

COSMIC QUESTIONS

Summary Evaluation Report
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Executive Summary

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PROJECT BACKGROUND AND DESCRIPTION

Cosmic Questions (CQ) is an interactive, 5000-square-foot exhibition developed by staff at the Harvard-Smithsonian Center for Astrophysics (CfA). The exhibition was designed by Jeff Kennedy Associates of Boston, and the CfA contracted with Boston's Museum of Science to develop the educational programs and materials. Major funding to support the project was provided by the National Science Foundation and by the National Aeronautics and Space Administration.

CQ was designed to promote reflection about and interest in “big questions” about the universe and humanity's place in the cosmos, and to provide the most up-to-date information about the universe. Through their experiences in the exhibition gallery and at the related activities of *CQ*—a play, a demonstration, and a planetarium show—visitors were encouraged to construct their own meaning from the content, reflect on their own personal relationship to what it portrays, and ask their own often unanswerable questions about the universe. In fact, the developers placed greater or equal emphasis on visitors' abilities to make personal connections with the content than on the learning of facts, although the latter is also an important aspect of *CQ*.

This summative evaluation, conducted from September 2002 to June 2003 by the Program Evaluation and Research Group (PERG) at Lesley University, was carried out in the first two sites hosting *CQ*—Boston's Museum of Science (MOS), and the Midland Center for the Arts (MCFTA), in Midland, Michigan.

This executive summary contains brief highlights of the full report which includes extensive examples and quotations from the data. We have provided an appendix which contains a few samples from the full report. These sections allow the reader to hear some of the many visitor and museum staff voices captured in the larger document.

FINDINGS PART ONE: VISITOR INTERACTION WITH *CQ* EXHIBITION CONTENT

Almost all of those interviewed at both sites enjoyed their visits to the *Cosmic Questions* exhibition. Approximately three-quarters of respondents indicated that *CQ* had helped them to think about the “big questions” raised by the exhibition. Over two-thirds said they had learned or experienced something new. A majority also reported that the

exhibition had prompted them to reflect on their personal relationship to the universe, and that they left the exhibition pondering a range of interesting questions. In follow-up phone calls, almost half of those interviewed from each site said that their mental picture of the universe had changed as a result of their experiences in the exhibition.

A: LAYOUT AND VISITOR PATHWAYS

Visitors interacted with the *Cosmic Questions* exhibition in two distinct sites during the course of this evaluation. While the components included in *CQ* were essentially the same, the physical layout of the exhibition, and the visitor pathways through it, varied between the two sites. The placement of particular components at each institution appeared to influence the impact of those components on *CQ* visitors.

B: VISITOR REACTIONS

WHAT STOOD OUT

On the day of viewing: Visitors were asked to identify what “stood out” for them during their visits to *CQ*. Respondents at both museums mentioned a broad array of components, with different but overlapping favorites, including the *Cosmic Kitchen*, *Infrared* area, *Fly Through the Universe*, *Multiwave Viewer/Night Sky*, and the *Black Hole*. Major differences in emphasis between the two sites were the *Cosmic Calendar*, *Alien Life*, and *Big Bang* components, which were more popular in Boston, and the *Interviews With Astronomers*, *Information About the Telescopes*, and the *Rhythm of the Cosmos*, which were relatively more popular with Midland visitors.

After returning home: Almost all the visitors interviewed by phone (3 to 7 days or 6 to 9 weeks after their visits) remembered *CQ*, and most said that they had enjoyed the exhibition. For many visitors, the interactive components stood out the most; for MCFTA visitors, the interactive components were almost the only components mentioned in follow-up interviews. In contrast, most MOS visitors also found many other components to be memorable, as well.

RESPONSES OF CHILDREN

Children responded to *CQ* in a manner similar to adults; they enjoyed the hands-on components and raised thoughtful questions about the universe. Even some of the younger respondents—boys and girls 6 to 12 years old—had questions about the universe, and many identified areas of new learning.

C: VISITOR REFLECTIONS, LEARNING, AND QUESTIONS

REFLECTIONS ON THE THREE BIG QUESTIONS

About three-quarters of our visitors said that *CQ* had helped them to think about one or more of the three questions asked by the large sign at the exhibition's entrance:

What is the universe like? Visitors gave considerable thought to the nature of the universe while in the exhibition, and many left still wondering about this question. They were especially struck by the vast scale of the universe and the relative size of our world, and often wondered about the makeup of the cosmos.

Was there a beginning to time? Visitors commented on time and issues related to the big bang, including what came before the big bang and about an end to the universe. Some visitors, particularly in Midland, related the big bang and the formation of life to their religious beliefs.

Where do we fit in? Many visitors wondered about their place in the universe, both as individuals and as part of the human race, and commented on the relative size of humans compared to the vast universe. Others were interested in the possibility of alien life, and some focused on philosophical issues, including their relationship with God.

VISITOR LEARNING

A large majority of our visitors reported learning something new during their visits to *CQ*—69% at the MOS, and 86% at the MCFTA. These visitors cited a broad range of topics related to various components within *CQ*. They learned about black holes; dark matter and dark energy; galaxies and the vastness of the universe; stars and light spectra; and alien life. Some visitors learned new information about the tools astronomers use and where they work, such as telescopes and observatories, and about scientific theories, such as the Big Bang and Einstein's theories of space and time. A smaller number of visitors said that they didn't learn anything new due to their previous knowledge of these topics, recent schooling, or professional experience. However, other visitors with similar backgrounds did identify new learning within *CQ*.

