*Marvelous Molecules: The Secret of Life*
Summative Evaluation
for the New York Hall of Science
Serrell & Associates

**Introduction**

*Marvelous Molecules: The Secret of Life* is a 3,500-square-foot exhibition installed on the lower exhibit floor of the New York Hall of Science (NYHoS) between *Hidden Kingdoms* and *Realm of the Atom*. The 27 exhibit elements are grouped in sections that feature molecules for sensing, moving, reproduction, defending, and other biological functions. The big idea of the exhibition is: *Inside what appear to be very different living things, molecules interact in similar ways to make things happen*.

In Spring 2001, a summative evaluation of *Marvelous Molecules* was conducted by Serrell & Associates. NYHoS staff and the other exhibit developers wanted to find out how visitors used the exhibits, which exhibit elements were most successful, and if visitors were getting the big idea. We wanted to know which elements attracted the most visitors, how long visitors spent at them, and what new things they learned from them.

The exhibition had been open since October 1999, and remedial evaluation was conducted by Letitia Doggett in November-December 1999 (see separate Remedial Evaluation Summary report). Findings from the remedial evaluation were used to make changes to the exhibition, mainly through edits in text panels and by adding object labels to the cases. Many of the findings, recommendations, and conclusions from the remedial report are echoed in this summative report and will provide useful guidelines for future exhibition development.

The first part of this report presents the evaluation methods used and general findings from each; the second part reviews eight selected elements in *Marvelous Molecules* in detail; and the final section discusses problems with each method and gives a brief wrap-up and recommendations.

The Appendix contains sample data sheets, spreadsheets of the timing data, and the full transcriptions of the interview data.

**Methods**

Three methods were used in the summative evaluation: station photos, focused observations, and dyad interviews. Each is explained below. We chose these three methods because together they would give a good overview of what people did in the exhibition and what they got out of it. Randomly selected casual adult and family visitors were the target audience (no school or tour groups) for the evaluations.

Four data collectors were hired and trained by Serrell & Associates to observe and talk with visitors on weekends in February and March 2001. NYHoS assisted with recruitment and provided minimal supervision while they were working on site. A "tool box" of supplies and equipment was made accessible each weekend and stored during the week. Data collectors reported on their progress each week to NYHoS and Serrell & Associates by e-mail.

Evaluation methods were applied to eight selected exhibit elements in *Marvelous Molecules*:

| *Component #* | *Element title* | *Abbreviations* |
|---|---|---|
| 2.01 | Build Molecular Models | Build |

| | | |
|---|---|---|
| 3.02 | Structures Made of Molecule Complexes | Structures |
| 3.03 | Zoom into Structures | Zoom |
| 5.01 | Smell--Different Shapes of Odor Molecules | Smell |
| 5.02 | Sensing Puzzles | Odor Puzzle |
| 6.03 | Medicines from Nature | Medicines |
| 7.01/7.03 | DNA | DNA |
| 8.07 | Shared Chemistry of Obtaining Energy | Food |

These elements were chosen because they represented a spectrum of topics, modalities, complexity, and amount of interaction. See Figure 1 for the locations of these exhibits on the floor plan.

Raw data sheets and tapes of interviews were mailed to and analyzed by Serrell in Chicago. Preliminary findings were presented and discussed at NYHoS in May 2001.

Station photos

Photographs were taken of the exhibits over a period of six hours on different days to cumulatively record the numbers of visitors attending to the exhibits. Photos were taken with a digital camera by Biology Department assistant Neyra Bermudez from a balcony overlooking the exhibition area. This panorama included a good view of about 15 of the 27 exhibits. Sixty-five images were made, covering weekend days usually between the hours of 11:30a.m. and 4:30p.m. Visitor numbers at each exhibit were added up for all 65 images. The results document the relative popularity--also called attraction power--of the exhibits.

Focused observations

Data collectors unobtrusively observed 30 randomly selected visitors at each of the eight selected exhibits, recording the amount of time spent and behaviors. (Sample data sheets are attached.) Time was measured with stopwatch and recorded in seconds. Behaviors, such as reading out loud, touching, or talking, were noted. Time and behaviors recorded during focused observations suggest the relative holding time and engagements at each exhibit.

