Summative Evaluation

Beautiful Science: Ideas that Changed the World

Serrell & Associates

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Executive Summary

Beautiful Science: Ideas that Changed the World, a 2,500-square-foot permanent exhibition, contains more than 100 rare, important, and beautiful books and manuscripts from the Huntington's collections, along with artifacts and interactive experiences. The content focuses on the changing role of science through the centuries, with particular emphasis on some of the astonishing leaps in imagination made by scientists and the importance of written works in communicating those ideas. There were 52 exhibit elements in subject areas of Astronomy, Natural History, Medicine, and Light.

The summative evaluation used two methods: tracking and timing and a cued questionnaire with adult visitors. The average total time spent by the tracked sample of 52 visitors was 18 minutes. The Sweep Rate was 139, indicating that visitors lingered a relatively long time. Stops ranged from a low of 1 to a high of 27, and on average visitors used 27% of the exhibits spread throughout the whole exhibition.

The percent of visitors with special interest in the history of science was a high 51%; there were only 4% Diligent Visitors. Reading labels, interacting with hands-on elements, and talking about the exhibits were commonly seen behaviors among adult groups and adults with children. Cued visitors (N=41) averaged a significantly longer time, 27 minutes. Feedback on the open-ended questionnaire gave evidence that visitors understood the big idea of the exhibition; the majority of visitors who claimed new learning made a specific reference to an exhibit or area; and many complimented the beauty, organization, and creativity of the show.

The three strong points of Beautiful Science were the high level of engagement by a wide range of visitors, resulting in a long stay time, and the lack of orientation problems. Discussion and recommendations included how to encourage visitors to use more of the elements, especially the audio stations and the Reading Room, and what follow-up visitor studies would be helpful.



Introduction

Beautiful Science: Ideas that Changed the World opened at the Huntington Library in November 2008. This 2,500 square-foot permanent exhibition about the history of science is divided into six main areas: Orientation, Astronomy, Natural History, Medicine, Light, and the Reading Room. It contains more than 100 rare, important, and beautiful books and manuscripts from the Huntington's collections, along with artifacts. Thirty-two interactive experiences are integrated throughout the exhibition, including audio stations, re-created experiments and scientific tools, digital books, and video animations. The content focuses on the changing role of science through the centuries, with particular emphasis on some of the astonishing leaps in imagination made by scientists and the importance of written works in communicating those ideas. Daniel Lewis, the Dibner Senior Curator of the History of Science and Technology at the Huntington Library, said, "We want people to think about the beauty of science in a historical context—the elegant breakthroughs, the remarkable discoveries, and the amazing people and stories behind them."

The original "big idea" was "We are on a continuum of change in science, and over time, scientific knowledge has been modified, improved upon, or dramatically undermined in the ongoing quest for a more accurate understanding of the universe's workings." But this proved to be too abstract and too all-encompassing. Through discussions with the advisors, it came into sharper focus on the Huntington's collection, changing to:

Beautiful ideas in these books and manuscripts changed the way we understand the universe. They're beautiful in their accuracy, elegance and the aesthetics of the ways in which they were represented.
The target audience was lay adults without specialized knowledge in the sciences. School programs targeted for 7th through 12th grades will be developed; museum staff members therefore took state science standards into account when creating the exhibition.

Evaluation was part of the exhibition development process from the start, including
• front-end discussions with scientists about what makes science compelling;
• reviews of visitors' prior knowledge about science and expectations for a history of science exhibition;
• prototype testing with staff and visitors;
• peer review by a local group of museum exhibit and education professionals who structured their review according to Framework for Assessing Excellence in Museum Exhibitions (Serrell 2006); and
• an advisory team of academics and museum exhibit specialists.

Lead exhibit developer Karina White had experience using visitor and advisor input in the planning and design of the Huntington's Conservatory award-winning exhibition, *Plants Are Up to Something*, and she applied many of the same methods to the development of *Beautiful Science*. She also saved 15% of the exhibition's budget for making changes and improvements after opening, based on the results of the summative evaluation.

As this report was being prepared, the Huntington received notice that *Beautiful Science* won the American Association of Museum's excellence in exhibition award for 2009. Congratulations, Dan and Karina!

Methods

The summative evaluation used two methods: tracking and timing (T&T) and a cued questionnaire (CQ). Tracking involved unobtrusive observations of a visitor as he or she moved through the exhibition. Subjects were chosen using a continuous random selection of individuals (youth, adults, seniors) who were not part of a tour group. No children were chosen as subjects, but they were included in the sample if they were part of the social group of an adult subject. The tracker noted where the subject went and stopped, and how many minutes he or she spent. Behaviors, such as reading labels, calling someone over to look at something, and sitting down also were noted.

For the questionnaires, data collectors intercepted and recruited (cued) visitors at the entrance of the exhibition to participate in the evaluation after they finished looking at it. Feedback from the questionnaires revealed visitors' thoughts, feelings, and what they could immediately recall about the exhibits. The combined data from these methods produced a well-rounded set of evidence for the degree of success achieved by the exhibition. Because these two techniques are widely used to evaluate visitors' responses to exhibitions, the feedback can be compared with the results of other studies, giving a broader interpretation to the findings in *Beautiful Science*.

Figure 1. Evaluation methods and sample sizes

Tracking and Timing (T&T)	Random unobtrusive observations	N = 52	What did visitors do?
Cued Questionnaire (CQ)	Random intercept, written feedback	N = 41	What did visitors think, feel, and learn?

Four data collectors were trained in the techniques, and they gathered feedback mainly on weekends in late December 2008 and early January 2009. All data were transcribed to spreadsheets where tabulations and coding were done. See all of the transcriptions in the Appendix. A sample of the tracking data sheet is on the next page, followed by a list of all the exhibit elements.

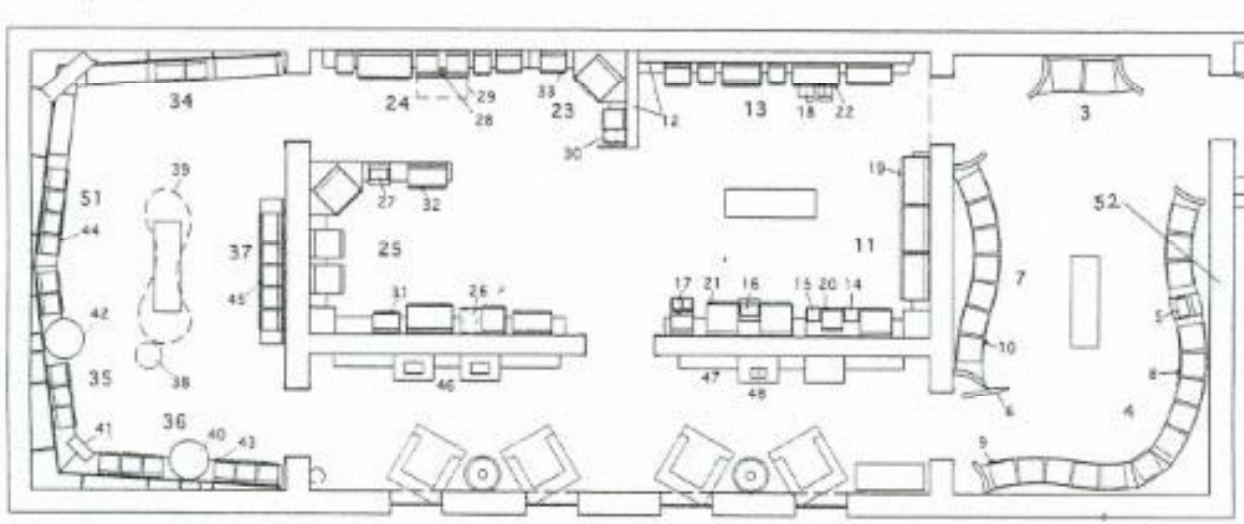
Huntington **Beautiful Science T&T** Summative Evaluation

