

Front-end Evaluation of
BIOMEDICAL TECHNOLOGY PROJECT
for
The Great Lakes Science Center

Appendix G: Summaries of Findings for Each Exhibit

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FOR APPENDIX G: Summaries of Findings for Individual Exhibits

These short evaluation studies were based on data collected in the existing *Medical Technology* exhibition. We restrict this discussion to exhibits that will be revised and included in the new *Biomedical Technology* exhibition. The methods used to collect and analyze the data are described in the full report (available as a separate document).

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EXHIBIT NAME:

“AN INSIDE LOOK” (MEDICAL IMAGING)



Fig. G1. Overview of the medical imaging exhibit. The monitor and controls used to select which part of the body to view are in the lower center, flanked by reading-rail panels of graphics and text.



SUMMARY	<p>This exhibit received attention from many respondents, most of whom enjoyed selecting, viewing, and trying to decipher the many internal views of the human body. However, most respondents spent little time differentiating among the views provided by different technologies or among the different ways medical doctors used these images. In other words, most visitors treated the exhibit as tour of the inside of the human body rather than a chance to learn about imaging technologies.</p> <p>To achieve its revised goals, the new exhibit will need to (a) develop an interface that gives visitors more control over the selection and viewing of the images; (b) select images that are both striking (“wow!”) and meaningful to visitors; and (c) shift at least some of visitors’ attention from interpreting internal anatomy to understanding the types and uses of imaging technologies.</p>
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VISITOR ENGAGEMENTS WITH THE CURRENT EXHIBIT

Physical	<ul style="list-style-type: none"> • Most respondent groups used the interactive computer monitor to choose which parts of the body to view. Children, when present, often took charge of these controls. • Visitors looked carefully at one or more images, often pointing at certain images that attracted their attention. • Some respondents glanced at the reading-rail labels, but few read them in depth.
Emotional	<ul style="list-style-type: none"> • Many visitors were fascinated by these internal views of the human body; many were also confused by certain images; but relatively few were grossed out to the point where they wanted to leave the exhibit. (Some young visitors said, “ewww,” but most kept on looking.) • Many visitors expressed curiosity about the internal anatomy visible in different views, but most were not as curious about the technology behind the images. • Young visitors enjoyed figuring out and using the controls. • Some visitors expressed personal connections to one or more aspects of the images, usually because they had had a similar image taken of their body, or because they encountered images like these at work.
Social	<ul style="list-style-type: none"> • Many visitor groups worked together to interpret the images, pointing and discussing the various organs visible in the images. • Parents often used this exhibit to teach their children something



	<p>about internal anatomy.</p> <ul style="list-style-type: none"> • In some adult groups, one member—often a medical professional—assumed a teaching role, providing a guided tour of the images and discussing how they related to their own work.
Intellectual	<ul style="list-style-type: none"> • Many groups devoted considerable effort to figuring out the anatomy visible in the images. • Some visitors (often children) misidentified various organs. • Groups that were not lead by a medical professional usually spent little time discussing the imaging technologies and the medical uses of the images. • There were indications that most respondents dealt with the images one-by-one, rather than comparing and contrasting theme with one another. Such comparisons were often difficult, because most sets of images differed in several ways ways. (For instance, in the views of the head, the CAT, MRI, and X-ray images all presented different orientations of the head.)

HINTS FOR APPROACHING THE TOPICS OF THE EXHIBIT

Gateways	<p>Note: The team used the term “gateways” to refer to those aspects of an exhibit or topic that tended to engage visitors.</p> <ul style="list-style-type: none"> • Visitors’ curiosity about what’s inside the human body. • Visitors’ personal connections to certain types of images, usually those that they (or their family and friends) have experienced.
Starting points for building understanding	<ul style="list-style-type: none"> • Most young visitors can navigate external human anatomy (i.e., they can identify and name the parts they can see). • Many visitors (including older children) have at least some knowledge of major organs, like the brain, heart, or intestines. • Most parents know enough internal anatomy to help their children increase their understanding.



<p>Barriers</p>	<ul style="list-style-type: none"> • Most visitors—especially young ones—have a limited understanding of the details of internal anatomy, and they usually do not think of organs as systems. • Interpreting medical images often seems counter-intuitive, especially when dealing with subtle differences in contrast. • Colored images introduce a whole new level of interpretive difficulty for visitors, because visitors are much more familiar with black-gray-and-white images. • Many advanced imaging technologies (such as PET) will be unfamiliar to most visitors.
<p>Visitors' alternative understandings</p>	<ul style="list-style-type: none"> • Most of the misunderstandings we encountered related to misinterpretations of the details of human anatomy. • Some visitors may misapply what they know about conventional x-rays (e.g., white means dense bone) to other types of images.