QUESTIONS RAISED BY THE EXHIBITION

On the day of viewing: Most of those interviewed said that *CQ* raised new questions or stimulated existing questions (56% of MOS visitors and 68% of MCFTA visitors).

Common topics visitors wondered about included: the existence of alien life; what happened before the big bang; "what's out there" in the universe; space exploration and technology; big-bang-related topics; black holes; the size/vastness of the universe; and

religious/spiritual questions, including, “Why are we here?” and “Is there a greater power out there that governs this?”

Lingering questions: In short and long-term follow-up phone interviews, more than half of MOS visitors were still wondering about very specific “cosmic questions.” Only about 30% of Midland visitors had lingering questions and many of these were vague. Some of the topics visitors identified included: religious and spiritual concerns; the big bang and what happened before it; alien life; black holes; space exploration and aspects of the space program; and philosophical issues.

D: CHANGES IN MENTAL PICTURE

In follow-up phone interviews, about half of visitors from both sites reported that their mental picture had changed as a result of viewing *CQ*. These visitors described their new awareness of the universe, especially its vastness; its shape, temperature, and expanding nature; and the existence of black holes and dark matter. Visitors also had a new awareness of the possibility of alien life; new images or “pictures” of the universe in their minds; and a new sense of the relationship of the universe to their daily lives.

E: PERSONAL, RELIGIOUS AND, SPIRITUAL REFLECTIONS ON CQ

PERSONAL RELATIONSHIP TO THE UNIVERSE

More than 60% of those interviewed at each site said that *CQ* helped them think about their relationship to the universe. Visitors often talked about “feeling small” in relation to the universe, which for many carried a negative connotation. However, others found the relatively small size of humanity reassuring, and liked feeling part of something bigger than themselves. Other visitors discussed spiritual topics and their connection with God, and some were struck by the idea that “we are made of the same elements as stars.” Other visitors mentioned their curiosity about alien life and the need for space travel and exploration. Finally, several visitors remarked that a relationship to the universe wasn’t possible because it was too big, or because “we can’t do anything except observe.”

RELIGIOUS/SPIRITUAL COMMENTS

About 10% of MOS visitors and almost one-quarter of MCFTA visitors discussed their belief in God or a higher power during exit interviews. Most of these visitors, including some who identified themselves as creationists, were comfortable with the exhibition and did not experience major conflicts with the science presented within it. Some visitors were

prompted to review pre-existing, unresolved questions about the intersection of science and religion. Others talked about how their faith gave them a sense of security and control in the face of a vast universe. Several saw evidence of God's power in the information about and images of the universe, including the Hubble pictures (only shown in Midland). Some visitors disagreed with some of the concepts presented in *Cosmic Questions* (such as the big bang), because they conflicted with their religious beliefs.

F: SPECIAL AREAS OF EMPHASIS

DIVERSE CULTURAL POINTS OF VIEW

While most visitors did not comment on the diverse cultural, historical, and spiritual points of view included in the exhibition, those who did notice cultural and historical references found them to be an important part of their *CQ* experience and often wished for more.

UNDERSTANDING THE WORK OF ASTRONOMERS

At both sites, visitors reported an interest in the work of space scientists and the tools that they use to explore the universe, including the infrared component, the Chandra and Hubble telescopes, and light spectra.

G: MAGICAL POSSIBILITIES

When visitors were asked, "If anything were magically possible, is there anything new you would like to do as a result of seeing this exhibit?" the majority expressed a desire to explore space. In addition to space travel, visitors wanted to see a black hole up close, immerse themselves with knowledge about space, and find aliens. Some visitors were interested in seeing and using the tools astronomers use, such as the Hubble or Chandra telescopes. Other visitors said they weren't interested in exploring space, but were "content to stay here on earth."

FINDINGS PART TWO: VISITOR REACTION TO CONTENT IN RELATED ACTIVITIES

AT MOS: PLAY, DEMONSTRATION, AND PLANETARIUM SHOW

At the Museum of Science in Boston, *Cosmic Questions* included four separate but interconnected components—the main exhibition; a play entitled *Girl Meets Boy*; a live demonstration, *The Real Time Machine*; and a planetarium show, *Journey to the Edge of Space and Time*. Each of the three presentations took place on a daily basis, all at sites within the MOS but at some distance from the exhibition hall. Live presenters told audiences about the *CQ* exhibition in the main gallery and encouraged them to see it, but the main exhibition offered little information about the other related activities.

Visitors' reactions to the related activities were overwhelmingly positive. Most indicated that they were thinking about their connection to the universe, had new questions, and/or learned something new as a result of the presentation they had viewed.

AT MCFTA: DEMONSTRATION AND PLANETARIUM SHOW

The Midland Center for the Arts presented the various “pieces” of *CQ* in a different format than at the MOS. Invited experts presented evening lectures and several *Science Sunday* events, including *The Real Time Machine*, which covered topics related to *CQ*. The *Journey to the Edge of Space and Time* planetarium show was presented at a planetarium about 10 miles from the Center. The play, *Girl Meets Boy*, was not presented in Michigan.

Visitor feedback from *The Real Time Machine* and the planetarium show was overwhelmingly positive. Most of the respondents said that they learned something new, and many had questions about the universe and space travel.

FINDINGS PART THREE: IMPLEMENTATION AND SUPPORT OF THE CQ EXHIBITION

TRAINING

In Boston, extensive training was provided to a large number of staff and volunteers, including guided tours, written materials, and special training sessions. In addition, staff members were invited to lunchtime discussions and seminars with professionals in the field, and had easy access to exhibition developers. Most felt that their training was excellent and essential to their ability to work with the exhibition.