Dyad interviews

Pairs of visitors (groups of two adults or an adult with a child over 6 years old) were recruited as they entered *Marvelous Molecules*. They were invited to participate in an interview, which would be tape-recorded, after they viewed five selected exhibits: Build, Structures, Food, Smell, and Medicines. (People were given a list with the exhibit names and numbers to locate them. Sample is attached.) Open-ended and structured interview questions elicited conversational feedback about what they did, what they noticed, and what they learned. See attached data sheet. Visitors were offered a choice of gifts for their participation in the interview: a small magnifying glass, a rubber molecule ball, or a bubble pencil (all are items available in the gift shop, valued at about $2 to $3).

The dyad interview concept comes from recent interest by museum visitor-studies practitioners to engage visitors in natural social interactions--conversation--rather than in a one-on-one interview where the data collector asks questions and an individual visitor gives his or her answers. By talking to pairs of visitors and encouraging them to talk between themselves, researchers hope to uncover the social learning that takes place in informal settings such as exhibits. Sue Allen at the San Francisco

Exploratorium has written about this technique and her papers served as a model for our study at NYHoS (see Allen, 2000, 2001).

Twenty-eight dyad interviews took place in the conference room or in the Discovery Lab area adjecent to the molecules exhibits. One of the questions that came out of the preliminary findings discussion in May was, Why didn't we talk to visitors at the exhibit elements? It is because in summative evaluations we are probing for what visitors can remember--what they found meaningful enough to recall on their own, unprompted by the actual exhibits or photos of them. During the remedial evaluations, visitors were interviewed on the exhibit floor. In that study, we wanted to know what visitors thought of the exhibits and what problems they had. For that, we wanted them to be prompted by the exhibits themselves rather than to depend only on recall.

The five exhibit elements involved in this evaluation method were chosen to represent a range of modalities and concepts that supported the exhibition's big idea. We did not ask visitors to look at more than five because we wanted them to stay in one area of the exhibition, spend about 10 minutes looking, and not wander off.

**Findings by method**

This section will briefly review the overall findings by each method, covering the good news and the not-so-good news. The section that follows will cover detailed findings at each exhibit.

Station photos

The good news is that the panorama photos revealed that every exhibit within view was used at least once. Build was used most often by far. More than half of all visitors

recorded at exhibits were seen at Build, where the activity engaged both individuals and family groups.

The relative popularity of all eight exhibits was similar to the results of the earlier remedial evaluation where the most popular ones were Build and Smell and the least popular were Structures and Medicine. Figure 2 shows the total number of visitors recorded in the station photos from highest to lowest counts:

Figure 2.
Station photo counts (total number of visitors).

| | |
|---|---|
| Build | 246 |
| Smell | 31 |
| DNA | 30 |
| Odor Puzzle | 22 |
| Zoom | 17 |
| Structure | 14 |
| Food | 14 |
| Medicine | 8 |

Photos were taken between 11:30AM and 4:30PM. The busiest time of the day was about 2:30p.m. At other times, many photos revealed few visitors in the area and many stations unoccupied.

Focused observations

Data collectors observed and recorded the amount of time that visitors spent at the eight selected elements. The goal was a sample of at least 30 visitors at each station. The final sizes of the samples ranged from 27 to 44. Average time spent is called the exhibit's holding time.

Holding times were more than a minute for four of the eight exhibits, and they ranged from 312 seconds at Build to 25 seconds at Food. Average times (in seconds, listed highest to lowest) and the maximum times for each station are listed in Figure 3.

Figure 3.
Average and maximum times recorded for each element, and sample size.

| Average time # seconds | Element name | Maximum # secs. observed (min:secs) | | Sample size (n=) |
|---|---|---|---|---|
| 312 | Build | 1619 | (26:59) | 39 |
| 84 | Zoom | 411 | (6:51) | 32 |
| 77 | Odor Puzzle | 207 | (3:27) | 34 |
| 63 | Smell | 285 | (4:45) | 44 |
| 42 | DNA | 141 | (2:21) | 36 |
| 33 | Medicines | 153 | (2:33) | 32 |
| 30 | Structure | 95 | (1:35) | 27 |
| 25 | Food | 104 | (1:54) | 41 |

Frequency distributions of time spent by visitors--shown as histograms in Figure 4--were not “bimodal.” Most of the curves appeared to be right-skewed, but with small sample sizes the shape of the curve can be difficult to establish.

