Note: This section will be sketchily developed in the first draft of the review. We plan to expand and complete this section in later drafts as we discuss the findings with the exhibit team.

A. Based on a synthesis of the literature cited in this review, what appear to be the keys issues that will need to be addressed during the development and design of *Outdoors Indoors*?

B. Given what we've learned from the literature, what appear to be the most appropriate ways to resolve the issues within the context of *Outdoors Indoors*?

C. Given what we've learned from the literature, what appear to be the most appropriate ways to approach the evaluation of *Outdoors Indoors*?