At the Midland Center for the Arts, administrators involved with *CQ* all received an orientation and some training for their roles during visits to Boston, which they found useful and informative. They also appreciated their access to the exhibition developers and MOS staff whenever necessary. The volunteers involved with the exhibition all received an orientation to the exhibition by either a *CQ* developer from Boston or the local administrator in charge of *CQ*. Extensive written materials and Web resources were also utilized by some staff and volunteers in Midland.

CQ INTERPRETERS/DOCENTS

Volunteers and administrators at both museums agreed that the presence of live, human resources available to help “interpret” *CQ* was essential for many visitors to fully experience and understand the exhibition. However, the interpreter/docent programs at MOS and MCFTA differed in a number of ways. The most notable difference was that volunteers in Boston usually presented predetermined interpretations, while those in Midland most often circulated within the exhibition to interact with visitors.

The volunteer interpreters interviewed at both sites were excited about *CQ* and thought very highly of it. They enjoyed learning about and explaining the “big ideas” presented in the exhibition, although some, especially in Midland, were intimidated by the content of the exhibition. Many volunteers found their work with *CQ* to be a welcome chance to immerse themselves in new areas of science or to explore more fully an area they were already familiar with.

DEMONSTRATION STAFF

At the MOS, museum staff developed a daily demonstration which presented information and concepts closely related to the exhibition but not fully covered by it. They were pleased with visitor reaction to the demonstration and its ability to keep the interest of even many young children. Like others working with *CQ*, demonstration staff thought highly of the exhibition and found their work with it to be extremely challenging and enjoyable.

ACTORS

Actors and supervisory staff reported that implementation of the play was a relatively smooth process, and that it was well-received by visitors. Based on audience feedback, the actors felt that the play often succeeded in providing visitors with a different “entry point” into the content of the exhibition, through the joining of science and art.

STAFF AND VOLUNTEER SUGGESTIONS

Staff and volunteers who worked closely with the exhibition made a number of important suggestions for improvements to *CQ* and its implementation. Volunteer recommendations concerned specific components, logistical issues, and the training and use of interpreters. Actors and demonstration staff made suggestions about staff training and the use of their components, including strengthening the link between their programs and the main exhibition. Administrators’ recommendations concerned promotion of the exhibition, support activities, training and preparation, teacher professional development activities, and installation issues.

EDUCATOR INVOLVEMENT

In order to support educator involvement with the *Cosmic Questions* exhibition, both museums sponsored symposia for teachers. In addition, staff at the Museum of Science produced a teachers’ guide to complement *CQ*, which became available as the exhibition traveled to Michigan.

Teachers who attended the MOS teacher symposium had very positive responses to the workshop. They found it to be useful, informative, and relevant to their classroom teaching. These teachers said that they taught differently, and gave their students more information about the scientific concepts covered in the exhibition as a result of their attendance at the symposium. The information presented in the workshop affected teachers’ lesson planning, increased their confidence, and enabled them to focus on

outstanding “cosmic questions,” along with the latest scientific theories. Those teachers who brought their classes to the exhibition also found the orientation they received at the symposium to be helpful in designing activities for their students.

FINDINGS PART FOUR: IMPACT ON THE MUSEUMS— BENEFITS AND CHALLENGES

BENEFITS FOR THE MOS

Cosmic Questions provided a number of benefits to the MOS. Staff and volunteers felt the exhibition enhanced the reputation of the museum; advanced the museum’s main mission; pleased staff and volunteers and increased their knowledge base; moved astronomy topics into the main exhibition hall; provided multiple ways to access the thematic content of *CQ* through the exhibition and related activities; left behind materials for ongoing use; offered an important resource for teachers; established new working relationships; produced high-quality educational materials; and assisted with fundraising.

BENEFITS FOR THE MCFTA

At the MCFTA, staff and volunteers identified an overlapping but different set of benefits. For that institution, *Cosmic Questions* enhanced their reputation; provided a good example of the integration of science and art; established new working relationships; increased visibility and visitorship; enhanced the internal teamwork between several member organizations within the MCFTA; revealed a maintenance crew eager for new projects; and provided a good winter activity for families.

CHALLENGES FOR THE MOS

MOS staff and volunteers identified a number of challenges related to *CQ*. These included getting participating staff and volunteers comfortable with the content of the exhibition; learning to communicate the “big ideas” of *CQ* to a varied audience; technical problems; keeping up-to-date with the content; space and layout challenges; scheduling issues for the demonstration and play; educator symposium-related challenges; and providing enough promotion and publicity for the exhibition.

CHALLENGES FOR THE MCFTA

The challenges identified by MCFTA staff included training the educational staff; technical problems; installation frustrations; space and layout challenges, including weight and size factors; and exposing a need to update their permanent exhibitions.

DISCUSSION OF FINDINGS

The *Cosmic Questions* exhibition had four major goals for its viewers, as described in project literature:

1. Learn about key astronomical and scientific concepts, including:
 - a. The composition of the universe and its vast scales of space and time
 - b. The physical and analytical tools of the astronomer; learning from light
 - c. The interplay of models, evidence, and explanation in forming our understanding of the universe
2. Increase their understanding of the nature of scientific inquiry by engaging in activities that explore “how we know” about the universe.
3. Encounter various human perspectives (historical, personal, cultural, artistic, etc.) on age-old cosmic questions.
4. Reflect upon their own ideas about the universe and the meaning and relevancy of the ongoing human search for answers to cosmic questions.