In addition to time spent, focused observations revealed what behaviors visitors engaged in at the exhibits. One of the behaviors considered indicative of learning is reading. This behavior was observed many times: 56% to 83% of the visitors we observed read labels. Reading a label out loud to another person is also a strong indication of engagement and learning. Figure 5 shows the percentage of all visitors to

each station who read out loud. Percentages over 25 are higher than we've seen in some other exhibition evaluation studies. (Percentages would be even higher if reported as the percentage of the readers who read out loud, e.g., instead of 27% at Smell, it would be 38%.)

Figure 5.
Percentage who read out loud.

_____

31% at Build
31% at DNA
29% at Food
27% at Smell
18% at Zoom
18% at Odor Puzzle
16% at Medicines
15% at Structures

In the rankings for popularity and average time (Figures 2 and 3), Food had ranked in the bottom half. Here, Food is among the top half. Build has held it's No.1 rank in all three factors (relative popularity, time spent, reading out loud).

Other behaviors were more specific or unique to each element, such as using a flip label or doing a puzzle, and these will be reviewed under the findings for each exhibit below. In general, the more time visitors spent, the more behaviors they engaged in. See Figure 6 for scattergrams of time spent vs. the number of different activities engaged in.

Figure 7 shows the percentage of the two group types observed using the exhibits: adults only (A only) or adults with one or more children (A+K). Build drew the highest

percentage of A+K, and probably prompted the most social interactions of adults working with children. Zoom was the least social, with a low percentage of adults with children (33%). The fact that adults and children tended to work alone at the Zooms is confirmed in the station photos.

Figure 7.
Percentage of the samples observed at the eight elements who were in groups of adults with children (A+K), adults only (A only) and children only (K only).

| *Element* | *Percentage of A+K* | *%A only* | *%K only* |
|---|---|---|---|
| Build | 70% | 5% | 24% |
| Smell | 57% | 18% | 25% |
| Structures | 52% | 30% | 19% |
| DNA | 50% | 22% | 28% |
| Food | 44% | 24% | 32% |
| Odor Puzzle | 44% | 26% | 29% |
| Medicine | 44% | 31% | 25% |
| Zoom | 33% | 27% | 39% |

If we assume that more than half the groups coming into the museum are A+K, then it looks like half of the elements in *Marvelous Molecules* are being used by adults while their kids were elsewhere. Given the abstract nature of the subject, this is not surprising. Data collectors noted that "members of a group would often split up, if a child was at an appropriate age to be alone, and focus on what their individual tastes might be." Children using exhibits without adults, however, show a tendency to spend less time than when they are with adults. See Figure 8.

Figure 8.
Time spent by A+K vs. K-only groups at three elements.

Average time (in seconds)

Build

| | | |
|---|---|---|
| | A+K | 329 |
| | K only | 296 |
| Smell | | |
| | A+K | 77 |
| | K only | 50 |
| Food | | |
| | A+K | 31 |
| | K only | 20 |

Dyad Interviews

Twenty-eight visitor groups (mostly A+K) were cued to look at five of the exhibits in *Marvelous Molecules*. The good news is that, overall, 93% of the visitors interviewed mentioned "molecules" in their tape-recorded conversations after they had seen the exhibits: "I didn't know that you had molecules and that you were made up of molecules." "When I think of science I think of molecules."

There was evidence in their remarks that some people got the big idea:

"At the smallest level, we're all the same, but then we just build up to different pieces."

"We look different, but at the lowest level we kind of look the same, right?"

"The molecule is like a basic thing. . . Doesn't matter human or animal, they all contain the same in some way but not in all."

"Everything that we saw basically had to do with molecules, and basically all the molecules--oxygen, hydrogen, nitrogen, carbons, they have the same infrastructure. As far as foods and living things, proteins etc. they all look the same from one exhibit to the other, and obviously everything is made up of molecules."

Transcripts of the conversations were analyzed for general and specific content that related to the molecules exhibits or other experiences in the NYHoS. Specifics about the five different molecules exhibits were mentioned by 45% to 75% of the visitors interviewed (Figure 8). Build was cited most often, and the least-mentioned element was Structures. Five of the 28 interviews (18%) included all five.

Figure 8.
Visitors who talked specifically about an exhibit experience.

---

75% mentioned “building” or “build”
64% mentioned “medicines” or named a medicine
57% mentioned “food”
54% mentioned “odors” or “smell”
45% mentioned “structures”

Here, Medicines, previously ranked low in popularity, time spent, and reading out loud, turns out to be highly memorable, after No.1-ranking Build.