Sheet #_____

Date_____ Time enter _____ Time leave _____ Total time_____ # Stops_____

Gender: M F Social group: A only A + K Age: Youth Adult Senior

Group 1 2 3 4 5+



Timing at individual elements—

Audio #		Time spent (min:secs)
(A)	8	_____
	9	_____
	10	_____
(NH)	19	_____
	20	_____
	21	_____
	22	_____
(M)	31	_____
	32	_____
	33	_____
(L)	43	_____
	44	_____
	45	_____
(RR)	46	_____
	47	_____

Check if behavior was observed:

__**CO** = calls/called over __**B** = takes brochure __**I** = used interactive __**IO** = watches someone else
__**L** = listens to audio __**R** = read labels __**ROL** = read out loud __**T** = talks about exhibit
__**S** = sat down on bench or chair(#49) __**WG** = read/looked at wall graphics (#50)

Notes or comments:

DataC initials _____

Figure 3. Exhibit areas, exhibit element numbers and names

Beautiful Science
Exhibt elements list (52 elements)

Orienation
1 Title and intro label
2 Banners and label

Astronomy
3 Naked Eye
4 Location in the Universe
5 Digital animations of Earth and Sun-centered universe models
6 Galilean telescope
7 Telescopes
8 Audio Kepler
9 Audio Hubble
10 Audio Galileo
52 Celestial ceiling graphics

Natural history
11 Observation
12 Darwin's books
13 Evolution
14 Marshall microscope w/flea
15 Leeuwenhoek microscope
16 Digital page-turning station (Merian & Catesby)
17 Hand-held magnifier w/Meunier images
18 Cabinet drawers w/Darwin letters
19 Audio Pliny
20 Audio Leeuwenhoek
21 Audio Catesby
22 Audio Darwin

Medicine
23 Childbirth
24 Healing
25 Structure (physical body)
26 Vesalius overlays
27 Digital page-turning station (D'Agoty & Albinus)
28 Herbal jars for smelling
29 Cabinet drawers w/herbal sheets
30 Spratt overlays of uterus
31 Audio Harvey
32 Audio Bell
33 Audio Roeslin

Light
34 Lightbulbs
51 Electricity
35 Color
36 Vision
37 Energy
38 Sundials
39 Light sculpture
40 Camera obscura
41 Kircher mirror trick
42 Newton prisms
43 Audio al-Haytham
44 Audio Priestley
45 Audio Lockyer

Reading room
46 Computer stations (2)
47 Reference library
48 Touchable book

49 Benches and chairs
50 Wall graphics

Limitations

This was the first time Serrell & Associates tried a "distance-education" training session for the data collectors. Instead of traveling to California for the training, Beverly Serrell worked with Karina White via conference call with the trainees Claire Kennedy, Katrina Denman, Alka Kumar, and Derek Christian Quezada. The rationale for doing this was that the methods (tracking and timing and the cued questionnaire) have been described in detail in *Paying Attention* (Serrell 1998) and used by many data collectors under different types of conditions. Therefore, Serrell thought that an in-person visit was not necessary. In retrospect, this was not a good idea because, as the data collectors noted in their reviews, more supervision would have been helpful. One data collector called the training "insufficient" and "inadequate." More time should have been allowed for multiple tryouts and more detailed instructions until all four data collectors were recording the same data the same way reliably. As it turned out, 19 CQ data sheets were not included in the final analysis because data were collected inconsistently with the written instructions. Nevertheless, adequate quotas were reached.

Another drawback to the lack of face-to-face training with Serrell was that the personalities of the data collectors could not be assessed accurately. Some people are better suited to unobtrusive methods than others. Women find it easier to blend into the background than do men. In this case the one male data collector noted that his T&T subjects "became subtly aware of my presence." Also, he found that recruiting visitors for the CQ was

difficult: Visitors seemed "disinterested," "unresponsive," and "suspicious." The women did not have this problem, and they thought that the visitors were "willing and courteous." All of the data collectors, however, agreed that a table should have been supplied for collecting CQ data--to give them a place to "look official" and to avoid the cumbersome problem of handing out clipboards for visitors to write on.

The evaluator's failure to provide on-site training and appropriate equipment for effective, efficient and accurate data collection accounts for most of the limitations in this evaluation.

Not so much a limitation as a unique consideration for this exhibition's evaluation was the numbering system, partly determined by the nature of the main objects, the books, and how they were displayed. Each of the 100+ books needed its own case for lighting, labeling, and conservation needs, but the exhibit developer and curator conceived the books in sets or groups to illustrate a theme. Instead of each case getting its own number, groups of books with similar themes were treated as a lumped exhibit element and assigned a single number, e.g., #4 included all the books about Earth's place in the universe; #7 contained all the books about telescopes; #12 grouped the multiple editions of Darwin's *The Origin of Species*.

Exhibit elements other than books that were interspersed with the volumes on display were given their own unique numbers, e.g., #5 for the touch-screen computer; herbal jars #28. Thus, an "exhibit element" could mean various things: a thematic group of books, an object, or an interactive. All of the large wall graphics in the exhibition were lumped into one element number.

Findings

In this section the findings data will be reviewed from several angles: visitor demographics; results from the T&T by visitor and by exhibit, and findings from the CQ.

Demographics

Huntington visitors who participated in the evaluation studies (N=93) were primarily adults, alone or in small groups. Adults with children constituted roughly 15% of the sample. The two methods gathered data from samples with similar characteristics regarding age, gender, social group, and group size. Cued visitors were asked questions about visitation and interests (reviewed later); no queries were made of the unobtrusively observed visitors.

Figure 4. Demographics for the samples of the two evaluation methods

	N =	Age: % adults % senior	Gender: % F/M	Group type: % adults only	Group size: % 1/2 /3
T&T	52	69% 25%	58/42	83%	17%/58%/12%
CQ	41	71% 22%	51/49	88%	17%/66%/10%

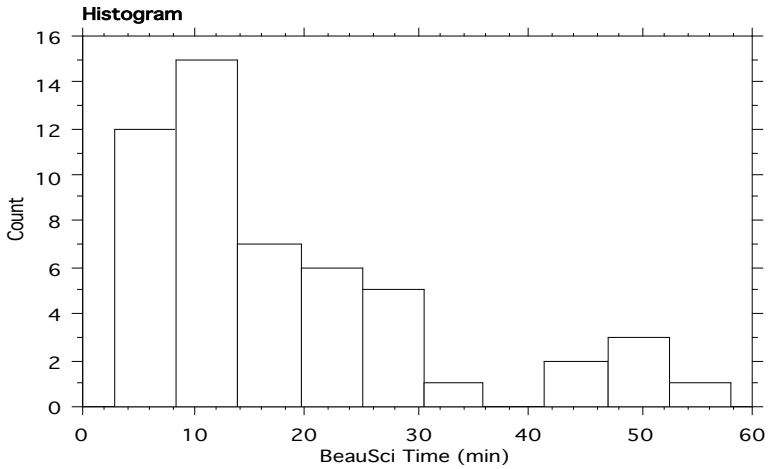
Time and Stops

The average total time spent by a sample of 52 visitors in *Beautiful Science* was 18 minutes. Times ranged from a low of 3 minutes to a high of 58 minutes. (If someone spent less than 3 minutes and made no stops, they were not included in the data set.) Spending less than 20 minutes in an exhibition, on average, is typical for museum visitors. The chart for Figure 5 suggests a normal distribution of the data, but the bar graph for Figure 6 reveals a different pattern.

