Effecting Science in Affective Places:
The Rhetoric of Science in American Science and Technology Centers

Dissertation

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Abstract

My dissertation traces and analyzes the identifications with science that emerge in the rhetorical tradition of the multimodal exhibition of scientific objects, concepts, processes, and practices in the museum context. I demonstrate how multimodal exhibits in science centers have embedded implicit instruction in scientific method and its value; these identifications with science are further reinforced and complicated by wider cultural expectations and ambitions for science and science centers, and how those expectations and ambitions come to be realized in the built spaces of the science centers enclosing the exhibits themselves. I argue that the display of science exhibits within the context of science centers’ built spaces reproduces a rhetorical tradition that encourages visitors to respond according to sense-making conventions that are historic in origins, and which privilege a “folk epistemology of common sense empiricism.” The compelling characterization of science as a process conducted through careful observation and inference was separated from the dominant definition of science when experimental science displaced analytical science and its practice moved from private homes and museums to university laboratories. In the twentieth century, through their reproduction of exhibits’ “naked eye science,” museums—both natural history and the emerging
institution of the science center—preserved the now-outdated theory of knowledge-making with objects. As cultural expectations and ideas about science changed during the twentieth century, the needs of local communities hosting science centers changed, and science center institutions and buildings were adapted to address new educational, economic and civic demands. While exhibits’ sense-making functions remained based on the assumption that science is done through careful observation of past events, new architectures and built spaces enclosing those exhibits realized celebratory functions for their surrounding communities, conferring on the exhibits the community’s value for science as a vehicle of economic and social progress, an exciting exploration of received facts, and a process to be mastered by the “noble scientist.” My study reveals not only varying levels of complexity by which communicative modes function together to realize scientific meanings, but also how the convergence of historic, social, and material factors influence the meanings that exhibits and their exhibit designers may make available to visitors. Additionally, because some research suggests that the primary effect of the museum experience is not better understanding of science, but a new excitement or curiosity about it, understanding the affective aspects of identification in science centers can help scholars better understand how attitudes towards science are shaped in specific contexts.

The celebratory identifications with science are the most prominent aspect of the
museum experience, and as a result, these science centers promote an outdated conception of science that is exciting, but sets up its audience—American children and families, primarily—for unexpected disappointment and frustration when they encounter the true intellectual challenges and laborious repetition of scientific practice. Further, those celebratory functions may be politicized and co-opted by other institutions with motives that run directly counter to those of the science center.
Dedication

To Dan and Simon, for teaching me balance (despite my best efforts to resist),
and for being the best part of my day, every day.

For my parents, who weren’t sure if I should,
but always knew that I could.

And to Sarah, Jess, and Becky for knowing I would do it
through all the times when I didn’t think I could do it.
Projects of this scale and duration are never solo endeavors, never created without material, intellectual, and social support. Mine is no exception. I am entirely indebted to the museum professionals at my research sites: the Cincinnati Museum Center’s Museum of Natural History and Science; the Carnegie Science Center; and of course, COSI: Center of Science and Industry. Many of them used personal time to meet and interview with me, and they also gamely reviewed the transcripts to revise details and ideas. Their insights and experience were essential, and their generosity and warmth were deeply appreciated.

I am grateful to include in my project photographs from the Hunterian Museum of the Royal Surgeon’s College in London, the Columbus Metropolitan Library Images Collection, as well as the National Archives. Without these illustrations, a dissertation on visual rhetoric would hardly carry the same persuasive weight.

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Chapter 1: Introduction: Science Centers in the United States

As a child and young adult, I spent many of my summers in the 1980s and 90s in the back of a station wagon, on extended road trips across the U.S. with my parents and older brother. My mother was an English teacher and my father taught high school biology, so our vacations were rarely planned for pure entertainment: no beach-loafing or amusement parks for this family! Rather, my parents chose destinations for their educational value, financial feasibility, and entertainment factor, often in that order. After driving for hundreds of sweaty miles, we arrived at national and state parks, historical landmarks, homes of famous authors and cultural figures, aquariums, zoos, and museums. My favorites were often the science centers—the oddly shaped buildings with air conditioning (A/C was a special treat in July after weeks of camping out), fascinating exhibits to play with, including a static electricity generator that would make your hair stand on end (and give you a giant shock if you took your hand off too soon), and even a gift shop where we might persuade Mom and Dad to buy space ice cream or a book of experiments to do at home.

Many Americans who have children or were children after the early 1980s or 1990s will find these experiences familiar. On a typical visit to a contemporary science and technology center in North America, a visitor would likely encounter colorful, exhibition halls with multimedia exhibit stations and displays, OMNIMAX theatres
featuring vertigo-inducing films of canyons or ocean ecosystems, cafés offering “Galileo Salads” and—of course—a gift shop lined with shelves of model dinosaurs and grow-your-own-crystal kits. That same visitor might sprint through an enormous model of a human heart, running her fingers along a mitral valve before drifting out and towards an exhibit station featuring a computer animation of colored pea-plants pollinating and cross-pollinating, chromosomes unwinding and recombining to illustrate the heritability of genetic traits. Passing behind this exhibit station, the same visitor’s attention might be captured by a wall adorned with beautiful optical illusions, seeming to shimmer and bend before her eyes.