Twenty-five percent of the interviewees mentioned elements other than the five they were “cued” to look at in *Marvelous Molecules*. Included were references to DNA, heat (infrared camera), eyelashes, large numbers of molecules, the movie, and shrimps.

The not-so-good news is that 54% of the interview transcripts included mentions of elements that were not even part of *Marvelous Molecules*, most often elements from *Hidden Kingdoms*, including germs, yeast, bacteria, and cheese. Others included light, shadows, bubbles, distorted room, bicycle, gravity, sound, Star Wars, Koko, 3D, telescope, mirrors, and the AV sculpture (e.g., “The top floor was real entertaining for the kids. The one where you jump on the people and they start to move” ). The reason

these comments are not considered good news in this study is because visitors had been cued to look at five exhibits in *Molecules*, and to answer questions about those exhibits, not other exhibits or the museum as a whole. (See DI instructions in Appendix.) That many visitors failed to see the integrity of *Marvelous Molecules* as a group of related exhibits may be working against visitors' ability to conceptualize the exhibition's big idea. That is, they are not able to construct relationships between exhibits with closely related themes if they move from one exhibit cluster to another with a different theme. As noted by a data collector, "The primary issue seems to be that it is difficult for people (kids especially) to distinguish between *Marvelous Molecules* and the other exhibits."

In other summative evaluations of exhibitions, it is not uncommon for a few visitors to mention unrelated exhibit elements, but 54% is remarkably high. "As a museumgoer, it was difficult, especially having such similar topics together (all small things, atoms, molecules, microbiology stuff)," another data collector said. A visitor commented in the interview, "The thing about all exhibits is that they get scattered in a lot of ways. I think if you keep the children on one theme . . . they would learn more than they learn from all these different things." Another visitor commented that the instructions to look at just the five exhibits got them to focus more: "Actually the sheets helped us to sort of look into what we were doing, otherwise I just would have passed over it." We know from other studies that cuing visitors in evaluations can cause them to spend more time and look more closely (Serrell 2000), and these behaviors are associated with learning (Borun 1998).

Another recurring comment by visitors that was not good news (but neither was it a surprise) was how the chemistry ideas were not understandable to children:

"It's kind of over the top for him."

"He's young, it's hard to explain these concepts. The one thing out of all of them, the best thing for younger kids was the one where you had to put the hand in the slot because it was sort of interactive. All the other ones you have to read something and understand what's going on."

"This is an interactive exhibit but it still sort of follows the vein of the old museums in a way, showing pictures of molecules...it needs to be more of a playful atmosphere but play with learning...similar to the water park outside."

"It should be a little more simple, there's something between the actual reading and the actual goal, I think there's a step missing. I thought wait a minute, if I'm having trouble learning this, how about the kids?"

"I think it's cool. But if it's a little too complicated then I'll just forget it."

Nevertheless, many visitors commented favorably about the exhibits:

"I thought they were great."

"Actually, is this part of the exhibit with the molecules new? It's great, I love it. That's like a fun Saturday night for me, Scientific American looking at the schematics...I'm exaggerating, but yeah, I like the idea of structure and form."

Some compared it to other museums or school:

"I was just at the Children's Museum in Manhattan with our younger daughter, and I'd like to compliment that everything here is in working condition and there are plenty of people to help and answer questions, which is exactly what you would need in a science exhibit. There's a lot less people here so you can enjoy it. The other museum is very crowded, and many of the things in the older exhibits are broken and not

working and it's very disappointing. . . I have great feelings for this museum and I'm sure we will come back."

"The exhibits on the medicines and the different molecules in bone and wood reminded me of a museum of natural history or zoo exhibits I've seen."

"There was something that I talked about that you learned that in school. You looked at the silk and said 'oh that comes from worms.'"

"When I saw the owl eating the mice it reminded me of school when we dissected owl pellets because we found the mice in there."

"Took me back to seventh-grade chemistry."

One person left wanting more:

"They could have elaborated a little bit more on the functions of these molecules, what they do, how they're essential to the world of science and everyday living. So they left a lot to your imagination, I guess they give you a quick 'this is what it is and this is what it does,' but it's an interesting subject and they should have gotten a little deeper into it. I guess that was just to whet your appetite, now I want more!"

**Findings by element**

In this section, we will review both kinds of data (from focused observations and from the interviews) about what visitors did at and said about each element. A photo montage, Figure 9, shows the elements "in action."