RECOMMENDATIONS

	<p>These recommendations are written for the proposed Medical Imaging Theater, which between shows will serve as an unsupervised exhibit where visitors can select the images on display.</p> <ul style="list-style-type: none"> • Develop an interface that gives visitors more control over the selection and viewing of the images. The spin browser under consideration for this exhibit may provide appropriate controls if properly programmed. • Select images that are both striking and meaningful to visitors. The message should be that these images are indeed amazing, yet non-professionals can make sense of them with appropriate support. • Shift at least some of visitors' attention from interpreting internal anatomy to the understanding the types and uses of imaging technologies. This last imperative may be achieved by helping visitors compare and contrast the views provided by the different technologies, such as comparing images produced by older and newer technologies. Also, some images should clearly show how imaging devices are now used to treat as well as diagnose medical conditions. Side-by-side comparisons should be selected carefully so that visitors both can see and match-up the similarities between the images and clearly identify and interpret the differences. • Program the series of images with text and simple diagrams that will help visitors make accurate and meaningful interpretations.
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These interpretive aides also can serve as prompts, encouraging adults to point out and explain things to their children.

- **Program in challenges for visitors to solve, such as medical problems they can diagnose with appropriate support.** Challenges like this will help visitors engage more deeply with the exhibit's content.
- **Use formative evaluation to fine-tune the spin-browser's medical imaging programming.** This can ensure that visitors can interpret the images correctly and are taking away appropriate messages.



EXHIBIT NAME:

“MAGNETIC RESONANCE IMAGING” (MRI)



Fig. G2. Overview of MRI exhibit. Control panel is lower left, scanner bed lower right, and monitor upper center.



SUMMARY	<p>This exhibit received attention from most visitors, but it was not particularly effective at engaging them in meaningful learning about MRIs and how doctors use them. Children manipulated the MRI scanner bed and investigated the manikin (“Is it real?”), but didn’t seem to learn much about MRIs. Adults often recognized a personal connection because they had experienced, or knew someone who had experienced, an MRI, or because they anticipated having one some day. However, adults also did not seem to find out anything new about MRIs.</p> <p>Issues that need to be resolved include (a) clarifying that this is an MRI (not a CT scanner); (b) making MRIs personally meaningful to visitors who have not had previous experience with them—especially to the target audience, and to younger children; (c) shifting the focus of the interpretation to highlight unique features and functions of the MRI; (d) making the bed controls more intuitive; (e) relocating the monitor so it’s easier for visitors to find the images; and (f) giving visitors greater control over the rate and order for viewing the images.</p>
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VISITOR ENGAGEMENTS WITH THE CURRENT EXHIBIT

Physical	<ul style="list-style-type: none"> • Visitors often walked part way around the MRI unit, peered inside, looked at the manikin, and sometimes inside the opening into the machine. • Many visitors glanced at the labels, but few read them in depth. • Visitors often pushed a button or two on the control panel, sometimes pushing the flashing button first. (Because the flashing button indicated which position the manikin was currently in, the MRI bed stayed put when it was pushed.) • Because the monitor showing the images was so high, many visitors missed it. (Most visitors failed to note the “SEE MONITOR ABOVE” text on the control panel.)
Emotional	<ul style="list-style-type: none"> • Visitors’ personal connections to this exhibit included having experienced an MRI themselves, or knowing someone who had one, or anticipating (often fearing) someday having one. • Visitors who had experienced an MRI themselves often talked about the feelings of claustrophobia they had experienced. • Many button-pushing visitors appeared frustrated that the manikin didn’t move immediately when they pushed a new button (This may have been because moving the manikin through the MRI seemed, to them, to be the purpose of the interactive, and they wondered why it took so long.) • Some visitors were disappointed to find out that the “insides” of the



	machine were not real.
Social	<ul style="list-style-type: none"> • Visitors talked about their MRI experiences with others in their group. • They also instructed others in their group about how to use the control panel, where the monitor was, and what the images meant.
Intellectual	<ul style="list-style-type: none"> • The most meaningful intellectual engagement was with other group members, discussing personal experiences with MRIs, rather than focusing on topics discussed in the labels. • Some groups worked to make sense of the images, trying to figure out what parts of the body they were seeing on the screen. However, the images cycled too quickly for many visitors to make sense of them. • A few visitors tried to figure out the inner workings of MRI technology.

HINTS FOR APPROACHING THE TOPICS OF THE EXHIBIT

Gateways	<ul style="list-style-type: none"> • Many adult visitors either had an MRI or knew someone who had one; they were familiar with the technology, and eager to talk about their experience. • As with the other medical imaging exhibits, the chance to see inside the human body was a motivation for some families, but this was not as strong here as at other exhibits. • For some visitors, the gateway was the chance to look inside the machine and find out how it works.
Starting points for building understanding	<ul style="list-style-type: none"> • Many adult visitors are familiar with MRIs and have a general idea what they do. • Many adults have seen body-slice images similar to the MRI, and have at least an idea of how to interpret them.



