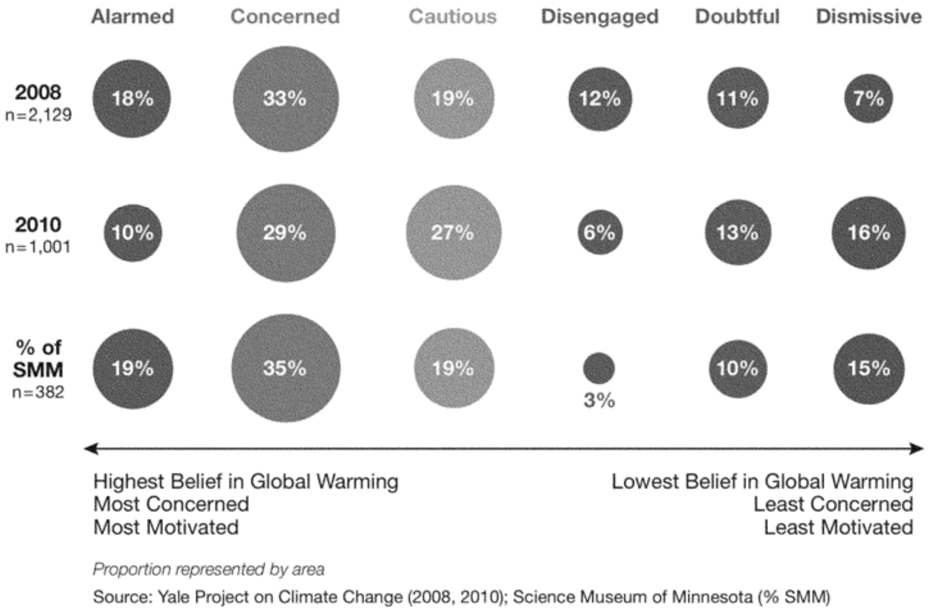


*Figure 1: Comparison among Science Museum of Minnesota visitors and the general public's global warming attitudes in 2008 and 2010. *Based on chi-squared analysis, there is no statistical difference among the samples.*

dards, and large enough to allow for meaningful statistical comparison (n=382), it was still much smaller than the samples taken by Maibach et al. (2009) and Leiserowitz et al. (2010). With a larger sample (and with the full suite of questions), it is possible that statistically significant differences would emerge. Additionally, this study was conducted at one science museum. We encourage other science museums to consider replicating our study. This would allow for a more robust comparison to the national results and for comparison among science museums. If you are interested in replicating this study at your museum, please contact Phipps to discuss details.

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# STRATEGIC INTEGRATION OF MEDIA IN EXHIBITIONS: A CASE STUDY OF SCIENCE STORMS

**Shari Berman, Olivia M. Castellini, Jim Cortina, and Rondi M. Davies**

The mission of a museum extends beyond mere information transfer to the target audience. Informal learning institutions seek to inform, educate and inspire their visitors around the topics they present. The task of balancing information and inspiration is particularly key for science museums, where the subject matter can frequently be a barrier for audiences and a challenge for exhibit developers to avoid dry, didactic presentations. Media–both linear and interactive–can be a powerful tool in enlivening the presentation of science; deepening the visitor experience and helping the visitor create an emotional connection to the content. Science Storms, a new exhibit at the Museum of Science and Industry, Chicago (MSI), makes strategic use of media to create a compelling visitor experience around the basic science that underlies natural phenomena. This paper will present a case study on how three primary types of media were chosen to strategically support major thematic elements of the exhibition.

## What is Science Storms?

Science Storms is a 26,000 square foot permanent exhibition that opened at MSI in March 2010. Visitors of all ages interact with dynamic, one-of-a-kind, large scale experiments that explore nature's most powerful phenomena—tornados, lightning, fire, tsunamis, sunlight, avalanches, and atoms in motion—and then, through hands-on experimentation and state-of-the-art interactive media, investigate the basic science behind nature's forces. By doing as well as seeing, visitors find themselves immersed in the adventure of ex-

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perimental science and in the imaginative and creative processes of scientists. Science Storms aims to inspire a new generation of scientists through the synthesis of compelling interactive exhibits, environmental media, and strong contextual storytelling.