Although it is difficult to attribute causality, visitor statements indicate that the *Cosmic Questions* exhibition succeeded in meeting these goals, usually to a high degree. *CQ* definitely contributed to visitors’ curiosity, reflection, and learning about the topics presented. The exhibition stimulated many visitors to think, to ask questions, and to develop a greater sense of their personal connections to the universe. Some respondents, including many staff and volunteers who worked with or around the exhibit at the two museum sites, were touched quite deeply by their interactions with *CQ*.

The exhibition provided multiple means for visitors to connect with the experience of space science, both in terms of the variety of components and through the related activities. For those who were interested, or who spent enough time at the exhibition to explore it thoroughly, *CQ* succeeded in conveying a variety of historical, personal,

cultural, and artistic perspectives on the universe. *Cosmic Questions* also had a wide appeal—across age ranges, levels of prior scientific background, and religious/spiritual beliefs.

According to visitor responses, a majority of those who experienced the exhibition developed new understandings and learned new information about a wide range of topics. This new knowledge included information about the tools of the astronomer. However, visitors were often left unaware of the significance of these tools, or how they were actually used in scientific exploration.

DIFFERENCES BETWEEN THE SITES

While all of the components of the main exhibition traveled from Boston to Midland, there were numerous significant differences between the two museums and their implementation of the exhibition. However, data indicate that visitors at the traveling site, the MCFTA, expressed generally similar responses and experienced similar positive outcomes as those at the pilot site, the MOS. However, follow-up phone interviews revealed fewer lingering questions for MCFTA visitors, and a smaller variety of memorable components (almost exclusively the most interactive components).

The differences at the two museums included:

- Identity of museum
- Size and structure of museum
- Relationship of *CQ* to other exhibits
- Visitor demographics
- Organization of *CQ* exhibition within the museum
- Difference in interpreter/docent roles
- Use of related activities (play; demonstration; planetarium show)
- Relationship and proximity to exhibition developers
- Promotion and publicity of *CQ*

Despite all the differences between the two sites, the *Cosmic Questions* exhibition offered generally positive experiences for visitors at both locations. Most visitors left with more knowledge and many thoughtful reflections, and they were more curious than when they had entered. In addition, many staff and volunteers at both sites felt personally and professionally enriched through their experience with the exhibition.

APPENDIX: SELECTIONS FROM THE FULL REPORT

Responses of Children

Visitor Reflections on the Three Big Questions

Impact on the Museums: Benefits and Challenges

RESPONSES OF CHILDREN

The children who agreed to be interviewed at both museums shared almost uniformly favorable reactions to *CQ*. (About half of the exit interview respondents in Midland were children under the age of 18, as most visitors to the MCFTA were in family groups. In Boston, about one-third of the exit interview respondents were children. A majority of all children interviewed were under 14 years of age.) Even some of the younger respondents—boys and girls 6 to 12 years old, had questions about the universe and identified new learning. Several children in this age group mentioned the big bang, and were curious to know when “time started.” Most children of all ages reported that they learned something new in *CQ*. They talked about the big bang, black holes, dark matter, galaxies, the vastness of space, stars and light.

G8: I didn't know anything about black holes, that time stops when you get near them. (MCFTA exit interview)

B15: I liked how they talked about the different wavelengths, and how there's so much other besides visible light. (MCFTA exit interview)

B9: How the universe is created . . . it started with the big bang. (MCFTA exit interview)

G9: I learned that the stars are going to explode some day and I thought they were going to live forever. (MOS exit interview)

G10: I liked the space and Albert Einstein part because it shows how space stretches throughout time. (MOS exit interview)

Many younger children—particularly in Midland—reported that they enjoyed the *Cosmic Kitchen*. They also identified interactive components as highlights of the exhibit, including *Fly Through the Universe*, *Multiwave Viewer/Night Sky*, the *Static Ball*, the *Infrared* component and the *Black Hole* area.

G17: The kitchen. I've never seen an exhibit like that before. (MOS exit interview)

B11: It was good, especially the apple thing. (MCFTA exit interview)

G8: I liked the things where you pressed the button and it talked and you held it up to your ear. (MOS exit interview)

B7: I liked the black hole. Trying to get into the black hole. (MCFTA exit interview)

G10: This thing's cool [*Multiwave Viewer/Night Sky*]. You find something, you can make it visible. (MOS interactive observation)

Older children (13–17) also enjoyed the interactive portions of *CQ*. They raised questions about the big bang and the structure of the universe. They were also interested in seeing the inside of a black hole and exploring space, including visiting the planets.

G15: I thought there was a theory about the big bang expansion and in the future, retraction. I wondered if there would be a retraction. (MOS exit interview)

G13: It was a good metaphor to compare everything to a kitchen. (MOS interactive observation)

B13: [I want to] go through the universe or make something that can go through it. (MCFTA exit interview)

B13: It showed me a lot about black holes . . . I didn't think it was hot near a black hole, that matter traveling into a black hole is at the speed of light. I found that interesting. (MOS interactive observation)

B13: I knew time and space distortion happened, but it's nice to see it . . . (MOS black hole interactive observation)

G13: Oh my gosh, that's a galaxy map. That's amazing. (MOS interactive observation)

Some children, like many adults, talked about how “small we are.” Many had questions about black holes and other aspects of “what's out there.”