<p>Barriers</p>	<ul style="list-style-type: none"> • The science and technology of MRIs is complex and difficult to understand. • Younger visitors were usually <u>not</u> familiar with the technology and its uses. • Visitors seemed to have trouble coordinating their use/understanding of the control panel, the position of the manikin, and the views on the monitor—a problem compounded by the position of the monitor. • Visitors (like children) who have limited understanding of what’s inside the body had trouble making sense of the scan images.
<p>Visitors’ alternative understandings</p>	<ul style="list-style-type: none"> • Some visitors (even repeat visitors) referred to the MRI as a CT scanner. Because major label headers used the term “body scan,” not MRI, these visitors may have just guessed that it was a CT scan. Although the monitor default screen said “Magnetic Resonance Imaging,” visitors rarely saw this when they first encountered the exhibit.

RECOMMENDATIONS

	<ul style="list-style-type: none"> • Use the term “MRI” in the main label headings. Because most adult respondents were familiar with this term, try to get visitors using it in conversations as quickly as possible. Use the term “Magnetic Resonance Imaging” in the body of the text, but not in label headers, because it’s too hard to say out loud—and the point is to get label readers to share the term with non-readers. • Shift the focus of the interpretation. Focus visitors’ attention on (a) the fact that soft tissues/organs are visible in the images, (b) the three-dimensionality possible with a sequence of views, (c) what doctors can do with these images, (d) what makes MRIs different than CT scans, and (e) the benefits of MRIs (especially avoiding exposure to potentially harmful radiation). • Make MRIs personally meaningful to visitors who have not had previous experience with them—especially to the target audience, and to younger children. One way to do this would be to provide an appropriate human-interest story. In addition to using the story to highlight the points in the previous recommendation, the story might deal with the patient’s feelings about the experience (e.g., how they felt about the time it took, how they dealt with claustrophobia) and the doctors’ reasoning for using the MRI (e.g., what they could see in the image and comparisons with the alternatives, like exploratory surgery and CT scans).
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- **Relocate the monitor so it's easier for visitors to find.**
- **Make the control panel more intuitive.** Find a different way to clue visitors in to where the manikin is positioned (i.e., the flashing light is too confusing).
- **Increase the interactivity of the exhibit in appropriate ways—especially for the target audience.** One way to do this would be to give visitors more control over the scan rate for the images, such as with a spin browser. Allow them to slow down and backtrack, so they have time to figure out and discuss what they are looking at. Another way would be to include scan images that were used to diagnose patient problems, which visitors could be challenged to find and/or interpret. This activity could focus visitors' attention on the uses of MRIs.
- **Discuss recent advances in MRIs.** For instance, discuss the “open MRI,” which should limit many patients' feelings of claustrophobia.



EXHIBIT NAME:

“SEEING AROUND CORNERS” (ENDOSCOPES)



Fig. G3. Overview of endoscope exhibit. The control panel is near the bottom of the photo and the monitor is at the top.



<p>SUMMARY</p>	<p>This exhibit received attention from most of the visitor groups we observed, and it was somewhat effective at engaging them in meaningful learning about endoscopes and how doctors use them. Children pushed the buttons to insert and withdraw the endoscope, asked questions about the organ system (“Is it real?”), and often learned something from their adults about how and why these tools are used. Adults often recognized a personal connection to this technology because they had experienced, or knew someone who had experienced, an endoscopy, or because they anticipated (or should we say dreaded?) having one some day. In part because they were unconscious (or barely conscious) during these procedures, many adults learned something new from the exhibit about what the endoscope looked like or how it worked. However, adults were more likely to learn from their observations of the exhibit in action and from others in their group, rather than from the labels.</p> <p>Issues that need to be resolved include: (a) identifying the organ system (e.g., as real pig stomach and intestine); (b) updating the endoscope tool; (c) making endoscopes personally meaningful to visitors who have not had previous experience with them—especially to the target audience, and to younger children; (d) getting more visitors to think and talk about the ways doctors use endoscopes; (e) relocating the monitor so it’s easier for short visitors to see; and (f) giving visitors something interesting to see once they get inside the intestine (e.g., a medical problem that needs to be solved).</p>
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VISITOR ENGAGEMENTS WITH THE CURRENT EXHIBIT

<p>Physical</p>	<ul style="list-style-type: none"> • Most visitors looked at the organs and tool first, then found and used the controls. • Most visitors figured out the controls quickly. The only problem seemed to be when the tool reached its inner/outer limits—some visitors didn’t recognize this and kept pushing the same button. • Although most visitors found the monitor relatively quickly, it was difficult for shorter children (and people in wheelchairs) to see. • Some children, without adults nearby, pressed the buttons, but never found the monitor—they left because nothing seemed to be happening • Some visitors read the labels (although usually not the sidebar on fiber optics).
<p>Emotional</p>	<ul style="list-style-type: none"> • Visitors’ personal connections to this exhibit included having experienced an endoscopy themselves, or knowing someone who had one, or anticipating someday having one.