<u>Build</u>

At Build visitors could re-create models of molecules on display or make up one of their own, using plastic "atoms" and "bonds." Labels gave instructions and identified the molecules shown.

| N= | %A+K | Average time | %R | %ROL | Duplicated model |
|---|---|---|---|---|---|

| | | (in seconds) | | | |
|---|---|---|---|---|---|
| 39 | 67% | 312 | 62% | 31% | 49% |

*We did the Build molecule together and made the same model at the same time.*

Forty-nine percent of the visitors duplicated a model, often holding theirs up for comparison with the one on display. Many visitors named it. "We built the adenine molecule out of the building blocks." "I built a caffeine molecule." Others made up their own. Five of the 39 samples did both. "If I had more time there I would have just made up a molecule or something that wasn't an example, and I would have tried to give it a name." Most of the groups (67%) working at the Build exhibit consisted of adults and children.

Visitors spent the most time at Build. During the remedial evaluation, the data collector said that she "often had to stop people after 15 minutes of observation and building to do the interviews." The amount of time spent at Build in this study ranged from 19 to 1619 seconds--an unusually wide range of time. In the histogram for Build in Figure 4, the bars show a cluster of times below 300 seconds and several extremely high scores over 1000 seconds. The average time reported on Figure 3 was 312 seconds, or 5 minutes--an average much higher than any other element in this study and many others, for that matter. (For example, four exhibits in *Seeing the Light* had the following average times: Hot Light, 78 seconds; Light Island, 58 seconds; Masks, 46 seconds; Shadows, 39 seconds.)

The basic idea of atoms connected to each other to make molecules was understood by many visitors, sometimes as prior knowledge. "The first thing I touched was the building, because I had a science fair and we had to make an oxygen and two hydrogens and I made them out of two marshmallows and a ball of play-doh." They

seemed to get the idea that different molecules did different things. "They're very big and long and sometimes they're very small, depends on where they are or what they're in." Some visitors, and very young children, did not know exactly what the structures represented, but they had fun playing with them. "One of the molecules that I built looked like a dog." "I was trying to make cinnamon DNA."

Build was clearly the most popular and the most memorable element. "I want to see if I can take my glucose home! (laughs) We'll put it back."

Structures

At Structures visitors could compare molecules of five different materials that had repeating building blocks. Samples of the material--wool, bone, wood, silk cocoon, and crab shell, some touchable--and a graphic of the repeated molecular structure were shown for each.

| N= | %A+K | Average time (in seconds) | %R | %ROL | Saw 3 or more sides |
|---|---|---|---|---|---|
| 27 | 52% | 30 | 63% | 15% | 63% |

*Was that the one where you just walk around and see what the different types of molecules look like? The one with the sheep, like you had the sheepskin and it showed you what the molecules looked like, and the wool. And the crab.*

Sixty-three percent of the visitors walked around this kiosk to look at three or more sides featuring examples of structures. Concrete, recognizable objects to see and touch probably kept them going around. The molecules' repeating structures were, however, one of the most abstract and difficult concepts for visitors to get, and we did not see much evidence of visitors making close scrutiny of it, although one visitor was noted to "put on her glasses to see better." The average time was 30 seconds, and no one spent more than 95 seconds.

Structures was probably the least successful exhibit of the eight in terms of visitor feedback, although it plays an important role in the overall story of molecules, that of repeating structures.

Food

At Food, visitors could see models of animals and their food and three molecular models. For each animal's food the question was asked, What energy-rich molecules does . . . . contain? Each answer, under the flip label, was the same: fat, carbohydrates, and protein.

| N= | %A+K | Average time (in seconds) | %R | %ROL | Av.# flipped |
|---|---|---|---|---|---|
| 41 | 44% | 25 | 83 | 29% | 3 |

*I didn't know grass had fat and carbohydrate and protein in it. I never knew that grasshoppers ate grass.*

To solidly get the point of this activity, a visitor needs to look under at least three flip labels, and 32% of them did. "The food one, when it asks you what was in all the different things, by the time we got to the end we knew what all the answers were." If they didn't read under the flips, however, it was only about what different animals ate. "We looked at all the different types of foods that different things eat. What did that bird eat?" "Mice." "What did the bat eat?" "Blood." The average time was 25 seconds, and 83% of the sample read something. The visitors who got it were most likely the ones who read more, but they were not in the majority. Unlike Structures, sides of the kiosk did not contain objects to see and touch to keep visitors going around. This element may be a bit subtle for the frenzied mood of a science center, although it did promote a

higher-than-usual number of “call overs”--visitors calling to another member of their group to come and look, and there was a high degree of recall about it.