The impetus for Science Storms came from the museum's core mission: to inspire and motivate our children to achieve their full potential in the fields of science, technology, medicine and engineering. It was not enough for the exhibit to merely update the museum's presentation of basic physics and chemistry; the exhibit had to *inspire* people. It had to draw visitors into a story and empower them to see themselves as part of the scientific endeavor. Science Storms needed to engage the visitor on both an intellectual and emotional level. No small feat, given that physics and chemistry subject matter is typically a turn off for many people.

### Mission Impossible: Creating a Compelling Experience around Physics and Chemistry

With the need clearly identified, a critical question emerged: how do we envision an exhibit about physics and chemistry that reflects MSI's core mission to engage and inspire? A task force of scientists, educators and civic leaders were engaged at the very start of the concept design planning phase in an effort to explore new directions to communicate essential physical science to the public, discuss the museum's present and future identity, its role in science education, and to describe what makes a compelling visitor experience. A significant breakthrough came when the scientists in the group responded to queries about why they do science and what inspires them. Many stories came from childhood, some even recalling museum experiences. The group quickly moved past driving the exhibit concept from a presentation of facts we should "know" towards a much more compelling place: inspiration and the process of science. Using this perspective as a discerning filter, the task force gradually focused in on an overall content and experiential strategy.

The Science Storms concept was born out of these lively and animated debates. The goal was to create a unique museum experience that would link the forces of nature to the fundamental laws of physics and chemistry with an emphasis on the joy and adventure of scientific discovery, sparking curiosity and interest from the general public and future scientists. Natural phenomena were chosen to anchor the exhibit, not only because the amazing science that underlies them could be tied back to basic principles, but also for the inherent beauty they possess.

An important component of the Science Storms concept was to put a human face on science, to show that science is a collective human endeavor, an innate human activity that begins with the curiosity of a child and is driven by a fascination with nature. Showcasing scientists talking about their own motivations and excitement about their work was key. Presenting beautiful imagery and dramatic video of natural phenomena to support the scientists' stories was chosen as a way to convey that sense of excitement to the visitor.

As such, it was vital to promote the idea that *anyone* can do science, combating the alienating misconception that science is a specialized activity for an elite group of people. Science Storms needed to empower a broad audience to participate in science, particularly the target age group, middle-school children. To that end, contextual stories portray science in all sorts of situations beyond the laboratory throughout the interpretive graphics and media. These stories highlight activities in dynamic natural and industrial environments, performed by a diversity of people.

Finally, the exhibit needed to re-enforce the understanding that science is not merely a collection of facts, but a cyclical, on-going process of wonder, investigation and discovery. More often than not, the public's primary exposure to science is through formal teaching and textbooks; this leads to a common perception that science is already all figured out and that there are no new discoveries to be made or questions to ask. Enabling visitors to engage in the scientific process, ask questions and do experiments within the exhibit was important in upending this misconception. Scientists' own stories of awe, investigation and discovery would provide real, tangible examples of the scientific process at work.

Once the intellectual framework for Science Storms was conceived, it informed every aspect of the project, large and small. It influenced the choice and scale of the project's location, the ambitious set of exhibits, the structure and tone of the interpretive system, the direction of the environmental and graphic design, and the use of media. The goal was to produce a highly synthesized exhibit that delivers an interpretively and aesthetically cohesive experience. The physical exhibits were designed within this framework, supported by a rich interpretive system of graphics, and interactive and linear media that provide meaningful information and context.

To achieve this ambitious program, a multi-faceted team of design and technical consultants was assembled to collaborate with MSI's internal exhibit development team. The execution and seamless integration of the media program required intense, collaborative relationships between the exhibit designer, the media consultant and the museum team. The key to achieving the collective goals of Science Storms depended on the buy-in of all core collaborators on the project to consistently apply them throughout the design and development.

The Science Storms experience is anchored by seven viscerally beautiful, large-scale, interactive demonstrations of natural phenomena, including a 40-foot tall tornado vortex, a 20-foot diameter sand avalanche disk, and a 1.2 million volt Tesla coil. These experiences can be measured, manipulated and observed by visitors. They leverage the drama and fascination of the forces of nature and are platforms for exploring basic scientific principles. The large exhibits are surrounded by a constellation of smaller, hands-on interactives that explore a piece of the science that underlies each of the seven phenomena. Linear and interactive media are natural complements to the mechanical elements of the exhibit. The narrative, storytelling capabilities of linear media and the ability to tailor the delivery and pacing of content with interactive media were identified as the primary means for delivering the interpretive, human stories of Science Storms.