- Respondents who had experienced an endoscopy often talked about anticipating discomfort from an endoscopy. Those who were anticipating a future experience also expressed discomfort at the thought.
- The relatively featureless view inside the digestive tract was a bit disappointing to many visitors.
- Some visitors were frustrated because they couldn't figure out if the organs were real or plastic. A few visitors expressed discomfort at their assumptions that the organs were from a real human.
- For children in the 7 to 11 or so range, this exhibit seemed to have an enjoyable edge of grossness to it. (They were probably too young to think that this could ever happen to them!)



Social	<ul style="list-style-type: none"> • Visitors talked about their endoscopy experiences with others in their group. • More experienced visitors often instructed others in their group about how to use the control panel, where the monitor was, and what the images meant. Parents were usually quite comfortable engaging with their children in this way.
Intellectual	<ul style="list-style-type: none"> • Many groups engaged intellectually without reading much label content—one or more group members knew enough to guide the interactions and discussions with the rest of the group. • Although the main label discussed topics that seem appropriate to the goals for the new exhibit (in addition to the text about how fiber optics work), most visitors didn't read enough label text to get them thinking and talking about these messages. • Some visitors were wondering if the technology had advanced beyond what was shown. A few had heard of advances like the "camera you can swallow." • Some visitors were wondering if the organs were from humans, and a few younger visitors thought the organs were something else (e.g., a heart) • Relatively few visitors seemed to pay attention to the fiber-optic technology, or the science behind it.

HINTS FOR APPROACHING THE TOPICS OF THE EXHIBIT

Gateways	<ul style="list-style-type: none"> • The technology and its use are fairly straightforward and relatively easy to understand. • Many adults are familiar enough with endoscopies that they can guide others in their group through the exhibit experience. • Once visitors recognize what it is, the organ system itself is relatively simple and familiar, even to younger children—especially if the exhibit includes diagrams that adults can point to and explain.
Starting points for building understanding	<ul style="list-style-type: none"> • Familiarity—of the technology, organ system, and potential medical problems that it can address. • Concreteness—a camera on a tube that goes down a patient's throat isn't an abstraction or a metaphor • Visitors responded positively to the idea of finding something with the endoscope—a swallowed penny, or sign of disease.



Barriers	<ul style="list-style-type: none"> • Perhaps adults’ discomfort with this technology is a bit of a barrier—but it also provides an opportunity for advancing the goals of the project. • Visitors’ disinclination to read labels. • Visitors’ confusion about the current organ system (what is it, and who is it from?)
Visitors’ alternative understandings	<ul style="list-style-type: none"> • Some visitors were wondering if the organs were from humans. • Some younger visitors (and at least one adult) thought the organs were something else (e.g., a heart).

RECOMMENDATIONS

	<ul style="list-style-type: none"> • Make the communication of the current messages more effective. Find a way to get more visitors thinking and talking about (a) the fact that endoscopy—although it may look intimidating—replaced much more invasive surgeries, (b) what doctors can do with these images, (c) the benefits of endoscopies, and (d) advances in endoscopy techniques. • Make endoscopies personally meaningful to visitors who have not had previous experience with them—especially to the target audience, and to younger children. One way to do this would be to provide an appropriate human-interest story. In addition to using the story to highlight the points in the previous recommendation, the story might deal with the patient’s feelings about the experience—before and after. • Identify the organ system in appropriate ways. Is it real? Is it human? • Relocate the monitor so it’s easier for short visitors (and those in wheelchairs) to see. • Replace the current endoscope with a more recent (and probably slimmer) model, and discuss recent advances in endoscopy. Perhaps, by doing this, we can help lessen visitors’ anticipatory discomfort. • Develop a level of interactivity that simulates the twists and turns of the flexible endoscope, as well as the in-and-out. • Provide a simple diagram of where the stomach and intestine are located. This can serve as a prompt, encouraging adults to point and explain the location to their children.
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- **Involve visitors in solving a medical problem as they explore the digestive tract.** Perhaps they can look for a swallowed penny or toy.
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EXHIBIT NAME:

“SEEING WITH SOUND” (ULTRASOUND)



Fig. G4. Overview of ultrasound exhibit. Fish tank is just above the main label rail (with the two button controls). Monitor and ultrasound unit are to the left of the tank.