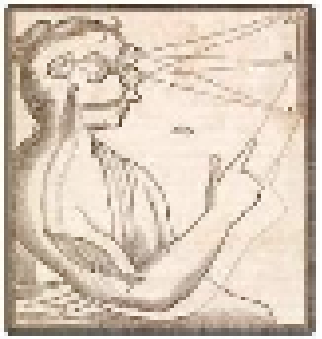
Figure 5. Time spent by tracked visitors (N =52) shown as a chart

Less than 10 minutes	Between 10 and 20 minutes	More than 20 minutes
25%	40%	35%

Figure 6. Bar graph of total time spent by visitors. ("Count" is the number of visitors for each time.)

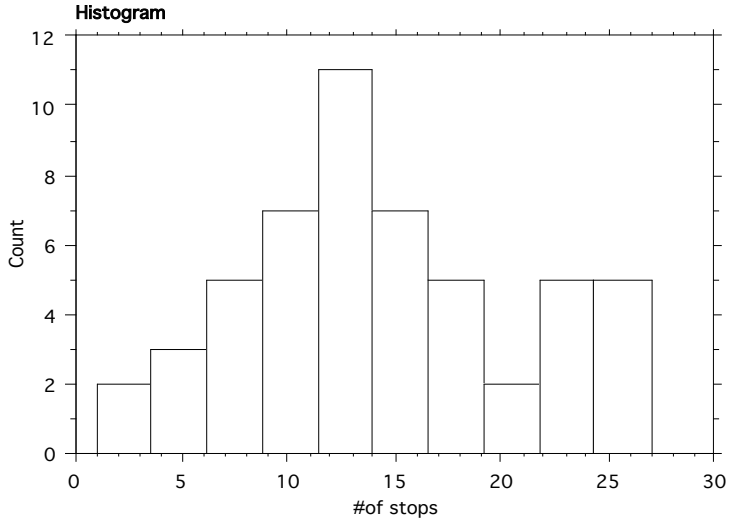


A skewed distribution (more people spending less total time) is typical for museum visitors (Serrell 1998).



The 52 exhibit elements in *Beautiful Science* allowed for 52 possible stops. The average number of stops made by visitors was 14 (the median was 13), and the distribution of data from stops was more suggestive of a normal curve. Stops ranged from a low of 1 to a high of 27. The average of 14 stops meant that visitors used 27% of the exhibition.

Figure 7. Bar graph of the data for the number of stops made by visitors out of a possible 52



Figures 6 and 7 each show a slight bump in the data spread, with a few higher "counts" on the far right side, a suggestion of a bimodal distribution (Serrell and Sulston 2001). Who were these people who spent more time or made more stops? We will look more closely at them below, after the attraction rates for each exhibit have been reviewed.

Attraction Rates

As visitors move through an exhibition, they stop at different elements. Data on the total number of element stops made by each visitor are added up. When the data are transcribed, the number of visitors who stop at each element are added up, and dividing that number by the number of visitors who were in the sample gives the attraction rate, the percentage of visitors attracted to the element. Attraction rates above 50% are considered high; below 10% is low.

In *Beautiful Science*, the wall graphics were the most popular elements, attracting 88.5% (46 of 52) of the visitors. No wonder: They were large, dramatic, aesthetically pleasing, and informative. They were directly related to the images and content in the books located in cases below and had captions and main ideas in supporting texts.

Data collectors noted several times that a subject had paid particular attention to them. The attraction rate may be especially high, however, because there were wall graphics throughout the exhibits, and visitors got credit for looking at any one of them (the lumping noted earlier under "Limitations").

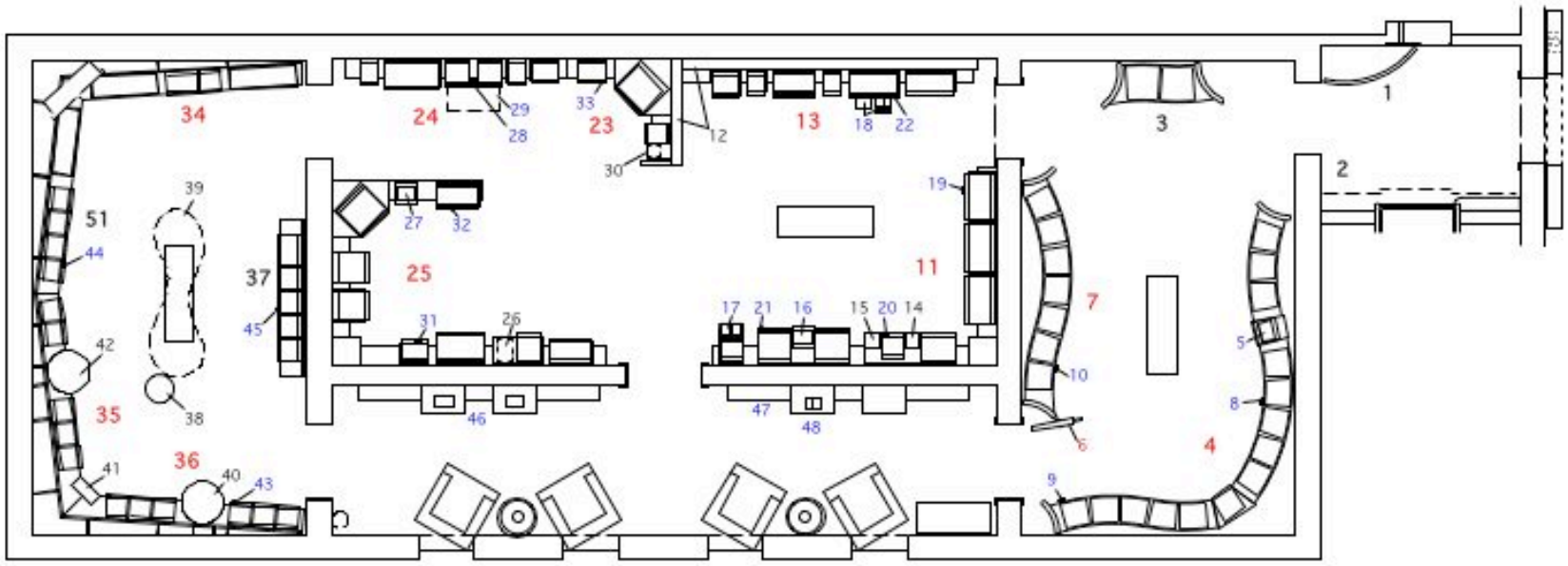
Every main area had a high attraction rate, which means that most visitors investigated the whole exhibition rather than coming in and looking at the first rooms and then leaving. The Light Bulbs theme group was located in the room farthest from the entry/exit door, along with two other popular areas, Color and Vision.

Figure 8. Elements with the highest attraction rates.

Exhibit # and name	Attraction rate
50 Wall graphics	89%
13 Evolution	65%
34 Light Bulbs	64%
23 Childbirth	64%
11 Observation	62%
4 Location in the Universe	62%
6 Galilean telescope	60%
25 Structure (physical body)	58%
24 Healing	58%
35 Color	54%
7 Telescopes	54%
36 Vision	52%
52 Celestial ceiling graphics	52%

The floor plan on the next page shows the locations of the "hot" exhibits in red.