Smell

At Smell, visitors could sniff four different odors, and compare two kinds of molecules, two visible ones and one that was concealed in a box but could be felt, before they lifted the top to see inside.

| N= | %A+K | Av.time (in secs) | %R | %ROL | % Smelled 1+ | % feel | % lift top |
|---|---|---|---|---|---|---|---|
| 44 | 57% | 63 | 73% | 27% | 75% | 61% | 52% |

*I knew when the molecules of the smell go into your nose--that’s how you find out what you’re smelling, but I didn’t know what molecules they were. I didn’t realize that there were actually atoms traveling through your nose to...brain and that’s what makes you smell.*

While the second statement is a misconception, it was clear that this was an engaging element for many people because there were several things to do. Sixty-one percent of the visitors felt inside the box, and 52% of them flipped the lid to look inside. Seventy-five percent smelled at lease once.

The activity of smelling is an interesting one to observe. As we’ve seen at other elements that involve smell, there is a portion of the audience who choose not to smell, as if they are cautious that the smell might be bad. Here, 25% did not smell anything, while 23% smelled two or more times. A data collector noted, “Subject was dared to stick nose on smell bottle.” Another note: “Read out loud to granddaughter. She smelled, he didn’t.” And a visitor commented, “I remember one time I came to the HOS and I smelled sour milk, so when I smelled the odors I was kind of nervous because I

didn't want to smell anything as bad as that." Others smelled the bottles multiple times, and parents would hold small children up to reach them.

Medicines

At Medicines, visitors could see examples of five different plants and animals and molecular models of medicines derived from them. Labels provided clues and asked questions about what medicine came from each natural source. The answers were under the five flips.

| N= | %A+K | Average time (in seconds) | %R | %ROL | Av.# flipped |
|---|---|---|---|---|---|
| 32 | 44% | 33 | 72% | 16% | 3 |

*I had known how the discovery of penicillin worked, but the foxglove plant, I didn't know about that, so that was interesting. I didn't realize that a German chemist found aspirin.*

Five of the groups interviewed mentioned something about aspirin. Frogs, foxglove, quinine, and penicillin were also mentioned multiple times. One data collector remarked that while Medicines was not very popular with children because it mainly involved reading and not doing, "Most adults seemed to enjoy that one, and from my interviews, that seemed to be the one that really stuck in people's heads." During observations, 31% of the visitors used three or more flips, which suggests that the reading-guessing-looking activity is reinforcing to about a third of the audience. "It seems that once adults realize what the display is about, they read the whole thing. But not kids," another data collector noted. Similar to Food, the sides of the Medicine kiosk did not contain objects to see and touch to keep visitors going around.

Medicine and Food, while not the most popular or engaging exhibits in terms of time spent, nevertheless proved to be highly meaningful and memorable to visitors.

Odor Puzzle

At Odor Puzzle, there were four places where visitors could fit a small molecule puzzle piece into another large molecule graphic puzzle piece, and if it was the correct fit, a photograph lighted up (a human, a dog, a moth, an amoebe) and a sound was played (sniffing, fluttering, ooozing).

| N= | %A+K | Average time (in seconds) | %R | %ROL | Av.# puzzles |
|---|---|---|---|---|---|
| 34 | 44% | 77 | 79% | 18% | 2 |

*We smell with our nose and some animals and organisms smell with different parts of their body. How would an amoeba smell? They would have to sense it with their blobby body because I don't think they have noses.*

Although dyad interviewees were not asked to look at this one, it sounds as if this visitor did.

Using a puzzle is an intuitive, easy behavior, even for young children who were attracted to this element. While the average number was two, a large percentage (44%) used all four puzzles, and many people repeated them to hear the sounds again. This element had the third-longest holding time of the eight elements studied. During evaluation training, data collectors had estimated it would be one of the least-engaging elements, probably because, as adults, they forgot how attractive puzzles are to children. This element had the next-to-highest percentage of children alone using it (refer to Figure 9).

While the puzzles are fun, unless visitors read the labels and understood the abstract concept of receptor sites in the nose or on the body of different animals, there can be

some misunderstandings about what it all means (as noted in the remedial evaluation where some visitors called the graphic a “brain” or a “germ.”)