<p>Summary</p>	<p>This exhibit received attention from most of the visitor groups who we observed, but it was not very effective at engaging them in meaningful learning about ultrasounds and how doctors use them. That was, in part, because the exhibit seemed designed to illustrate and explain an analogy between ships’/dolphins’ sonar and doctors’ ultrasound. In other words, it was more about explaining the science of ultrasounds than about medical uses of this tool. Visitor groups worked together to control the probe and locate the fish on the monitor screen, and they were often frustrated with either the difficulty of the task or the minimal payoff if they succeeded. Adults, especially parents, often recognized a personal connection to this technology because they (or their wives) had experienced ultrasounds during pregnancy. Some mothers said they had hoped to learn more about interpreting ultrasound images, because at the time of their ultrasounds it had happened too fast for them to master this skill.</p> <p>Issues that need to be resolved include: (a) developing a more meaningful target for the ultrasound—giving the visitors something that is less frustrating to generate, large enough to see detail on the insides, and more relevant to the biomedical technology theme; (b) updating the ultrasound tool; (c) making ultrasounds personally meaningful to visitors who have not had previous experience with them—especially to the target audience, and to younger children; (d) relocating the monitor so it is easier for short visitors to see and for visitors to use the controls and see the image at the same time; (e) giving visitors images that persist long enough that they can make sense of them; and (f) challenging visitors to solve a medical problem with ultrasound.</p>
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VISITOR ENGAGEMENTS WITH THE CURRENT EXHIBIT

<p>Physical</p>	<ul style="list-style-type: none"> • Most visitors looked at the fish tank first, then found and used the controls for the ultrasound probe, then found the monitor. • Most visitors figured out the controls quickly, but relatively few were successful at seeing an ultrasound of a fish. • Although most visitors found the monitor relatively quickly, it was difficult for shorter children (and people in wheelchairs) to see, and it was too far from the probe/tank for visitors to effectively use the controls and see the image at the same time. • Although visitors glanced at the labels, relatively few read them in depth, and they did not seem to have much of an impact on visitors’ experiences.
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Emotional	<ul style="list-style-type: none"> • Adults—especially parents—often recognized a personal connection to this technology because they (or their wives) had experienced ultrasounds during pregnancy. • Some visitors enjoyed the challenge of positioning the probe over the fish (at least initially). • Many visitors were frustrated because they couldn't see the fish on the monitor screen. • When visitors were able to see the fish on the monitor, they experienced some satisfaction with accomplishing their goal, but they were not very impressed with the image itself (in part because they couldn't really see much detail inside the small fish). • Mothers who had had ultrasounds while pregnant sometimes told us about their frustrations with making sense of the images they had seen at the doctor's office, because it had all happened so fast. A few said they had hoped to learn more about interpreting ultrasound images as part of this exhibit.
Social	<ul style="list-style-type: none"> • Mothers (and some fathers) talked about their ultrasound experiences with others in their group. • Older visitors often instructed others in their group about how to use the control buttons and gave suggestions about how to locate the fish on the monitor screen. • Groups often divided up the tasks of using the controls and spotting the fish on the screen, because it was hard to do both at the same time. • Group members sometimes tried to make sense of the images as a group, although this was difficult because the fish kept swimming out of view.
Intellectual	<ul style="list-style-type: none"> • Most visitors who were familiar with ultrasounds associated them with pregnancy, and rarely any other medical uses. • The main label's comparison between sonar and ultrasound didn't seem particularly helpful to most visitors. Most adults were much more interested in talking about ultrasound and pregnancy and were not very interested in the science. • Most of the learning that took place here was based on visitors sharing their experiences and knowledge, especially parents sharing with their children.

HINTS FOR APPROACHING THE TOPICS OF THE EXHIBIT

Gateways	<ul style="list-style-type: none"> • Most parents were familiar enough with ultrasounds that they could help others in their group make sense of the exhibit. • Many visitors wanted to learn more about the medical applications of ultrasound during pregnancy—and to have some help interpreting
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	ultrasound images.
Starting points for building understanding	<ul style="list-style-type: none"> • Parents’ familiarity of the technology and what it can accomplish during pregnancy. • Many parents have at least a beginning understanding of how to interpret an image from a pregnant woman’s body (although many would like to learn more). • Children’s interest in human reproduction. • Parents’ interest in learning more about interpreting ultrasound images.
Barriers	<ul style="list-style-type: none"> • Most visitors were not particularly interested in the analogy between ships’/dolphins’ sonar and ultrasound. This may have been, in part, because most visitors had, at best, a very basic understanding of sonar. • Some children and parents may be a bit intimidated by confronting images of pregnancy—that may not be something they are ready to talk about as a family.
Visitors’ alternative understandings	<ul style="list-style-type: none"> • Many children will not know much about the anatomy of pregnancy—parents will need visual aids to help explain the ultrasound images to them.