*Tesla coil from the floor*

## The Media

Linear and interactive media are used extensively in Science Storms to support the interpretive goals of the project. Thirty of the fifty-six experiences in the exhibition include media. These media-based experiences can be broken down into three major types: large-scale linear media, interactive media (including media that control electro-mechanical elements in the exhibit, self-contained media experiences and role-playing games), and context interactive experiences. Each type serves a very specific purpose in supporting the goals of the project. In the following sections, we present a case study of each of the media types; the advantages the formats present and the challenges they posed in their implementation.


*The full gallery is a huge array of engaging, large-scale interactives*

## Primary Media

The Primary Media are large-scale, linear videos that feature striking visuals of natural phenomena and the stories of the scientists who investigate them. These pieces were conceived to carry the core interpretive message of the exhibit — to show the exciting face of science and explore the innate human desire to understand the forces of nature. A linear video format was chosen because of its ability to tell a narrative story. There are seven primary media pieces, one for each of the natural phenomena featured in the exhibit. The screens on which they play are located close to, and in some cases on, the large-scale exhibit elements to which they are related. The screens themselves are large: the Atoms video screen is 42 feet wide and encompasses the entire back wall of the exhibit balcony space. Not only do these presentations complement the scale of the exhibits, they function as dynamic signage, animating the phenomena throughout the gallery while visually tying it together.

Each primary media piece is five to seven minutes long and plays in a continuous loop. The narrative arc of the story is tied to key words that echo the scientific method: *wonder, observe, speculate, investigate* and *discover*. This was intended to demonstrate science as a cyclical process. The words also serve to segment the videos, which allow visitors to enter and exit the story at any time. Each video shows beautiful, graphic imagery of natural phenomena and showcases scientists actively working in the field and discussing their research and personal thoughts about what inspires them as a scientist.

The Lightning primary media is a good example of how the media directly connects the natural phenomena to the Tesla Coil demonstration. Visitors sit on reclined seats in a theater setting and look upward at the ceiling-mounted coil and adjacent media screen. The media introduces a series of contemporary scientists exploring fundamental questions related to understanding lightning. Visitors learn what lightning is and see beautiful and powerful imagery of lightning on small and global scales, including high-speed video. At the end of the primary media, the Tesla coil is triggered to discharge in a dramatic display of electricity, similar to lightning.

The Atoms presentation explores the dynamic inner world of atoms, the basic building blocks of matter and the underpinnings of every natural phenomenon in the exhibit. The primary media was especially important in anchoring this thematic area of Science Storms because atoms cannot be seen with the naked eye, nor be held or put on display. Custom computer-generated image renderings of atomic particles accompanied by lively dialogue from contemporary atom scientists are displayed on a giant 42-foot wide screen, transporting the wonders of this sub-microscopic world to the macroscopic.

The challenges encountered in creating the set of primary media were extensive. Since the media covers an enormous scope and breadth of contemporary science subjects, immense research efforts were conducted to find and engage scientists, and then coordinate filming with them in the lab or field. To ensure the pieces tied closely to the interpretive messages of the related exhibitry, a member of the core exhibit team often accompanied the production crew on location to assist with content direction. For example, the producers and an exhibit developer joined a large team of scientists to chase tornados across the Great Plains during tornado season. They visited avalanche labs in Montana, explosives testing grounds in New Mexico and wave research facilities in Oregon.

In addition to the logistical challenges of the production, the diverse research stories had to be combined into a single, coherent story arc. Each primary media features three or more scientists and–with the exception of Atoms primary media–are unscripted. A documentary-style, interview approach was adopted in order to capture a pure sense of the scientist's enthusiasm for his or her work. This meant that the story arc of each video could not be fully determined until the footage had been shot. Because the exhibit's core messages were well-defined, special care had to be taken to craft interview questions that would elicit the desired responses.

Other issues related to how the story arc was structured. Each piece is divided into segments that reflect steps in the scientific

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process. Organizing the stories into loose chapters means that visitors are not required to view the entire piece; they can experience as much of the story as they like and still get the sense of inspiration and wonder the videos convey. Although segmented, the media still tell a compelling and somewhat linear story. Finally, the film footage that was shot determined the lengths of each segment and the pacing of the storytelling. Thus, the length of each media piece and each segment are different.