B10: What black holes were and what they did . . . was there a big bang, what are the details of it? (MOS exit interview)

G9: The question I had is why can't we get a picture of the galaxy . . . and I got an answer that it's too far away. (MCFTA exit interview)

G10: I was just wondering if the big bang was the beginning of time or something earlier or later was the beginning. (MCFTA exit interview)

G12: I don't really know how big the universe is. (MOS exit interview)

Most children surveyed wanted to explore space—some to visit other planets, while others hoped to visit stars or black holes.

G8: I would definitely explore other galaxies and learn about space. (MCFTA exit interview)

G9: I would build a big space ship and float around and see stuff . . .
(MCFTA exit interview)

B10: Really go into a black hole. *Why?* Because it sounds interesting, kind of like the Bermuda triangle.
(MOS exit interview)

Several of the children we interviewed made reflective comments and developed their own “big questions,” like those below.

G9: I wondered how big it must really be if I am only one out of a million parts of the universe because not even the planets are a big part of it.
(MOS exit interview)

B13: What happened before the big bang? What’s on the other side of a black hole?
(MCFTA exit interview)

B10: It made me think of how the universe even got here and the big bang. All the stuff that’s happened since the big bang; all the stars exploding and dying.
(MCFTA exit interview)

VISITOR REFLECTIONS ON THE THREE BIG QUESTIONS

Cosmic Questions presented visitors with three “big questions”: “What is the universe like?” “Was there a beginning to time?” and “Where do we fit in?” While most of our visitors did not notice the entrance sign with these questions at the front of the exhibition gallery or inside the exhibition itself, most respondents did say that they were thinking about some of these themes as they went through *CQ*.

As I look at them now [the three questions], those were all answered as I walked through. If I had read them as I walked through, I would have thought about them a little more.
(MCFTA exit interview)

At the Museum of Science in Boston, 78% of exit interview respondents asserted that the exhibition helped them to think about one or more of these three questions, and only 6% said that the exhibition did not have that effect on them. (16% had no answer for that question.) At the Midland Center for the Arts, 74% of exit interview respondents said that the exhibition helped them to think about these questions, while only 3% said that it did not. (23% did not answer that question.)

WHAT IS THE UNIVERSE LIKE?

According to their responses during exit interviews and comments during the interactive observations, visitors gave considerable thought to the nature of the universe while in the *Cosmic Questions* exhibition. They were often struck by the size and scale of the universe.

That first thing where he was zooming in and out—I was realizing how vast it was.
(MOS exit interview)

G9: It helped me know what the universe was like because I didn’t know it was so big. I didn’t know there were as many stars . . . It made me really think about it.
(MOS exit interview)

That’s incredible! [Looking at universe in 3D] What it represents . . . each little dot represents billions of stars. It must be what infinity is like.
(MOS interactive observation)

I guess a lot has changed since I learned about it in school. When I was learning, it was just the planets. But now it’s universe upon universe.
(MCFTA exit interview)

It gave you a good feel of how the universe is, and our little piece is just a small speck. You don’t usually think about that very often.
(MCFTA exit interview)

The reason I didn't appreciate [space science] before the last few years is that I would see a picture of exploding stars, but didn't see them as real. I'm beginning to understand the models better. (MOS interactive observation)

Others were prompted to think about a variety of details about the nature of the universe.

It gave a lot more information based on actual facts than I've ever seen before. (MOS exit interview)

It helped to answer some of my questions about all of the planets and the solar system. (MOS exit interview)

F17: It just kind of explained what the universe was made of. (MOS exit interview)

I thought about the curvature of space-time, around the *Black Hole* exhibit. It showed some models of limits of where space and time break down. (MOS exit interview)

It seems much more colorful than I imagined, because when you stand down here you just see black and white. (MCFTA exit interview)

Of course, because I see the descriptions of how far these bodies are so it tweaks me to try to imagine how far is 400 trillion light years. (MCFTA exit interview)

I learned today that there is an observatory in Hawaii. It's significant to learn where they are located in our own country. (MOS interactive observation)

Many visitors found themselves still wondering about what the universe was like as they left *CQ*.

I'm still trying to understand what [black holes] are. I'm not sure I can get my head around them yet. (MOS interactive observation)

Are there other planets like ours? Is there another galaxy similar to ours? If there are other galaxies, what are they like? I hadn't previously thought about them in depth. (MOS exit interview)

Is it the same everywhere? Could you go to different parts of the universe and would they be different . . . fundamentally? Does it look the same everywhere? (MOS exit interview)

G13: How did oxygen get inside the stars? How did the stars get all this stuff? (MOS interactive observation)

G10: I just was wondering if there are huge galaxies that are billions and billions of light years away. And if there really are aliens somewhere in the universe. (MCFTA exit interview)

Some visitors in both museums (although more often at the MCFTA), said that thinking about the nature of the universe made them think about God.

Is there a greater power out there that governs this? (MOS exit interview)

I'm speechless . . . I believe in God. I believe God put all this here. I see the beauty of what he or she did. I don't try to understand it, but you see what's here. It's like magic. (MCFTA exit interview)

WAS THERE A BEGINNING TO TIME?

Visitors also thought about issues and questions related to the beginning of time. They often wondered about what may have come before the big bang, and about an end to the universe.