RECOMMENDATIONS

	<ul style="list-style-type: none"> • Redevelop the interpretation to emphasize the biomedical applications of ultrasound during pregnancy. Find a way to get more visitors thinking and talking about (a) uses of ultrasound during pregnancy, (b) how doctors interpret these images, (c) the benefits of ultrasounds compared to other technologies, and (d) advances in ultrasound techniques. • Make ultrasounds personally meaningful to visitors who have not had previous experience with them—especially to the target audience, and to younger children. Parents would probably do a pretty good job with this for their children if they were given the proper set of images to work with. • Relocate the monitor so it’s easier to see while controlling the probe, and so it’s easier for short visitors (and those in wheelchairs) to see. • Replace the current ultrasound with a more recent model, and discuss recent advances in ultrasound.
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- **Provide simple diagrams of where a woman's reproductive organs are located and of how a fetus is positioned in the womb.** These can serve as prompts, encouraging adults to point out and explain the anatomy of pregnancy to their children.
- **Challenge visitors to solve a medical problem as they use the ultrasound.** A challenge like this will help visitors engage more deeply with the exhibit's content.



EXHIBIT NAME:

“BRINGING MUSCLES TO LIFE” (FES OR FUNCTIONAL ELECTRICAL STIMULATION)



Fig. G5. Overview of the FES exhibit. The rail label with buttons is on the lower right side of the photo.



SUMMARY

This exhibit received attention from most visitors. Many visitors pushed at least a few buttons on the FES rail, but they were sometimes frustrated by the results. Adults and older children were more apt to watch the video, which sometimes inspired an empathetic response. Visitors who watched the video usually achieved a better understanding of FES than those who used the interactive

Recommended revisions include (a) provide diagrams that illustrate (and help parents explain) the basic biology behind paralysis; (b) explain FES systems by analogy with the biological systems they replace; (c) develop an interactive that focuses visitor attention on the FES system, rather than just an aspect of the system; and (d) provide physical evidence of advances in FES technology, allowing visitors to compare old and new versions of FES components.

VISITOR ENGAGEMENTS WITH THE CURRENT EXHIBIT

Physical	<ul style="list-style-type: none">• Many visitors pushed at least a few buttons on the FES rail, but it was difficult for them to achieve a satisfactory gait even if they followed the label instructions to push the buttons in numerical order.• When visitors noticed the “Automatic Walk” button, they pushed it and achieved a more satisfying result.• Adult visitors and older children were more apt to watch the video. Although many left after 20 to 30 seconds, some respondents watched it all the way through.• Some visitors glanced at the labels, but few read them in depth.
Emotional	<ul style="list-style-type: none">• Visitors seemed to enjoy the interactive, although they often were frustrated by their inability to achieve make the legs “walk” smoothly• Mostly adults and older children enjoyed the video.• Video viewers often seemed to achieve an empathetic connection with the patient.
Social	<ul style="list-style-type: none">• Groups sometimes worked together as they tried to get the legs to walk.• The opportunity for parallel use allowed parents to watch the video while their children experimented with the buttons.
Intellectual	<ul style="list-style-type: none">• Visitors who watched the video seemed to achieve a better understanding of FES.• The leg interactive attracted visitor attention but, in itself, did not seem as successful at increasing visitors’ understanding of FES.



HINTS FOR APPROACHING THE TOPICS OF THE EXHIBIT

<p>Gateways</p>	<ul style="list-style-type: none"> • Thanks to publicity surrounding cases like Christopher Reeve’s, many adults and older children are aware of paralysis and feel empathy towards people with paralyzed limbs. • Some visitors also have personal experience with this medical condition.
<p>Starting points for building understanding</p>	<ul style="list-style-type: none"> • Even younger respondents had some starting knowledge about parts of the neuromuscular system. For instance, most children knew or guessed that a muscle would twitch when an electric shock was applied. Many also knew that the brain played a role in controlling muscles. • Children recognized that computers were similar to human brains in some ways. For instance, they knew that computers could be robots’ brains. • Adults often had knew enough about the anatomy of paralysis that they could help their children increase their understanding. (However, parents’ teaching efforts could benefit from better support of their efforts.)
<p>Barriers</p>	<ul style="list-style-type: none"> • Although children had bits of knowledge about this subject, their limited understanding of the neuromuscular <i>system</i> will be a barrier to their understanding of FES. For instance, children often understood that the brain played a role in controlling muscles, but they could not always remember that nerves connected the brain with muscles. Younger visitors will need help constructing or reconstructing their understanding of the system based on their fragments of knowledge. • Many children and even some adults did not seem to understand the role of electricity in the nervous system • Even basic terminology seemed a bit confusing to some visitors. For instance, one adult respondent used the term, “electrolysis,” to describe FES. • If one looks beyond the basics at the range of conditions that result in paralysis, the subject becomes more complex. • FES systems can be very complex. One issue with the current interactive was that it focused visitors’ attention on only a small part of the overall system.
<p>Visitors’ alternative understandings</p>	<ul style="list-style-type: none"> • Visitors did not always think about the body having and using electricity.



RECOMMENDATIONS

The developing plans for the new FES exhibit include replacing the existing interactive.