DNA

At DNA visitors could look at and read about a large model of a DNA molecule, see live mutated fruit flies--up close with the help of a magnifying glass--and see a test tube containing real DNA.

| N= | %A+K | Average time (in seconds) | %R | %ROL | %Mag. | %Tube |
|---|---|---|---|---|---|---|
| 36 | 50% | 47 | 56% | 31% | 81% | 19% |

*“You ever learn about DNA in school?” “No, I never learned about DNA.” “No, I guess that 5 -and 6-year olds don’t really learn that in school yet. You will though, you will.”*

This element was not part of the dyad interviews, but nevertheless, DNA was mentioned by four different groups. During observations, the flies seemed to attract a lot of attention. Eighty-one percent of the visitors used a magnifying glass, usually to look at the fruit flies, but some used it to look at the DNA model or tubes. The high percentage of ROL was probably adults pointing out the live flies to kids.

Zoom

At the Zoom to Structures computer (as with the other Zoom computers in *Molecules*), visitors could choose a material and select various magnifications to zoom in on the molecular structure.

| N= | %A+K | Average time (in seconds) | %R | %ROL | Av. #Options selected |
|---|---|---|---|---|---|
| 33 | 33% | 84 | 73% | 18% | 2 |

One person mentioned the computer interactive at the Build station, but no one mentioned a Zoom (although dyad interviewees were not told to look at it). This was an unusual element in that users were predominantly male (67%; all other elements showed roughly 50-50 male-female users) and it had the highest percentage of K only users (refer to Figure 7) and the lowest percentage of A+K, meaning that most people were using it alone. There was one exception: one person in an A+K group who worked through four different options, stayed almost seven minutes, read out loud, and talked. Most people looked at one or two sequences, and the average time was 84 seconds, the second-highest holding time after Build. The higher average time for this element is probably due to a selective factor: Visitors know that when they approach and select to use a monitor/screen (computer or video), it will take longer than a few seconds to experience it. The more sequences you click through, the longer it takes.

**Problems with the methods**

The three methods (station photos, focused observations, dyad interviews) used in this study answered many of our questions about how visitors are using *Marvelous Molecules* and what they can learn from it, but they don't tell us about the whole exhibition. We recorded detailed behaviors at eight elements and asked visitors to look at and talk about five, and while these selected exhibits are representative of the whole, we did not document visitor behavior at every element. Normally tracking and timing is used in a summative evaluation to measure visitor interactions at every element, but the open floor plan at NYHoS invalidates this method: Many visitors move from one exhibition area to another (e.g., between *Marvelous Molecules* and *Hidden Kingdoms*) without realizing the boundaries. This makes it difficult, if not impossible, to record the total amount of time a person spent in *Molecules*. A data collector noted, "The one

thing I didn't like about the exhibition was that it was really difficult to differentiate between where one ended and the other began. There was no real demarcation."

In future studies, researchers can look for ways to avoid or overcome some of the challenges we encountered with our methods, which are listed below.

Problems with station photos

This study was the first time we had used this technique, so we did not have any prior experience to go on. The plan was to take six photographs at one-hour intervals on each of 15 weekend days for a total of 90 shots. Each shot consists of an A and B frame to cover the complete wide view of the exhibition area from the balcony above it. This was a taxing schedule for the photographer (who also had other daily duties). Some days the digital camera ran out of memory. In all, we got 65 photos instead of 90. The photo quality was fairly grainy, and from the balcony, parts of the glucose molecule obscured some of the exhibit elements (DNA and Odor Puzzle). If a person moved during the shot, they were blurred. Sometimes children appeared hidden behind adults.

About one-quarter of the photos were printed out in color; the rest were black-and-white. Color is easier to read because people's clothing colors help distinguish them (e.g., explainers' red aprons were easy to see in the color shots).

Solutions

- Do more extensive trial runs with a new technique before collecting all the data.
- Schedule photo shoots only for the most busy times of the day.
- Shoot at the highest resolution possible, and print all photos in color.

Problems with focused observations

This was not a new technique, and we did not encounter many problems. "Observations were the easiest part of the job," remarked one data collector. On some days, when visitation was sparse, data collectors had longer periods of time waiting for another visitor to come along. "It grew a little tedious from time to time." Thus, we did not gather as many samples for each station as we would have liked. At first we set our sights on four elements and aimed for a sample of 30 at each one. When that number was reached, we started collecting data on four more. It was a choice (given time and budget) to get smaller samples on more exhibits or larger samples for fewer, and we went for more exhibits. Larger sample sizes for each (e.g., 50 or more) would give us more reliable data for judging the shape of the histograms and subdividing demographic groups (e.g., adults only vs. adults with children) for comparison.