Figure 9. Floor plan showing "hot" and "cold" elements



> 50% Red indicates more than 26 visitors stopped at element

Black indicates between 20% and 50% of the visitors stopped—between 11 and 25 people

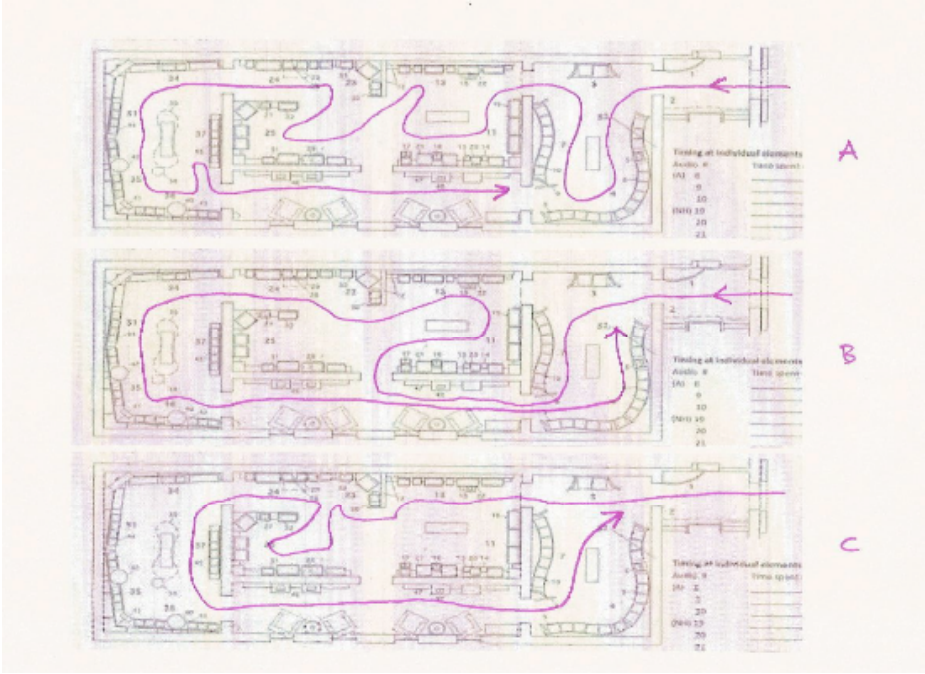
<20% Blue indicates that fewer than 8 people stopped

Figure 10. Element number, element name (thematic group of books, object, interactive), and the number of visitor stops

	# stops		# stops		# stops
50 Wall graphics	46	41 Kircher mirror trick	25	48 Touchable book	8
13 Evolution	34	39 Light sculpture	24	28 Herbal jars for smelling	7
34 Lightbulbs	33	3 Naked Eye	22	49 Benches and chairs	7
23 Childbirth	33	42 Newton prisms	20	17 Hand-held magnifier	6
11 Observation	32	12 Darwin's books	18	5 Digital Earth/Sun-centered models	5
4 Location in the Universe	32	51 Electricity	15	16 Digital pages (Merian & Catesby)	5
6 Galilean telescope	31	1 Title and intro label	15	18 Cabinet drawers w/Darwin letters	5
25 Structure (physical body)	30	40 Camera obscura	14	47 Reference library	4
24 Healing	30	38 Sundials	14	29 Cabinet drawers w/herbal sheets	3
35 Color	28	26 Vesalius overlays	14	43 Audio al-Haytham	3
7 Telescopes	28	15 Leeuwenhoek microscope	14	46 Computer stations (2)	3
36 Vision	27	14 Marshall microscope	13	8 Audio Kepler	2
52 Celestial ceiling graphics	27	30 Spratt overlay of womb	12	27 Digital pages(D'Agoty & Albinus)	2
		37 Energy	11	9 Audio Hubble	2
		2 Banners and label	11	33 Audio Roeslin	2
				10 Audio Galileo	1
				19 Audio Pliny	1
				22 Audio Darwin	1
				32 Audio Bell	1
				44 Audio Priestley	1
				45 Audio Lockyer	1
				31 Audio Harvey	0
				20 Audio Leeuwenhoek	0
				21 Audio Catesby	0

Evolution, Childbirth, Observation, Structure, and Healing, and were topic areas in the middle Natural History and Medicine sections. Location in the Universe and Telescopes were in the first section, Astronomy. (Elements #50 and #52 are not shown on the map, Figure 9.)

Figure 11. Visitor traffic flow patterns. A = 45%; B = 27%; C = 27%



The most common flow pattern (A) was to come into the Astronomy room and explore it in a loop, proceeding to the Natural History area from the door near Evolution, moving through Natural History to Light near the light bulbs, making stops in Light, then exiting the exhibition through the Reading Room and Astronomy.

The next two patterns, B and C, each had about 27% of the sample. B viewed Astronomy, then moved into Natural History via the first half of the Reading Room, then explored Natural History and Light. C went straight through Astronomy to Natural History, made stops there and beyond to Light, and maybe made stops in Astronomy on the way out. In all three patterns, people exited through the Reading Room, usually without stopping. There was a trend for visitors who went through in pattern C to spend less time than visitors who made A or B patterns. Larger sample sizes would be needed to confirm this subgroup comparison.

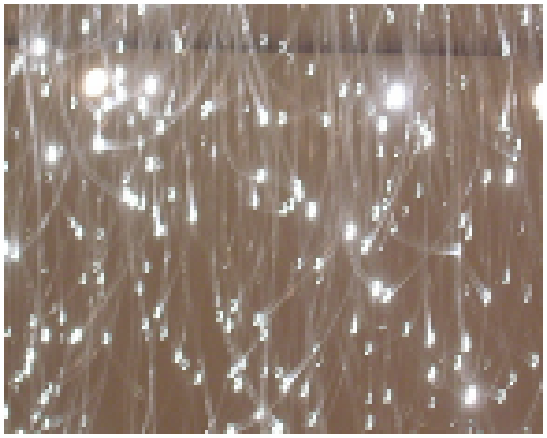
Exhibit elements with mid-range attraction rates (21% to 48%) included the introductory area, many of the interactives, and the remaining main sections of the exhibition: Naked Eye in Astronomy, and Electricity and Energy in the Light section. We anticipated that these areas would not be as strong as the others. People's attention was drawn away from element #3 by the many other attractive elements in Astronomy. Electricity was "dull" by comparison to Light Bulbs, and Energy had a lot of competition also, especially from several interactive exhibits.

The mechanical interactive exhibits (noncomputer-based) were attractive to 23% to 48% of the visitors. Their popularity depended partly on their size--some were easier to notice than others. Visitors may have missed engaging with a small hands-on element if they didn't look closely.

Figure 12. Attraction rates of the mechanical interactives

Exhibit # and name	Attraction rate
41 Kircher mirror trick	48%
42 Newton prisms	38%
40 Camera obscura	27%
26 Vesalius overlays	27%
15 Van Leeuwenhoek microscope	27%
14 Marshall microscope w/flea	25%
30 Spratt overlay of womb	23%

The 250 copies of *The Origin of Species* attracted 35%, and the collection of sundials attracted 27%.



The light sculpture was popular (46%), and data collectors noted that many visitors took a photo of it.

Exhibit introductory graphics are notoriously unpopular, often with attraction rates of less than 20%. But in *Beautiful Science* the banners were noticed by 21%, and 29% stopped to read the title and introduction text.

Although 23% of the tracked visitors stopped in the Reading Room, most people used it as a hallway to walk through without stopping on their way out of *Beautiful Science* after exploring other areas. Improvements to the room are planned (see Discussion and Recommendations).

The elements that attracted fewer visitors included six hands-on, nonelectronic exhibits and four computer-based interactives.

Figure 13. Lower attraction rate elements

Exhibit # and name	Attraction rate
48 Touchable book	15%
47 Reference library	8%
28 Herbal jars for smelling	13%
17 Handheld magnifier w/Meunier book	12%
18 Cabinet drawers w/Darwin letters	10%
29 Cabinet drawers w/herbal sheets	6%
46 Computer stations (2)	6%
16 Digital pages (Merian & Catesby)	10%
5 Digital Earth & sun-centered models	10%
27 Digital pages(D'Agoty & Albinus)	4%

There were three elements in the Reading Room: a touch-screen computer station with videos of scientists talking about the beauty of science; reference books on shelves to browse through; and a large touchable book, which was encountered first in the Reading Room by visitors navigating in flow pattern B (see Figure 11).