- **Provide simple diagrams explaining the basic biology behind FES.** The revised exhibit will need to explain some basic human biology if visitors are going to understand and appreciate FES, perhaps by giving parents diagrams and other resources to help them explain the basics to their children.
 - **Explain FES systems by emphasizing parallels with the human nervous systems.**
 - **Develop interactives that focus visitors' attention of the functioning of the whole FES system, rather than on one of its parts.**
 - **Help visitors appreciate advances in FES technology by comparing older and newer examples of FES systems' components.** For instance, develop an exhibit that allows visitors to compare the sizes of components today and 10 years ago.
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EXHIBIT NAME:

“SPARE’ PARTS FOR PEOPLE” (PROSTHETICS)



Fig. G6. Overview of prosthetics exhibit, “Spare’ Parts for People.” The computer modules are in the foreground, examples of prosthetic devices (under glass bell jars) are visible on the lower right.



<p>SUMMARY</p>	<p>The prosthetics exhibit attracted lots of attention from both children and adults. Visitors who had received a prosthetic or implant themselves made the strongest personal connections to the exhibit. Other visitors focused on the identities and interesting shapes of the devices. Children were often mildly grossed out by the devices, but in a fun kind of way. Because of the limited interpretation adjacent to most of these devices, parents sometimes had difficulty explaining the prosthetics to their children.</p> <p>In the redeveloped exhibit, it will be important to (a) provide more and better context for the prosthetics—adjacent to the actual objects; (b) present one or more human-interest stories for these devices, so that visitor groups who do not have their own stories to share about prosthetics will be able to connect on the affective level; (c) provide hands-on examples of sturdy prosthetic devices; and (d) allow visitors to compare old and new examples of prosthetics.</p>
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VISITOR ENGAGEMENTS WITH THE CURRENT EXHIBIT

<p>Physical</p>	<ul style="list-style-type: none"> • Many visitors stopped and looked at the prosthetic devices, sometimes bending over for a closer look and reading the objects’ labels. • Children often engaged superficially with the computer interactives, attempting to place the drawings of prosthetic devices on the human outline. • The stories about patients and researchers, available through the computer programs, were rarely watched for very long by visitors.
<p>Emotional</p>	<ul style="list-style-type: none"> • The strongest personal connections were made by visitors who had received a prosthetic or implant themselves, or who knew someone with a prosthetic or implant. • Many children considered certain prosthetics “gross,” but in a cool kind of way. This judgment was most often applied to prosthetics that looked like body parts (like artificial limbs, noses, and eyes). • Visitors sometimes were frustrated by the computer interactives, because there were few obvious clues about where to place the images of prosthetics on the body outline. • There were indications that children were bored by the computers’ videos. Adults sometimes displayed more interest. • Few visitors expressed interest in how or where these devices were developed—until we mentioned the Cleveland connection. • Visitors who expressed the most interest in development of new



	<p>devices included (a) visitors who had received a prosthetic or implant, and (b) visitors who had seen television shows or read about advances in prosthetic technologies prior to their visits—these visitors said they wanted to learn more.</p>
Social	<ul style="list-style-type: none"> • Visitors who had received a prosthetic or implant often shared stories about their experiences with their companions. • Groups sometimes discussed what individual prosthetic devices were and how they were used. • When parents realized their children were misunderstanding the prosthetics, they often engaged in teaching behaviors in an attempt to set them straight.
Intellectual	<ul style="list-style-type: none"> • Most older children and adults achieved at least a general understanding of several types of prosthetic devices and implants (e.g., limbs and artificial hearts). • Younger children sometimes misunderstood what the prosthetics were (e.g., thinking the devices were real human organs or not knowing where they fit on the body). • Because of the limited interpretation adjacent to most of these devices, parents sometimes had difficulty explaining the prosthetics to their children. • Some devices (such as the hip replacement) were displayed in ways that made it hard to figure out what part of the display was the prosthetic and what was not. • Although in-depth information about each type of device was available in the computer interactives, few visitors explored at the computers in much depth. Parents rarely used the computers to find answers to their children’s questions.

HINTS FOR APPROACHING THE TOPICS OF THE EXHIBIT

Gateways	<ul style="list-style-type: none"> • Personal connections by visitors who had received a prosthetic or implant themselves, or who knew someone with a prosthetic or implant • Many visitors also had some understanding and interest based on popular culture (e.g., bionics and the “six-million-dollar man”). • The prosthetics were gross, but in a cool sort of way.
Starting points for building understanding	<ul style="list-style-type: none"> • Visitors’ understanding of basic anatomy (which was much stronger for older children and adults). • Many visitors had at least some understanding of the concept of prosthetics and knew someone who had received one.



<p>Barriers</p>	<ul style="list-style-type: none"> • Providing context for the prosthetics within the limited space available. • Distinguishing the actual prosthetic from the materials used to display it (e.g., the hip joint replacement versus the clear plastic used in its display). • Within the existing exhibit, detailed interpretation was far from the actual objects (accessed through a complicated computer interactive that was not adjacent to the objects).
<p>Visitors' alternative understandings</p>	<ul style="list-style-type: none"> • Young children sometimes thought the prosthetics were real body parts.