Integrating the primary media into the overall design and aesthetic of the exhibit space had its own set of challenges. Each projection screen has a close physical relationship to the large-scale exhibit element with which it is associated. This led to large sizes, unusual formats and different aspect ratios for each screen. For example, the Tornado primary media plays on a two-story, vertical projection screen mounted to the exterior of the cylindrical tornado vortex enclosure. The sheer size of the exhibit hall and the traffic flow through the space required a two-fold functionality for the primary media as well. When viewed from a distance, the media needed to paint a beautiful and ambient visual reference to an exhibit area. However, close-up it had to tell inspirational stories that provide context to the exhibit area.

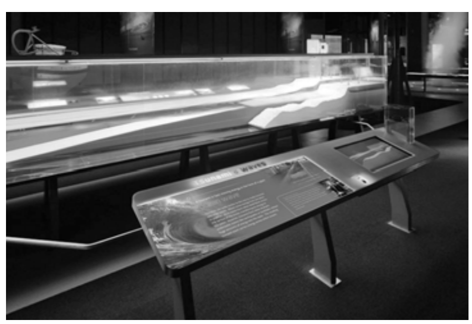
### Interactive Media

The interactive media is intended to enhance the visitors' understanding of the exhibit content when they control and measure large-scale experiments, interact with compelling and rich content in a fun way and meet contemporary scientists. Although each piece is unique, the interactive media can be broken into three types: media that control physical elements of an exhibit, stand-alone interactive experiences and role-playing games.

Nine exhibits provide the operational interface and controls for large-scale electro-mechanical exhibits. With or without a host, these interactives guide visitors through the process of doing a scientific experiment. When visitors take measurements, feedback and content is delivered at the point of the visitor's interaction with the exhibit. Visitors are provided with explanations for what their measurements mean and other helpful information including how scientists do similar experiments to study the same science principles.

In the Heat from Sunlight exhibit, a heliostat mounted on the Museum's roof directs sunlight into the exhibit space on sunny days. A digital touchscreen interface allows visitors to control a Fresnel lens, raising and lowering it in order to focus the sunlight and heat pools of liquid. The Sun's heat causes the liquid to heat up via convection which is vibrantly and dynamically shown as a thermal image display on the screen. The media also makes connections between convection in the pools and sunlight-driven convection of the global oceans.

In another example, visitors can stand at a 30-foot long wave tank and use digital controls to activate a paddle that generates tsunami-like waves that inundate on two shorelines. Visitors can use the monitor to intuitively change the wave parameters to generate various different waves. Wave energy, wave speed, wavelength, and wave height values are set by stretching and dragging an image of a waveform to increase or decrease its height and change its length. Up to five waves can be captured on video and visitors can compare them by playing them back in slow motion.

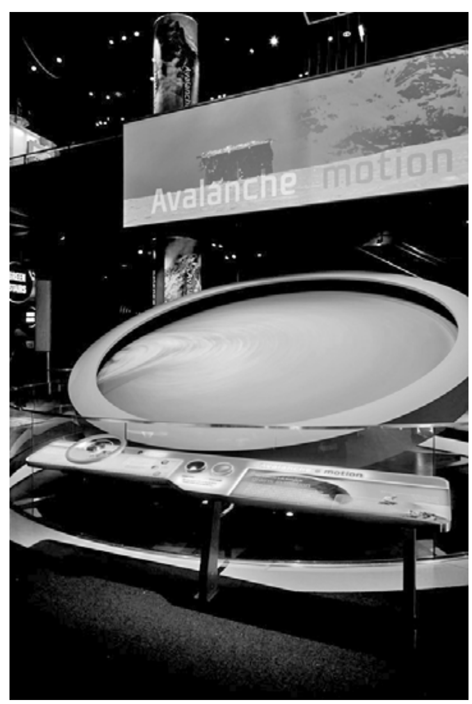


*Wave tank*

In the Fire area, the interactive media facilitates visitors' interaction with a live flame experiment. Controls on the graphical user interface (GUI) allow visitors to change the size of the flame, adjust the size and flow rate of water droplets falling on the flame, turn on lasers to observe the turbulent patterns created when the fire and water mix, and using a live thermal image observe convection patterns and measure the temperature of the flame in different parts of the booth. By playing with the many parameters visitors can create stunning and dramatic effects and better understand fire suppression science.