I knew about the big bang, but I never thought of how it all began, how the cosmic ooze all got together . . . If it all had a beginning, then it all must have an end. I hadn't thought of that. (MOS exit interview)

I was concentrating most on the beginning of time [of the three questions] . . . I love the shape of space-time. They compare Einstein's ideas with the current ideas of today. (MOS exit interview)

B10: I read the big bang one. That was interesting and made me start thinking about the beginning of time . . . I don't know if there was a beginning to time and that's kind of scary. (MOS exit interview)

It definitely makes you think about the beginning of time, because we watched the video and looked at the computer images . . . I can agree with some of it, but how can they know this if they were not around? (MCFTA exit interview)

I've come to the realization that humans think in a linear fashion. I think there is another dimension. There is another way to explain and describe time that we have no idea of. (MCFTA exit interview)

I understand space-time fabric, but not enough to apply it. (MOS interactive observation)

A number of visitors, especially in Midland, brought up the topic of religion when discussing their experience in *CQ* in relation to this question.

For beginning of time, it's the question of creation vs. evolution. If you believe in creation, you know what the beginning of time was, from the Bible.
(MCFTA exit interview)

This is an interesting question—What's before the big bang? Maybe religion will find an answer.
(MOS interactive observation)

WHERE DO WE FIT IN?

Finally, visitors also found themselves wondering about their place in the universe—both as individuals and as part of humanity—and how they “fit in.” For many, their thoughts concerned the relative size of humans compared to the vastness of the universe.

That is so immense, you know; where do we fit in? Actually, I have more questions and things going on in my mind now than before.
(MOS exit interview)

The first one about the Milky Way made me think about where we fit in. You know what a tiny speck we are in the whole scheme of things.
(MOS exit interview)

My amount of time in the grand scheme of things is a fraction of it and it is daunting to think about.
(MOS exit interview)

It makes you think. We're not even an atom in all this. People think we're the be all and end all, and we're not.
(MCFTA exit interview)

A number of visitors were prompted to think about the possibilities of other life in the universe.

I enjoyed looking at the pictures of other landscapes. It does make you wonder about what else is out there and how significant we are in the whole universe.
(MOS exit interview)

That's the question that really struck me—Where do we really fit in? Are we the only life form? Are there any civilizations outside our galaxy?
(MCFTA exit interview)

Some were struck by the similarities of the chemical make-up of all matter in the universe.

I liked . . . that we are made of the same chemicals that were made at the beginning of time.
(MOS exit interview)

B14: It makes you think about everything is the same and nothing is different because we're all made of the same thing. [In *Dark Matter* room, looking at wall of objects.]
(MOS interactive observation)

Finally, visitors also shared their thoughts about various philosophical issues, including religion.

Where would I be if there wasn't a universe? (MOS exit interview)

We're a speck of dust; mankind is so insignificant. But it seems that everything fits together. We are an integral part of the cosmos. Without mankind, the cosmos would be meaningless. There would be no one in the world to understand it or pay attention to it. (MCFTA exit interview)

"Where do we fit in?" Yeah, right where God wants us to. (MCFTA exit interview)

IMPACT ON THE MUSEUMS—BENEFITS AND CHALLENGES

This part of the evaluation report discusses the institutional benefits and challenges that *Cosmic Questions* provided to the two museums, primarily as reported by museum administrators and others who worked with the exhibition. Although a number of items were site-specific, others were similar for both museums.

BENEFITS FOR THE INSTITUTIONS

Museum of Science

At the MOS, *Cosmic Questions* achieved the following:

- **Enhanced the reputation of the museum, generally due to the high quality and important content of the exhibition**

It gave us an example of a really, really good exhibit about the universe. I would like to keep it, frankly. (MOS staff)

I think it was a great exhibit and I think it did a lot for the museum to have it there. It's pretty much pure science, and it answers an interesting question—"How did this stuff come together?"—the most interesting question there is, I think . . . The museum has good science, and I think this part of it was some of the best. I was impressed by the accuracy, validity of the information.

(MOS interpreter)

- **Advanced the main mission of the museum**

It was an excellent fulfillment of museum promise . . . People pay money to come here to learn science. We have to fulfill their expectations and I think *Cosmic Questions* did that . . . It's one of those exhibits that help us accomplish our mission very well.

(MOS staff)

- **Pleased the staff and volunteers with its content of challenging scientific concepts**

I did have a staff member come down and say this is a really challenging topic and I'm really happy to see we're addressing that. I'm glad to see that it's being done. Other staff members from outside this department commented on that. (Demonstration staff)

I think the *Cosmic Questions* exhibit was unique. It was asking questions I have not seen around, questions that an exhibit that wants to be more successful with the public stays away from . . . but you are a museum of science, you have a mission to the public, and this

exhibit furthers that mission . . . I applaud the museum's willingness to host it. (MOS interpreter)

I think that the exhibit provided an excellent example of how science touches our lives, affects our lives. Even though cosmological questions may not be of immediate practical importance in most people's work lives, it does concern questions that affect each and every person . . . Cosmology is an area where science has the chance to address some of those issues—How did everything come into being and where is it going? It's an area that ties into philosophical questions that everyone has. It was illuminating to host an exhibit to deal with those questions so clearly and touching on what implications those answers have. (MOS demonstration staff)

- **Increased the knowledge base of staff and volunteers, which will be useful in relation to other exhibitions**

We found ourselves talking more about models than we have in the past, and the museum is building a new exhibit about making models. It got us more ready for working with that. A few of the people really grew during the development of the program. (MOS staff)

Since in Science Theatre we insist on a certain amount of research on the topic so that audience questions may be fielded with some assurity, the actors are also increasing their knowledge on scientific subjects. This makes them more "employable" in our viewpoint. (MOS staff)