In the Natural History section, two drawers containing objects had attraction rates of 6% and 10%. The herbal jars for smelling attracted 13%, and a small handheld magnifier was used by 12% of the visitors. The drawers and jars were easy to miss.

The three other computer programs (two digital books--page-turning displays of a nearby book and a program that compared the Earth-centered and sun-centered visions of the universe) were not as popular as the mechanical interactives.

The elements that attracted the least attention (6% to 0%) were the 13 audios--short excerpts from selected books, read by actor Michael York. The button-activated handsets had labels giving the title of the book, a brief statement about the content, and the running time. Two things probably contributed to the low attraction rates: The labels were unobtrusive, and the audios were located low along the bases of the bookcases, which meant that if you stopped to listen, you would be blocking the traffic flow along the line of displays.

Looking at the audio data by visitors instead of by stations (as above), we see that nine visitors stopped at one audio and two visitors stopped at three audios, for an "audio users" total of 21% (11 out of 52 samples), which seems encouraging. But a different trend emerges from an analysis of the data on the amount of time people spent: Only three of the 15 total "listening events" lasted long enough to hear the complete reading. The three highest times spent by visitors listening were 125, 90, and 80 seconds, very close to the corresponding audio running times.

Figure 14. Audio running time and highest times spent listening

#	Audio	Seconds listened	Running time (in seconds)
10	Galileo	125	122
33	Roeslin	90	90
8	Kepler	80	98
9	Hubble	68	138
43	al-Haytham	35	77

The remaining listening times ranged from 5 to 68 seconds, only two of which amounted to a visitor hearing half of the total recording. Thus, the time data paints a less encouraging picture: Few visitors (3 of 52 or 6%) stopped long enough to hear a complete story at an audio station.

Another contributing factor was the density of objects, graphics, interactives, and texts in the exhibition. Even a one-and-a-half-minute audio or video represents a longer commitment than many visitors can make with their limited time budgets and so many things to see and do (Serrell 2002).

Behaviors Noted

Besides noting where visitors went and where they stopped, data collectors made observations of their behaviors as they used the exhibits. Reading labels, interacting with hands-on elements, and talking about the exhibits were commonly seen behaviors among the 52 tracked visitors.

Figure 15. Visitor behaviors observed

Behaviors	#people	%
Read labels	45	87%
Interacted with exhibit	39	75%
Talked about exhibit	31	60%
Watched someone use interactive	20	39%
Took a brochure	11	21%
Listened to an audio	11	21%
Called over	8	15%
Sat down to look, read, or wait	7	14%
Took photo of light sculpture	4	8%
Read out loud	3	6%

It is not uncommon for people to watch someone else use a hands-on exhibit without touching it themselves. Often it is possible that interactive exhibits can communicate with both styles of use, but with a microscope or a telescope, actually looking through it is the behavior hoped for by exhibit developers.

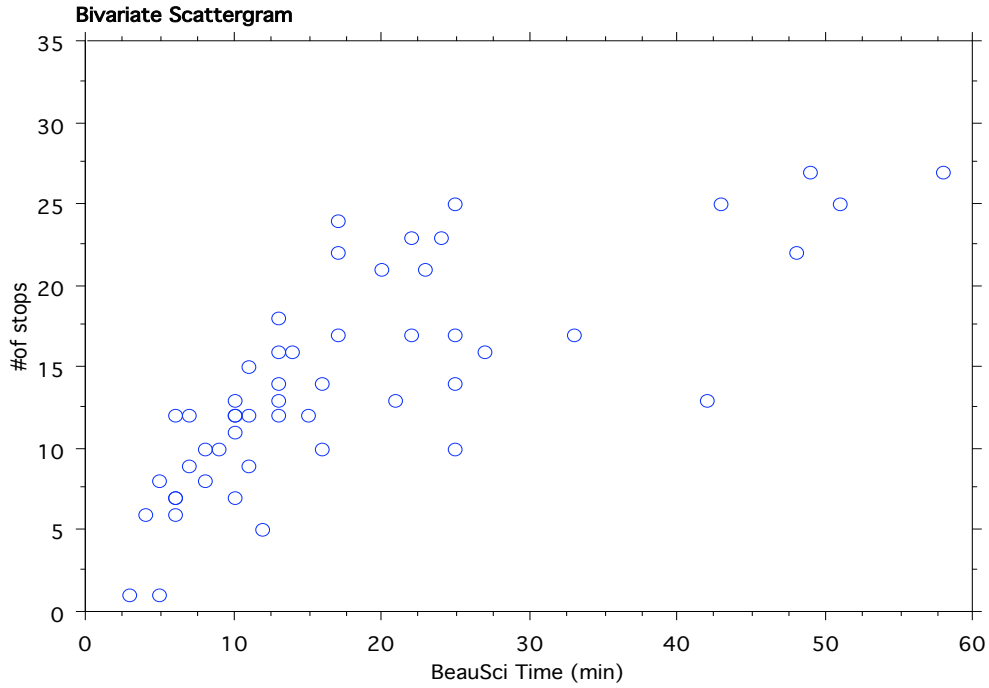
Calling someone over to look and reading a label out loud to someone in the same group are considered evidence of social engagement with exhibits, a valuable aid to informal learning. The levels of social engagement in *Beautiful Science* were higher than other library exhibitions at the Huntington, according to museum staff members. A data collector commented that "all three age groups found something to interest them (judging by the amount of time they spent, how carefully they looked at each object, and their behaviors--some took notes or had lengthy conversations), which to me speaks to the quality of the exhibit and the fact that it is accessible to a wide range of social groups without either speaking down to or going over the heads of any of them."

Before reviewing what people said about the exhibition on the questionnaires, we will look at time, stops, and behavior feedback from the tracking data from three more angles--scattergram, sweep rate, and diligent visitors.

Scattergram and High-time Visitors

The scattergram shows the distribution of visitors by the number of stops and total time they spent.

Figure 16. Each point on the scattergram represents one visitor



There is a trend that more time spent equals more stops, which shows most strongly in the lower left quadrant—less than 20 minutes. After 20 minutes, the points are more diverse. Some visitors made more than 20 stops in less than 30 minutes while others spent more time seeing fewer elements. A cluster of points slightly separate from the rest of the data represents visitors who spent the most time--more than 40 minutes. One point seems to be on its own (42 minutes, 13 stops), reflecting a long time spent but relatively few stops--not an overall trend.

A closer look at those six higher-time visitors (those who spent more than 40 minutes) shows more women than men, but no patterns in terms of age or group type. All but one made more than the average number of stops, but some skipped whole sections of the exhibition. On the tracking sheets, data collectors made these notes:

Visitor #	Minutes	Stops	
#27	58	27	Young woman with four friends, Chinese tourists, lots of talking while looking at the exhibits, especially wall graphics, pulled out a drawer at Evolution, used interactives and watched others use them, laughing, acts amused
#24	51	25	Woman who read a lot, including intro label, backtracked, used one audio, skipped Evolution section, spent part of time looking at exhibits by herself and partly with other adult in group, looking/reading thoroughly at Childbirth section
#35	49	27	Woman with three children, reading labels out loud, interacting, sat down at audio, spent most time in Light area, passed through Reading area without stopping
#51	48	22	Male, senior, after 22 stops, he sat on chair in Reading Room for 15 minutes reading the exhibit brochure and waiting for others in his group to finish
#25	43	25	Female, backtracking in Astronomy, calls friend over, talked a lot enthusiastically, seemed to know about it already, skipped Energy, spent several minutes at open book in Reading area, several minutes at Light Bulbs
#11	42	13	Female, senior, read intro label, taking notes, visited Astronomy thoroughly and first two areas of Natural History (Evolution and Observation only), took a brochure, sat down, interacted with computer and audio

Visitors who spent the most time were a diverse group. Can we conclude anything about visitors who spent more time, other than that they tended to spend it doing more things? Not really, because there seem to be many motivations, situations, and other variables involved. For whatever reasons, these visitors were more engaged.