*Adjustable flame interactive*

Six interactive media exhibits are stand-alone experiences that allow visitors to do an experiment and explore related content in more depth. The Avalanche Cam exhibit creates another opportunity for visitors to interact with the 20-foot diameter rotating Avalanche disk. Visitors stand at a station on the balcony that overlooks the disk on the level below and capture video to explore the dynamic patterns of the granular materials moving in the disk. They can focus their investigations on whether the grains are flowing, packing or shearing; zooming in and out to capture the evidence they want. While visitors on the main floor can operate controls that change the disk's rotation speed, this in-




*Avalanche disk*

teractive layers and expands the capacity of the experience by introducing a new content focus.

Two interactive exhibits are role-playing games where visitors step into the shoes of scientists and are challenged to react and respond to "real-time" events. One of these interactives is a group theater simulation where visitors are transported to tornado alley and don the shoes of storm chasers. They outfit their Doppler on Wheels vehicles, deploy instruments in the field, and track the path of a tornado, drawing from their measurements of the atmospheric conditions. In the process, visitors ride shotgun with real tornado chasers and learn about their research and the instruments they use. If they conduct their work well and have some degree of luck, they have a close encounter with a giant tornado on the large screen overhead.


*Toronado Alley*

The primary technical and design challenges in creating the interactive media were making sophisticated scientific data accessible to the public, integrating the software with the hardware components of the mechanical exhibits and developing meaningful and fun experiences from real scientific experiments, data and tools. Each interactive media piece delivers different content and has unique functionality and experience goals. Every piece was developed individually without taking a cookie-cutter approach to designing the interface and presenting the content. The Fire Modeling interactive is an example of one of the more difficult interactives to produce because it required integrating real fire testing simulation data of a burning room from Underwriters Laboratories into a meaningful game-like experience.

Some interactives required melding digital interfaces with traditional, mechanical ones. In the Projectiles exhibit, visitors launch tennis balls across the exhibit hall to investigate how gravity affects the motion of the ball. Electro-mechanical controls are used to set the trajectory and launch the ball, but a nearby (non-touch) screen delivers the content and instructions. The design challenge here was that the screen needed to be placed so visitors did not intuitively react to it as a touchscreen, and oriented such that it did not distract attention from the physical action of the exhibit.

*Projectiles control panel*

Extensive prototyping and evaluation of the GUI and content for each experience was required. In addition, integrating the media with the hardware required producers to work very closely with engineers, fabricators, audiovisual hardware integrators, content developers and designers. For the tsunami tank in particular, a very high level of content and design integration was needed, so the two elements were developed simultaneously.

### Context interactives

These stand-alone interactive media occur in six of the seven thematic areas of Science Storms and create a bridge between the large-scale iconic exhibits and the smaller secondary exhibits. They provide visitors with a unique opportunity to play with and explore the physics and chemistry of the natural phenomena in a tactile and intimate way; visitors can virtually make lightning, tornados and tsunamis all while conducting their own scientific experiments. Along the way, visitors use the tools of science and meet contemporary scientists that study these phenomena. The interactives also have an updatable feature devoted to the recent news and events related to each phenomenon. For example, in the tsunami context interactive, visitors can select different physical parameters and set off an underwater seismic event to generate a tsunami wave. In the process they learn how tsunamis are generated, how they propagate and inundate shorelines, and how scientists plug scientific data into computer models to help predict and avoid potential disasters.

The main challenge encountered with the context interactives was uniting complex content that draws on data from contemporary scientific research with a fun, engaging game interface. The content had to be accurate and on point with exhibition key messages, yet it had to be presented simply so it could be easily and quickly absorbed. Scientists were intimately involved in game play development to ensure the accuracy of the content.

### Specialty Media Platform: Create a Chemical Reaction

The Create a Chemical Reaction exhibit is a great example of appropriating media technology to an exhibit experience. The experience allows visitors to engage with the Periodic Table of the Elements using a sense-table hardware platform developed by Patten Studios. The goal of the exhibit is for visitors to have a tactile interaction with atoms and chemistry. Atoms are far too small to be seen with the naked eye or be experienced directly without the use of advanced instrumentation. The novel hardware platform provided a way to let visitors "hold" an atom and create chemical reactions. On a large tabletop projection, visitors use a puck to roll over the Periodic Table and learn about various chemical elements. They can then drag an element to a reaction space. By combining two or more elements, they can create a virtual chemical reaction and produce a new substance. When a reaction occurs, a colorful video or image of the new substances is projected in the

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reaction space and contextualizes the activity.