- **Moved astronomy topics into the main exhibition hall**

It offered another opportunity to present astronomy, where people could continue their planetarium experience . . . Usually astronomy is limited to the planetarium and many people don't go there, but only go to the exhibit halls. (Planetarium staff)

The Real Time Machine let us experiment with a cosmology presentation outside the planetarium, to expand our repertoire where we don't usually do anything on that topic. Now we are going to continue to do it even though the exhibit is gone. (MOS staff)

- **Provided different ways and more chances to access the content through the thematic approach of the exhibition hall, demonstration, play, and planetarium show**

A lot of people didn't see *Cosmic Questions* before they saw the demonstration. The show really helped people want to see the exhibit. (Demonstration staff)

I think a lot of people who came to the show wouldn't have gone to the exhibit if they hadn't see the [play]. (Actor)

We could link the program to the exhibit. We could say, “Be sure to see this particular component in the exhibit.” It was nice because the show is 35 minutes and . . . there’s limited time to spend with visitors.
(Planetarium staff)

- **Left behind materials for ongoing use**

We have a traveling planetarium. One of the women who does that is going to use one of the components [from the demonstration] in her program—the radar gun . . . to measure speed using invisible light . . . We wouldn’t have developed it if we didn’t have the exhibit.
(Demonstration staff)

Our volunteers love [the props]. Some of the props are still being used and implemented in other ways. Only a few of the items we were not able to keep here.
(MOS staff)

- **Offered an additional high-level resource for teachers and classes**

It really was a great enhancement to our current programming for students and teachers . . . I felt that it brought a lot of strength in astronomy and Earth science ideas . . . It was a benefit because I could promote going to that exhibit in my other programs, because it helped people understand those complex ideas . . . It was an additional resource to offer teachers for their own learning and for their field trips.
(MOS staff)

- **Established new working relationships with the playwright, astronomers, Jeff Kennedy Associates (CQ’s design firm), and the Harvard-Smithsonian Center for Astrophysics**

The playwright is a very well-known and popular playwright, Melinda Lopez. We’d never worked with her before, and this was an appealing topic to her. It gave us entry . . . My department worked with constituents we hadn’t worked with in the past like JKA and CfA . . . We’ve built relationships with astronomers we can use in the future.
(MOS staff)

- **Enabled the funding of high-quality educational materials**

We were able to create a better product, knowing we weren’t on a shoestring budget . . . We’re printing using beautiful full-color images, and it’s so much more powerful as an educational tool . . . So the final product will look very professional.
(MOS staff)

- **Assisted fundraising efforts due to the collaboration with NASA and NSF and their reputation for high standards**

NSF-funded projects are a stamp of approval, because it is well known [that] it has a rigorous peer review process. So when we are looking for sponsors, it's easier to find a sponsor for an exhibit if NSF has also agreed to fund it. [The developers] also had support from NASA, so they were able to draw on that whole body of resources. When you have cross-agency projects, it brings together the criteria for effective programs for both, and leverages additional funding. (MOS staff)

Midland Center for the Arts

At the MCFTA, an overlapping but different set of benefits were cited by museum staff. *Cosmic Questions* achieved the following:

- **Enhanced the reputation of the museum as a place for high-quality, important, and scientifically-challenging exhibitions**

It further enhanced our reputation for doing exhibits at a high level of science . . . It continued us along a path of increasing the level of exhibits and did it in a significant and dramatic way. (MCFTA staff)

- **Provided a good example of a high-level exhibition that integrated science and art, advancing the core mission of the institution**

It provides us on the art staff a good example of the nature of things from the science perspective that we can look forward to as we begin to integrate art and science. (MCFTA staff)

It was a way for us to fulfill our mission as it relates to science. It provided us a wonderful complement to the Hubble photographs. (MCFTA staff)

- **Established new working relationships with the local planetarium, local university physics professors, the MOS, and the CfA**

We loved having the opportunity to reach out to the planetarium which we had no need to reach out to without this exhibit . . . There's a connection between us now because of this exhibit . . . This particular part of Michigan tends to be insular from one small city to another. I hope we struck a blow for regionalism in this kind of work. (MCFTA staff)

We've had a totally positive experience working with CfA. Anytime we could work with them again, we'd be pleased to do so. (MCFTA staff)

- **Opened new possibilities due to NASA sponsorship**

The benefits [of NASA sponsorship] were tremendous. We wanted to embellish the exhibit so we contacted [NASA staff at different sites] and got Hubble pictures, a space suit, transparencies. Because it was NASA-funded, I think they were more likely to cooperate with us. It enabled us to get some great speakers here as well—from NASA, from the Hawaii observatories. (MCFTA staff)

- **Advertising and collaboration led to increased visibility of the museum and planetarium, bringing in new visitors**

Because of the success of it, it brought people in who may not have visited before, and hopefully we'll benefit by having people come back for other shows . . . It showed us that if we can get the word out, people will come . . . It was the publicity, but also having people who regularly go to MCFTA come here. (Planetarium staff)

We were well above our average visitorship for the period and we did draw in a lot of people from the surrounding areas. (MCFTA staff)

- **Enhanced the internal teamwork between several of the member organizations within the MCFTA**

We learned that we really can do a lot as a team. We've always worked by department here, there's always been some territoriality between art, science, performing arts. In these lean economic times, we've learned a lot about bringing those barriers down. Through this, we learned we could really kick ass here as a team. (MCFTA staff)

- **Revealed a maintenance crew eager for new projects**

We learned that [the maintenance crew] are willing to take on new and exciting projects. We were apprehensive because we thought they would see it as stepping outside of their responsibilities. They loved it. It was more interesting. (MCFTA staff)