Looking at the other cluster of seven visitors who also stopped at more than 20 elements and stayed between 15 and 25 minutes, they were also diverse in terms of gender, age, and social group, but they did less backtracking, they did not sit for long periods, and in general they made shorter stops. As a data collector commented about one of them, "Did not spend more than a minute at any one exhibit."

An interesting trend is hinted, however, in the subsample of 13 visitors who made more than 20 stops: Five of them were with children. In the total tracking sample, only nine groups included children. Clearly some families found *Beautiful Science* especially engaging.

Sweep Rate Index (SRI) and Percentage of Diligent Visitors (%DV)

Two other ways to analyze tracking-and-timing data are to calculate the sweep rate index and the percentage of diligent visitors. The SRI is the square footage of the exhibition divided by the average time spent by the tracked sample of visitors. For *Beautiful Science*, 2,500 square feet divided by 18 minutes equaled an SRI of 139. Sweep rates lower than 200 indicate that visitors are lingering for a long time in the exhibit space. Sweep rates are useful because they allow time-use comparisons among exhibitions of different sizes.

Diligent visitors are defined as visitors who stop at more than half of the available exhibit elements. The %DV is the percentage of the visitors in the sample who were diligent. The %DV for *Beautiful Science* was low, only 4%. That is, only 2 of the 52 tracked visitors stopped at more than half of the exhibit elements. There is a direct relationship between the attraction rates of exhibits and the percentage of diligent visitors; the higher the attraction rates for more exhibits, the higher the %DV. High %DV is evidence that the exhibition as a whole was used thoroughly. Low %DV does not mean that visitors are not enjoying themselves or learning, but a high %DV is evidence for more engagement, enjoyment, and opportunities to learn.

If visitors are having satisfying experiences with 10 to 20 exhibit elements (out of 52), and if the exhibition effectively communicated its main learning objectives under those conditions, that is evidence for success, albeit without the exhibition being thoroughly used. This is true for *Beautiful Science,* and the supporting data is described next.

Feedback from Cued Questionnaires

Data collectors recruited subjects at the entrance to *Beautiful Science*, and when the visitors were finished looking at the exhibits, they participated in a brief interview and then filled out the questionnaire by themselves in their own handwriting. The demographic characteristics of the sample were shown on Figure 4 (page x). Other background data included information about visitation and interests.

Figure 17. Characteristics of Cued Subjects

Has special interest, knowledge, or training	First visit to Huntington	Repeat visit to Beautiful Science
51%	34%	10%

Thirty-four percent were making their first visit to the Huntington, and 66% were repeat visitors; 90% were making their first visit to *Beautiful Science*; 10% had been to it before. For the random sample to include 10% repeat visitors, after the exhibition had only been open two months, seemed surprisingly high. With such a high repeat visitation overall to the Huntington, perhaps revisiting will be a strong characteristic for the audience of this exhibition in the future.

Types of Prior Knowledge

Subjects were asked if they had "any special interest, knowledge, or training in the history of science." A surprisingly high 51% said yes. This very open-ended question captures education, employment, casual interest, and family relationships--anything from hard-core academics (history of science major, Harvard University) to "secondhand smoke" (e.g., I date a Ph.D. botanist). Other responses included:

Ph.D. in optics, historical books collector

History minor in college

Took history & science classes in college

I'm a chemical engineer & inventor

Interested in early science, history of science

Grad student in developmental biology

President of science teachers organization

Interested in early science, history of science

My parents are doctors

Time Spent by Cued Subjects

Data collectors noted the time spent by the cued questionnaire subjects in the exhibition. The average time spent was 27 minutes, which is significantly longer than the average 18 minutes spent by the uncued tracking sample. Cuing visitors typically increases the amount of time they spend if the average time for uncued visitors is less than 20 minutes, which was the case here (Serrell 2000).

The Questionnaire

Cued visitors responded to three questions with four prompts:

1. What would you say is the main purpose of the displays in these galleries?
   To show...
   To make people...

2. What is one new idea you are taking away with you?
   I didn't know, or I never realized ...
   and/or
   It reminded me ...

3. Anything else?

The first question gathers evidence for visitors' understanding of the exhibit developers' intentions from two aspects: What was the exhibition trying to communicate (output), and what effect on visitors did they hope to have (outcomes). The second question probes for evidence of visitors' learning outcomes: Did they learn

something new, or make a new connection with their existing knowledge? Were they reminded of something they already knew, felt, or believed? The final question is to let visitors speak up about their likes and dislikes, or add to something they've already said in response to the first two questions. These questions and the open-ended format have proved to be very efficient at capturing immediate, authentic, useful information for assessing visitor learning outcomes, and the data gathered has the breadth and depth desired in the instructions for evaluating exhibitions recently published by in the National Science Foundation Informal Science Learning guidelines (NSF 2008).

Analysis of the CQ feedback is done qualitatively by looking at all of the answers by each visitor and all of the answers to each question. Answers are coded for being complete, concrete, and appropriate; vague or incomplete; or no answer. The presence or absence of key words is noted. The answers and words are compared to the exhibition's big idea, the content and layout of the exhibits, and the exhibit developers' objectives.

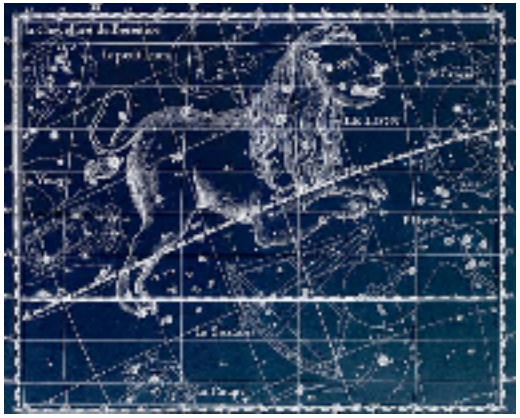
The big idea for *Beautiful Science* contained the key words "ideas," "books," "understand," and "universe." The content emphasized "beauty," "changing role," "discoveries," and "amazing people and stories." The title itself, *Beautiful Science: Ideas that Changed the World*, said a lot, and it was very effective, judging from what visitors said. They didn't just repeat the title, they used their own interpretations in their answers to all three questions. The quotations in the following reviews are examples from different people. A complete list of their responses is included in the Appendix.

The process of change and the display of books were included in visitors' answers to the prompt "to show":
The history of science through primary text
How different ways of knowing the world were represented textually as well as visually
The advancement of ideas, as each scientist builds upon the knowledge of those who went before
How discovery and knowledge have evolved over centuries, how technology often opens avenues of discovery
The beauty & complexity of nature & man's greater understanding of it through the centuries

They often used the word "evolution," as in "evolution of thoughts," "evolution of changes in scientific knowledge," and "evolution of different ideas." Some made accurate reference to the different sections of the exhibition ("various perspectives on astronomy, natural history, & light"). Everyone answered this prompt. Although six were very short and simple, e.g., "history of science," there were no inappropriate answers.

In their responses to the prompt "to make people…," visitors gave evidence of the two kinds of outcomes the exhibit developers had hoped for--cognitive and affective. Feedback equally included these words for their thoughts and feelings:
understand, learn, know, see, think, realize
aware, appreciate, curious, intrigued, enjoy

Thinking and feeling outcomes were included in visitors' answers to the prompt "to make people":
Understand the significance of previous discoveries upon which the current science builds
Appreciate where our knowledge of the world comes from, and understand it has history and a perspective
See that science is a fluid subject
Visually understand scientific concepts of light, color, energy
Aware of the evolving dialogue that contributes to our understanding of the world
Appreciate historical contributions, value of early publications, get excited about science
Aware of how beautiful, how precise, how glorious nature is, as is the human faculty to chronicle
Only one person did not answer this prompt.