Data sheets for each element needed to be tailored to capture the unique set of possible behaviors. On Structures, we neglected to note "touch."

Solutions

- Raise budget (time and money) to include larger sample sizes.
- Pretest instruments more thoroughly to check that all possible behaviors are being recorded for each station.
- Sample only on days and during time of day that will yield the largest number of samples in the least amount of time.

Problems with dyad interviews

This was the first time we tried dyad interviews at NYHoS, and we encountered numerous challenges with the method from all sides: the data collectors, the equipment, the visitors, and the environment. "Every time I turned around, there seemed to be some new problem cropping up," sighed a data collector. First, noise was a problem. We could not hear well with all the ambient sound in the area, and the tape recorder did not pick up the visitors' voices clearly or completely. The tape recorder did not function reliably. Second, visitors either did not understand or chose not to follow instructions. They went to other exhibits or left before being interviewed, and some did not stick to their dyad (one person refused to participate). "One guy decided it was worth wasting our time by answering 'no' to everything just so he could get a $1.99 bubble pencil." Third, the conversations were more one-sided than intended, and they sounded rushed. Data collectors asked questions rapidly and did not probe effectively. Children's input was brief and sometimes inarticulate. Yet, fortunately, even with all the challenges, we still got a lot of useful information.

Next time

- Get better equipment and backup equipment.
- Do more training for interviewers.
- Get more feedback from data collectors during process to try to fix problems.
- Consider using cued questionnaire instead.

As one data collector remarked, "By the end, I was starting to think that having them fill out a questionnaire wasn't a bad idea." In fact, for the time and effort (and costs) to do the dyad interviews, we easily could have administered and transcribed twice as many questionnaires. Some of the detailed comments may not have been as rich as with the recorded interview, but we would have been able to quantify the responses a little

better because the questionnaire form creates a more systematic framework for the feedback (see Cued Questionnaire instructions in Serrell 1998).

**Overall conclusions and recommendations**

The good news is that *Marvelous Molecules* elicits lots of social interaction--with visitors calling each other over to "Look!" at the exhibits, reading labels and reading out loud--and evidence of recalling the big idea, as well as remembering many specifics about the individual elements. Almost every element showed some strengths, either in terms of popularity, time spent, or learning behaviors.

The not-so-good news is that the concepts may not be comprehended by amajority of children under 12 and some of the adults. The target audience is 12 years and older, but what's to prevent parents with younger kids from wandering into *Molecules* over their heads.

Recommendations

--With the less interactive experiences (e.g., Medicines, Food), encourage visitors to walk all the way around the kiosks by putting real objects on the reading surfaces (e.g., like Structures, How Many) to make them more attractive to visitors.

--Buy more stools so that visitors will be able to sit down at the computer interactives.

--Duplicate the Build exhibit and install it on the other side of the Molecules area.

--Make Structures look more like it's about repeating molecule groups, e.g., more interactive light-up portions of the molecule when a button is pushed.

--Make exhibits appeal to both age groups (A and K) at the same time to encourage social learning, so family groups don't split up (A only vs A+K).

--Put *Molecules* farther away from other exhibit areas and mark the boundaries more.

**References cited**

Allen, Sue. 2000. "Froggy Talk: Lenses on Conversation." Poster presentation. Unpublished report, The Exploratorium, San Fransciso.

Allen, Sue. 2001. "Looking for Learning in Visitor Talk: A Methodological Exploration." A chaper in an upcoming book as part of the Museum Learning Collaborative.

Borun, Minda, et al. 1998. Family Learning in Museums. Philadelphia/Camden Informal Science Education Collaborative (PISEC), c/o The Franklin Institute, Philadelphia. 67 pages.

Serrell, Beverly. 2000. "Does cuing visitors significantly increase the amount of time they spend in a museum exhibition?" in Visitor Studies Today, July 2000.

Serrell, Beverly. 1998. Paying Attention: Visitors and Museum Exhibitions, American Association of Museums, 1998, 234 pages.

*Thanks to the data collectors*

*Rachel Cooper, Maria Davis, Lindsay Lifrieri, and Trevor Quachri*