RECOMMENDATIONS

	<ul style="list-style-type: none"> • Assist parents (and other visitors) by providing more and better context for the prosthetics, perhaps including diagrams <i>right next to the devices</i> showing where, and sometimes how, they would be implanted in or attached to the human body. • Present one or more human interest stories for these devices, so that visitor groups who do not have their own stories to share about prosthetics will be able to connect on the affective level. • Explore the use of hands-on physical interactives for certain prosthetics. Perhaps hands-on prosthetic joints could be displayed on an open “workbench” or during programming • Allow visitors to compare older and newer examples of a given prosthetic device. This would be the most effective way to focus visitors’ attention on advances in prosthetics.
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EXHIBIT NAME:

“HEALTH CAREERS QUEST”



Fig. G7. Overview of the “Health Careers Quest” exhibit. The flat-panel computer monitors are barely visible in the center of the unit (because they are at an angle to the camera).



SUMMARY	<p>In part because of its location in the central core, this exhibit received attention from relatively few visitors, and it was not particularly effective at engaging children in meaningful learning about careers. For a variety of reasons, adult visitors seemed more interested in this interactive than younger visitors.</p> <p>Even with the limited budget for this reinstalling this interactive, it could be made more effective by providing two stools per computer. Gallery programming could also focus young visitors' attentions on careers in biomedical technology.</p>
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VISITOR ENGAGEMENTS WITH THE CURRENT EXHIBIT

Physical	<ul style="list-style-type: none"> • Most visitors walked past this interactive with barely a glance. • Adults sat and used the computers more often than children. • The navigation for this program seemed odd and non-intuitive, probably because there have been so many advances in navigation structures, including development of navigation standards for websites and other computer applications.
Emotional	<ul style="list-style-type: none"> • Children and adults related to the topic of health careers in very different ways. Most children expressed little interest in learning about health careers during their visits. However, parents often expressed interest and even enthusiasm about exhibits that could inform and interest their children about medical careers. • Educators often expressed excitement with "Health Careers Quest" because they considered it a resource for developing career presentations for their students. • Medical professionals sometimes expressed disappointment or frustration with the computers when they couldn't find much, if any, information about their own branch of the medical profession.
Social	<ul style="list-style-type: none"> • We saw little social interaction at the computers. This may have been due to the low overall interest, but we also noted that there was only one stool at each computer.
Intellectual	<ul style="list-style-type: none"> • Most visitors' thinking about biomedical technology careers was severely limited, because they failed to recognize the true interdisciplinary nature of biomedical technology. The existing program was not designed to expand visitors' understanding of BMT careers.



HINTS FOR APPROACHING THE TOPICS OF THE EXHIBIT

<p>Gateways</p>	<ul style="list-style-type: none"> • Parents and teachers wanted to develop their children’s interest in careers, particularly medical careers. • Because of its multidisciplinary nature, biomedical technology has career opportunities that may surprise visitors (in a good way!)
<p>Starting points for building understanding</p>	<ul style="list-style-type: none"> • Some children were already interested in possible medical or technology careers.
<p>Barriers</p>	<ul style="list-style-type: none"> • Many young visitors arrived with a science-center agenda that focused on having hands-on fun rather than contemplating their futures. • Most children had only a cursory understanding of the world of work and of the variety of health careers available to them. • Some older children had already decided they do not have what it takes to enter health-related careers, especially medicine, because they did not consider themselves smart enough or because they disliked needles or blood. • Most visitors did not understand that it takes a wide variety of skills and talents to develop new biomedical technologies.
<p>Visitors’ alternative understandings</p>	<ul style="list-style-type: none"> • Some visitors expressed the opinion that medical doctors are the only professionals involved in developing new biomedical technologies.

RECOMMENDATIONS

	<p>As this is written, it seems unlikely that GLSC will have the resources need to make major changes to this exhibit. Therefore, we first make some suggestions that may be implemented with limited funds.</p> <ul style="list-style-type: none"> • Place two stools at each computer. This can increase the amount of social engagement at the computers. • Include career information and representatives of different biomedical technology professions in the gallery programming. As noted in the full report, parents and teachers told us that hands-on experiences led by medical professionals had proved highly motivating to their children. <p>If it is possible to make changes to the program, consider making these changes first:</p>
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- **Upgrade the navigation so that it meets the standards developed for websites and related applications.** Make it feel more “intuitive” for those who have experience on the World Wide Web.
 - **Include several ways for visitors to find careers,** including a hierarchical menu, alphabetical list, and search option.
 - **Develop a more interactive option for accessing the information,** such as a quiz that helps users find a career that matches their interests and skills.
 - **Add at least a few screens that deal specifically with biotechnology careers related to engineering and computing.**
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