- **Provided a good winter activity for families**

I had hoped this would be a perfect way for families to spend the weekend with their kids . . . in the middle of a cold, grey Michigan winter. And it was. (MCFTA staff)

CHALLENGES FOR THE INSTITUTIONS

Museum of Science

Challenges connected to the *Cosmic Questions* exhibit at the Museum of Science were the following:

- **Getting staff and volunteers comfortable with the challenging content of the exhibition**

The topic was very complex and there weren't many of us who felt comfortable with the topic at the beginning. There was a lot of catch-up to get enough understanding. (MOS staff)

We do not have professional astronomers on staff, so we had the double challenge of becoming comfortable with the topic and vocabulary and research, and then the challenge [of turning] that into the high-quality products we were expected to produce. (MOS staff)

- **Learning to communicate the big ideas to a varied audience**

The subject matter is very, very difficult to communicate to the general public . . . The subject matter of *CQ* deals with the broadest questions you can imagine in the world. So communicating this to a family with young children, with teenagers, with the few who have a background in astronomy, fewer in cosmology, is a tremendous challenge. That was the biggest challenge—how to communicate the big ideas behind the exhibit. (MOS staff)

- **Technical problems**

Some of the equipment was not working well and the black hole stopped working, which was very important because it was very impressive. (MOS interpreter)

- **Keeping up-to-date with the content**

The world of cosmology is changing weekly, it seems . . . It was exciting and shows the dynamism of the research, but that was a product challenge—to make sure we had the latest information. (MOS staff)

- **Space challenges in the main exhibition hall**

One of the most inconvenient things, challenging things, was the location of the exhibit—the physical layout and placing of the exhibit, stuck in a corner of the museum. The way it was set up in that space, the introductory panel with the big picture on it looked like a wall preventing visitors from noticing there was an exhibit there. (MOS interpreter)

- **Space challenges for the related presentations**

I think the biggest challenge was finding the correct space for the play in the museum. An intimate, beautiful piece, but that space is far away from everything . . . and near a noisy exhibit. (Actor)

- **Scheduling issues for the demonstration and play**

There were internal scheduling issues. We ended up doing the live presentations and play on the same stage. We were running into ourselves because there were so many things happening on the stage.

(MOS staff)

- **Challenges using actors**

If a museum is starting to use actors, they should be cautioned that actors create problems, but are a powerful way of educating . . . If you have good actors, they are going to have scheduling problems . . . Actors tend to not know a lot of science, but you want them to be science educators. Museums are not the best place in the world to put on plays. Actors are used to being the reason people come to a place . . . You have to choose your actors carefully—people who will not be affronted if the audience leaves.

(MOS staff)

- **Symposium timing, content, and promotion for educators**

We would have loved to have had this [exhibition] into the winter and spring. Obviously, we were limited in when we could offer the symposium, because it was there so early in the year . . . The challenge was to try to reach all the teachers, that whole marketing piece. Trying to determine what would be a good balance [at the symposium] between content, the experience with the exhibit, and process.

(MOS staff)

- **Meeting the high standards, especially for reporting, required by the funding agencies**

Having been granted funding from both organizations [NASA and NSF], you understand you're being held to a high standard and identified as an organization they can trust to produce high-quality, accessible, accurate products, so there are standards expected in return for their funding you . . . [You have to report] more extensively than for a private foundation.

(MOS staff)

- **Providing enough promotion and publicity, inside and outside the museum**

I didn't see or sense a lot of internal enthusiasm for creating [CQ] as a big event . . . *The Quest* drew a lot of people's attention away, just when it was needed to promote CQ.

(MOS staff)

I would have liked to have seen this exhibit get more attention and it was intended to, but we got the Egypt exhibit here at the same time . . . [CQ] was going to get more museum-wide attention if it hadn't started at the same time.

(MOS staff)

Midland Center for the Arts

At the MCFTA, challenges connected to *CQ* included the following:

- **Training the educational staff**

It was challenging getting the education staff up to snuff, getting to guide people to what is fascinating about it. (MCFTA staff)

- **Technical issues and problems**

I think the greatest challenge that we faced [was] a lot of technical bugs [that had] to be worked out . . . I think we're leaving the exhibit in much better shape than we found it, by working out the bugs. (MCFTA staff)

It required an upgrade in one of our systems . . . It was a challenge to upgrade the system, but it's great because now we have other shows we can run. We had a bit of stress to do the upgrade in a short period of time. (Planetarium staff)

- **Resolving installation frustrations**

When we could . . . deal directly with Mary, everything went fine. ASTC got in the way of allowing my staff to function, with the very best of intentions . . . Sometimes they would allow three days for something we could do in four hours . . . Once we got over the fact that ASTC didn't need to guard the exhibit against us, we were fine. (MCFTA staff)

I think we could have been more efficient, especially when you're looking at paying people overtime . . . We wanted to install this exhibit on weekdays, but had to install it on a weekend . . . And that there wasn't a good installation document to work with was a challenge. (MCFTA staff)

- **Space challenges, including size and weight factors**

The size—we're a fairly small museum, so the size and the weight were of concern. (MCFTA staff)

We really didn't do a good job estimating the size . . . It's a real tribute to the exhibit that it can stand being split and still be a good experience. (MCFTA staff)

- **Exposed a need to update the permanent exhibition**

The level of sophistication the exhibit employed is a watermark. It leaves you looking at everything else in your permanent exhibit and realizing you need to update. (MCFTA staff)