*Puck on elements table*

## Conclusion

Linear and interactive media can be used strategically to support major thematic elements of an exhibition. Each type of media has its own strengths and weaknesses and some are better suited to deliver certain messages. In Science Storms*,* media is applied in a range of formats to enhance the visitor's understanding of the exhibit, contextualize the physical exhibits, and bridge the connections between the large- and small-scale exhibits.

The strength of the linear media is that it carries the core interpretive message of the exhibit, setting the scene and inspiring wonder in the audience using large, dramatic visuals of natural phenomena and the dynamic face of contemporary scientists and their research. The strengths of the interactive media include delivering content and instructions right where the visitor's hands are interacting with exhibit. They aid in the exhibit interpretation, particularly when the GUI is controlling a real-time experiment. They also pace the experience, leading visitors through a process and providing activity when the physical portion of an exhibit is busy. The context interactives connect the large and small-scale exhibits and explore the content in a tactile and intimate way. Specific hardware platforms were chosen to meet experiential goals, such as the Reaction Table where we wanted visitors to "touch" atoms and create chemical reactions.

The selective use of media and the combination of multiple media elements in Science Storms—large-scale linear media, context interactives and the three types of interactive media—are what makes the media strategy so effective in this exhibition. The many elements allowed developers to tailor the exhibit message and play to the strengths of the various media formats. To date, visitor feedback to Science Storms has been overwhelmingly positive and the strategic use of media has played a major role in the exhibition's success. The media deliver the exhibition narrative in a compelling way and connect with visitors on an intellectual and emotional level, ultimately achieving the project's mission—to inspire a population, young and old, and engage them in a dialogue about the pure thrill of science.

All images credited to Sean Hemmerle, except for Wave Tank and Fire.

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Book Review

# LOST IN LEARNING: THE ART OF DISCOVERY

**Alison Dineen**

In November, our office received a review copy of *Lost in Learning: The Art of Discovery*. This handsome coffee table publication, filled with lush black and white by fine art photographer Eva Koleva Timothy, features historical books, paintings, and scientific tools as evocative, material links to some of world's greatest explorers, scientists, and artists. An accompanying essay by Adam Timothy (Oxford MBA and spouse) provides too brief context, but succeeds in celebrating the passion of curiosity and creativity that fuels the human desire to experiment, discover and learn—against the odds and, sometimes, in contradiction of societal expectations and beliefs. The book is also part of a larger project that includes the Lost in Learning traveling exhibition of Timothy's photographs and a website (http://www.illumea.com/lost_in_learning/home.asp).

Extraordinary individuals of the Renaissance are primarily considered here: Christopher Columbus, Galileo Galilei, Isaac Newton, Isabella D'Este, and Leonardo Da Vinci. Many intriguing scientific instruments featured in the book are from the History of Science Department, Collection of Historical Science Instruments, at Harvard University. These include a planispheric astrolabe (c. 1400), geometrical and military compass (1604), sundial (c. 1660) and terrestrial globe (1552). Timothy's photographs highlight the intricate details of instrumental metalwork so beautifully that you want to touch the surface.

A photograph used to consider the exploratory aspirations of Christopher Columbus features the text *Imago Mundi* (1410), written by the French theologian, astrologer, and Roman Catholic Cardinal Pierre d'Ailly. The book is believed to have strongly influenced Columbus' estimations of the world land mass and conceptual planning for his voyages. The Italian explorer recorded his personal observations in the margins of a copy of it. A photograph of the text with notations somehow telegraphs information about the man, in contrast to the legend, as one imagines Columbus engaged in this careful act of comparison and calculation.

The technique known as sfumato (used in paintings during the Renaissance that, in brief, blurs the edges so there is no definitive line) is utilized by Timothy to combine separate photographic images such as, for example, a sketch of the moon and a portrait of Galileo. Other devices include placement of magnifying glasses, prisms, or wire-rimmed eyeglasses to bring attention to details in paintings or books. There's an insistence here that says look deeper or consider this—and works for the most part.

*Lost in Learning* urges readers to explore deeply and joyfully (or at least it prompted me to do some research on scientific instruments). It is clearly in-