"What is one new idea you are taking away with you?" was a very direct prompt, encouraging subjects to provide evidence that they learned something. Thirty-one of the 41 CQ respondents (78%) answered the question; 10 did not. Usually when more than a few people do not answer this question it might be an indication that people are not having meaningful, memorable experiences.

• Four of the 10 people who didn't answer identified themselves as having a special interest in the history of science, and one of them said, "I may know too much, can't think of anything" as a response to the prompt. Were they underwhelmed or not impressed by any new experience?

• Five of the nonrespondents had no special interest and gave very short and simple answers to the other questions. Were they overwhelmed or unable to focus on a single idea to report?

• One person gave an alternate answer: "I never knew I could feel so tired from the flu :)"

Analysis by matching answers with the gender, age, or special interest of the respondents in these small samples did not reveal any patterns; rather, it suggested the diversity and variability of visitors' backgrounds and motivations.

Of the 31 who did answer the question about one new idea, 61% made a specific reference to an exhibit or area. For example, after the prompt "I didn't know, I never realized," they said:

That Darwin's The Origin of Species *was actually a condensed version of what he could have written*

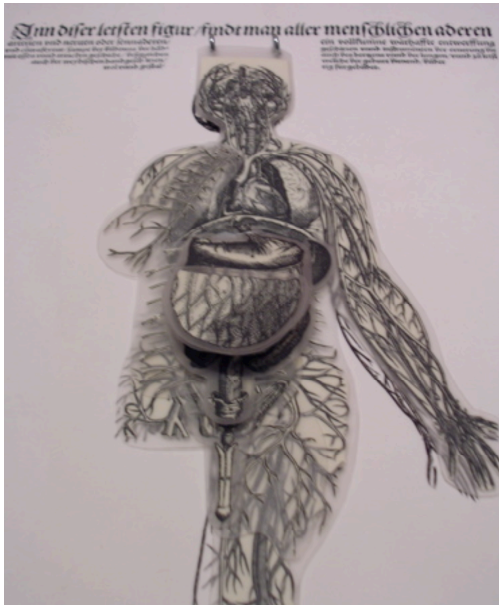
The history of astronomy & the arguments of the Earth-centered vs. sun-centered solar system

How well Galileo's telescope worked in viewing the moon

That the museum had a light bulb collection, and that Franklin had to argue for lightning rods

That the planets orbited in curlicues

Books of anatomy were created with flaps to show deepening layers and other bodily systems



When a majority of "new idea" responses contain concrete examples from the exhibition, it is evidence that the exhibit environment afforded memorable, meaningful experiences.

Other new things included accurate and appropriate generalizations, such as
The extent of censorship and religious resistance to some of the presented materials
That when books were the primary mode of distribution of knowledge that larger chunks came about as opposed to the constant stream we live in today
The significance of books in promoting scientists to search with better focus
That so many original documents exist
When visitors construct their own generalizations, we have evidence of constructive learning.

The prompt "It reminded me" is intended to capture how people relate what they experienced in the exhibition to their prior knowledge, and often the answers are reflective, personal, and philosophical. There were 16 non-responses to this prompt, but there is a trend for fewer people to answer this one, which is not considered a negative sign (Raphling and Serrell 1993).

Of the 25 responses, five of them were about the amount of knowledge available, indicating that they might have felt a little overwhelmed:
How little I know compared with what I would really want to know
There is much to be taught
How little we know about the universe we live in
That I need to keep increasing my knowledge
To come again with much more time

Other responses resonated positively with *Beautiful Science's* big idea:
That ideas change frequently
How important certain inventions are and how critical they are to today's world
Of the incremental way knowledge develops

What amazing artists so many scientists were

Still others were more affective and reflective:

How small our world is

That the magnitude of space/universe still overwhelms the imagination

It brought me back to what I had once lost

How glorious and adventurous life is and what a gift to be alive

How lovely nature is, how sublime to take time to study it

Two respondents elaborated on an idea sparked by the exhibition:

Galaxies were unknown for 40 years after the first large telescope plates--1890

Why women's medical science/study of female anatomy is so far behind ("all" books on male body)

"Anything else?" was the last question. It tends to capture compliments and complaints or suggestions and to have a high nonresponse rate. Out of the 20 answers, 19 were positive. For example:
Beautiful exhibit. A great motivator to participate in science as opposed to just being exposed to it.
This was awesome!
Amazing exhibit, well organized.
I appreciated the beauty of the physical presentations of the exhibit. The natural history wall with its double helix of origin from 300-20th century from never changing to evolving is nicely set up. Beautiful display for all four areas! I loved the emphasis of science being the perfect blend of logic and creativity.
Great exhibit!
I loved and identified with the videos of various scientists on the beauty of science. It was inspiring.

There was one suggestion:
I think there should have been more mechanical exhibits to demonstrate the concepts.

Key Words
Looking at the total responses to the CQ for key words, there are many, and they are spread across all sections of the exhibition, including *astronomy, universe, sun-centered, telescope, Milky Way, planet orbits, evolution, origin of species, anatomy, body, medicine, smallpox, light, color, optics, light bulbs, energy.*

But missing are *microscope, childbirth, healing, sundials, electricity.*
And considering the popularity of the interactives in the Light area, it is surprising to not see these mentioned: *camera obscura, prisms, mirror trick.*

Scientists' names that were mentioned included the already familiar: *Darwin, Newton, Galileo, and Franklin.*
But there was no mention of less familiar researchers who were also mentioned, such as *Kepler, Hubble, Pliny, Van Leeuwenhoek, Harvey, Priestley, al-Haytham, Lockyer.*

This raises the question about what an exhibition can hope to teach visitors about a very large subject in a relatively short amount of time in a densely packed informal learning environment. The answer is, Probably not a lot. That is why we can get excited when there is evidence that some people took specific new ideas away with them, and why we shouldn't be too disappointed when everyone doesn't. To the "Anything else?" question, one person said he was quoting John Lennon with a sentiment that was reflected by others in the "Reminded" section: "I vaguely mind people knowing something I don't know." The goal of helping visitors feel competent in the face of a large quantity of information that is not familiar will be discussed in the last section, after some comparisons of the evaluation data are made with other findings.

Comparisons of *Beautiful Science* and Other Museum Exhibitions

The data points on size, number of elements, average time, median percentage of stops, SRI, and %DV can be compared among exhibitions. They give some context to understanding the evidence for the effectiveness of the exhibition in capturing and holding visitors' attention and in communicating its learning objectives. The data for comparison was drawn from Serrell's 1998 database of 110 exhibits in *Paying Attention: Visitors and Museum Exhibitions* out of which 55 were classified as "small, nondiorama exhibits" that are most similar to *Beautiful Science*.

Figure 18. Comparison of database averages and data from *Beautiful Science*

"small nondiorama exhibits"	Size (square feet)	Number of elements	Average time (minutes)	Median % exhibit stops	SRI	%DV
Paying Attention database	<3,900	30	11	37%	244	30%
Beautiful Science	2,500	52 (40)	18	25% (35%)	139	4% (23%)

Beautiful Science is a comparatively small exhibition at 2,500 square feet. The average time spent by the sample of visitors who were tracked and timed was 18 minutes--considerably longer than the 11-minute average time for others in the database. Higher average times usually translate into lower sweep rates (SRI), and the SRI for *Beautiful Science* was 139, among the lowest sweep rates for the whole database. Visitors were lingering longer because they were engaged.

Beautiful Science had 52 elements, more than the average compared to other exhibitions of that size. The median percentage of stops for "small nondiorama exhibits" in the database is 37%; for *Beautiful Science* it was

25%, which indicates that visitor use was not as thorough as in similar exhibitions that typically had fewer elements (30, not 52). Thus, visitors were spending more time but spending it on fewer elements.

Exhibitions in the database that were defined as "exceptionally thoroughly used" had an SRI of less than 300 and a %DV of more than 51%. In comparison, *Beautiful Science* had a great SRI, but it did not attract or inspire many diligent visitors. Why? Most likely because

- There are many things to do at the Huntington--from the gardens to the art museum, from the conservatory to the café to the library. It is a big place. Many people come to see it "all," while others are just sampling what is in the exhibitions.
- Data were collected during the holiday season, when there were large numbers of tourists/families/Rose Bowl crowds who may have been under more time constraints than usual.
- There are many things to do in *Beautiful Science*, and many visitors, even though they found the exhibits interesting, were pressed for time.

If the number of exhibit elements is reduced to 40 by lumping the 13 audios into one stop, the percentages for median exhibit stops and diligent visitors become higher and closer to the average for the database, as shown by the numbers in the parenthesis in Figure 18, on the previous page.

Discussion and Recommendations

Beautiful Science has many fine qualities, from its aesthetics to its ability to engage visitors and communicate its main messages successfully, which were evidenced by the evaluation data on visitor behaviors in the exhibition and from cued feedback on the questionnaire. Visitors lingered for a relatively long time in the 2,500-square-foot space, and they understood the exhibit developers' intentions.

Unlike many exhibitions, orientation did not seem to be a problem. More than the usual number of visitors stopped at the introductory labels, and the most-used exhibits were distributed through all areas of the exhibition. The themed rooms distinguished themselves clearly through the use of bold colors, graphics, and walls. Visitors could easily tell when they'd moved from one section to another and could name the topics (e.g., astronomy, medicine, light). The planning and design emphasis placed on making orientation easy seems to have paid off.

The wall graphics, which summarized the main ideas in each section, captured and held visitors' attention and stimulated discussion among visitor groups. A high percentage of visitors were noted reading the wall graphics and also the labels that accompanied the books on display. The mechanical interactive exhibits, many of which recreated of scientific discoveries, were very popular, engaging, and related closely to the books nearby.

As with all exhibitions, there is room for improvement. In *Beautiful Science*, the overall weakness seems to be the low attraction rates for some exhibits, resulting in less-than-thorough use and a low percentage of diligent visitors--a comparative calculation for exhibition success. The low attraction rate for the audios was a particular disappointment for the evaluator. She expected and predicted that they would get much more use because they were so well done. A recommendation that might increase visitor engagement with the audios is to move them to, or make duplicate stations in, the Reading Room, where visitors can sit down to listen out of the way of others trying to see the books in the cases nearby.

Two other behaviors expected to be more common were reading out loud and reporting concretely about "one new thing" on the questionnaire. Reading out loud might be a no-no in a library, but there are ways to encourage visitors to be more social verbally in this exhibition, such as writing the interactive labels in a less formal, more playful and quotable voice and phrasing (Serrell 1996). Sharing information through reading out loud, talking, and calling each other over can help personalize the exhibit experience more for individuals (Leinhardt and Knutson 2004). With such a wealth of information available, more ways are needed to help every visitor grasp more memorable specifics along with the general chronological flow of the history of science. Lingering a little longer, sampling a few more related and reinforcing exhibits, or listening to some audios, would afford more learning opportunities.

Is it possible to get a longer average stay time, and can the percentage of diligent visitors be increased? The evaluator believes that *Beautiful Science* has the potential to be an exceptionally thoroughly used exhibition, that is, to have the evaluation characteristics of a low sweep rate (SRI) and a high percentage of diligent visitors (%DV). It already has a low SRI. One way to achieve a higher %DV would be to decrease the number of exhibit elements by changing the math, that is, lumping the 13 separate audio elements into one, making the total number of elements 40 instead of 52. The average number of stops was 14, and dividing that number by 40 instead of by 52 raises the average percentage of stops to 35%. To achieve exceptional status, %DV needs exceed 51%. Fifty-one percent of 40 exhibits equals 21 exhibits. Since there is a relationship between time and the number of stops, could the average time (now 18 minutes) increase to more than 20 minutes? Strategic marketing could help target more intentional visitors who would come to the Huntington prepared to spend a little more time in *Beautiful Science*.

Should there be fewer elements? Another way to decrease the number of elements is to take some things out. The exhibit developers are thinking of adding more interactives, but there are already plenty of things to do, and visitors on average are not engaging with more than half of what's already there. Perhaps exhibits that do not attract more than 20% of the audience could be replaced with more popular and effective ones. But it seems

hard to justify adding elements if thoroughness of use is a goal--and it should be, because the more visitors who use a high percentage of elements, the more bang for the buck, that is, a higher cost-benefit ratio is achieved--for the Huntington and for the visitors.

The Reading Room takes up a large area of the exhibition, and many people went through it without stopping, or stopping only once to look at the touchable book on display. But the sunlight-filled room was visible from every other room, and it served as a reference point to help people orient themselves in the exhibition. So while it did not function as a place where many visitors became engaged with the activities there, it still played an important role in the visitor experience. Resource areas in many exhibitions are underutilized, and in several instances the areas have been repurposed. The Huntington has plans to make the Reading Room more inviting by adding carpets, lamps, paintings on the wall, and current science journals. A reasonably high expectation for this area's use would be around 30%.

Another surprising finding for the demographics of the evaluation sample was that the Huntington seems to have a very high revisitation rate. Even at the early testing time (in January, only two months after *Beautiful Science* opened) 10% of the visitors were already making a return visit to the exhibition. Visitors are enjoying the show, coming back again, and if they are recommending it to their friends, and they come back, this permanent exhibition could have a very high rate of repeat visitors.

One of the big questions in the field of visitor studies is, What do repeat visitors do, compared to first-time visitors? This question has not been answered because, first of all, not many exhibits have high percentages of repeat visitors to study. Assumptions abound, especially for large, densely packed exhibitions: "When they come back, they will look at things they missed the first time" is the most common one. (Contrary anecdotal evidence, however, suggests that many people come back to see the same things or to show their friends things they have seen and enjoyed before, and if it's not there anymore they are disappointed.) Perhaps another evaluation study could be done in a year or so, including one quick post-tracking question, "Was this your first visit to *Beautiful Science*?" to find out if the attraction rates, average time, SRI and %DV are the same between first-time and repeat visitors.

Another question for a larger tracking-and-timing research study would be to see if visitors who flow through the exhibition in different patterns spend significantly different amounts of time in the exhibition and what variables influence which pattern they chose.

Bibliography

Leinhardt, Gaea, and Karen Knutson. 2004. *Listening in on Museum Conversations*. AltaMira Press, CA.

National Science Foundation. 2008. *Framework for Evaluating Impacts of Informal Science Education Projects*.

Raphling, Britt, and Beverly Serrell. 1993. "Capturing Affective Learning," *Current Trends* 7:57-62, Committee on Audience Research and Evaluation, a standing professional committee of AAM.

Serrell, Beverly. 1996. *Exhibit Labels: An Interpretive Approach*, AltaMira Press, CA.

Serrell, Beverly. 1998. *Paying Attention: Visitors and Museum Exhibitions*. American Association of Museums, Washington, DC.

Serrell, Beverly. 2000. "Does cuing visitors significantly increase the amount of time they spend in a museum exhibition?" *Visitor Studies Today*, Vol. III (July):3-6.

Serrell, Beverly and Ingrid Sulston. 2001. "In Search of the Elusive Bimodal Distribution," *Visitor Studies Today* Vol. IV (Summer):4-9.

Serrell, Beverly. 2002. "Are They Watching?: Visitors and Videos in Exhibitions," *Curator* 45 (January):50-64.

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Appendix--Electronic files (on CD):

A. Element list by attraction rate

B. Spreadsheet of T&T data

C. Spreadsheet of CQ data

D. Transcription of CQ data

E. Data collectors' summary comments