This scene I have described exemplifies typical elements that shape visitors’ science center experience. Yet our experiences of sciences in these physical places differ, as do our understandings, attitudes, and beliefs about science that we bring and take away from these encounters. How are shapes, colors, animations, images, and texts resolved into scientific principles and concepts? What identifications with science do these exhibits create, and do the “nuggets” of information conveyed offer a coherent picture of scientific practice and its products? What are the potential identifications with science made available through the ways of seeing science offered in the museum experience? What attitudes towards science are encouraged and fostered and how can we characterize the scientific information made available? How does the experience inside the museum shape affective orientations towards science outside its walls—and conversely, how does a science center’s community—its city, with its unique history and characteristics—shape the museum and influence the ways of seeing science inside? These are questions that
scholars interested in the rhetoric of science have yet to answer, and which this study aims to address.

Science and technology centers (or science centers) are common sites of informal science learning within the American public sphere. According to the Association of Science-Technology Centers, there are nearly 400 science centers in the United States alone, and most major U.S. cities boast some sort of science museum. Science and technology centers are often significant community and tourist fixtures: almost every American student visits a science museum at some point in their educations; parents take their children, often more than once a year, and often to science centers in other cities; museums work with schools and communities to present programs and educational outreach, and so on. Science centers and the representations of science they make available carry an authority and aura that affects public perception of science, and so these sites present a unique location\(^1\) for scholars interested in rhetoric of science and scientific accommodation, rhetoricians generally, and museum professionals. By investigating museums’ contexts—their surrounding communities, architectures, and interior built spaces—and the affordances of their multimodal media of communication—particularly the multimodal exhibit stations that constitute their exhibitions, I contribute to scholarship in rhetoric of science seeking to understand the ways that material, visual, and spatial artifacts combine with written texts to make particular ways of understanding science available to the public. Science centers are sites where the scholarship in museum studies and rhetoric both overlaps and differs in exciting ways; synthesizing these

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\(^1\) That individual museums and their narratives of science available to audiences can be viewed as
perspectives to better understand the rhetorical effects of multimodal rhetorics in science centers is of value for multiple disciplinary interests.

My research focuses on the ways in which the aspects of the museum experience cohere to accommodate scientific concepts and practices for an imagined (often very young) public audience. Information is lifted from one context—usually scientific articles or consultations with scientific experts—and is then transformed into material/spatial exhibits, presenting concepts in multimodal forms that encourage visitors to adopt specific ways of seeing science. These ways of seeing science constitute terministic screens—symbolic cues that direct our attention towards one way of seeing the world and, by necessity, away from others—and may thereby connect visitors to or separate them from attitudes, ideas, and beliefs about science through what Kenneth Burke, in *A Rhetoric of Motives*, calls identification. This research also examines the ways that a city’s individual characteristics reflect citizens’ expectations about science, demand for science education, and their ideas about how the science center itself interfaces with those needs and expectations. I aim to articulate how each of three sites’ architectures, geographies, exhibitions, exhibits, and built spaces address those expectations and create identifications with science through their semiotic function. In conducting this research, I extend our understanding of the relationship between Burke’s concepts of identification and terministic screens as rhetorical terminology, as well as deepening our knowledge of multimodal scientific accommodation and its semiotic function in public spaces. Additionally, I hope to contribute to museum studies by rigorously investigating a genre of museum that often remains outside of cultural criticism, thereby illustrating the
significance of the role of science and technology centers in defining science in the public sphere.

Description of the Project

The Sites

The primary goal of this study is to understand the techniques of multimodal rhetorical practice that science and technology centers employ to accommodate scientific concepts for visitors; a primary assumption is that these techniques shape cultural conventions for understanding science that may shape visitors’ attitudes, beliefs, or ideas—their *identifications*—with science and scientific practice. To study this relationship, I focus my analysis on three Midwestern science centers—two in Ohio, and one in Pennsylvania: COSI: Center of Science and Industry (better known, and referred to hereafter, as COSI) in Columbus, OH; The Museum of Natural History and Science in the Cincinnati Museum Center, OH; and the Carnegie Science Center in Pittsburgh, PA. These sites were chosen primarily for their exhibitions’ emphasis on *interactive* exhibits, what Victor Danilov identifies as a key characteristic that differentiates science centers from other kinds of science or natural history museums: “[Science and technology centers] are best known for their contemporary rather than historic perspective and their reliance on participatory exhibit techniques rather than objects of intrinsic value” (viii). Sites were also chosen for their proximity to my home institution, as well as for the willingness of museum staff to participate in the research.
The Methodology and Chapter Summaries

The construction of meaning in science centers involves how the exhibit, as a multimodal communicative medium, accumulates conventionalized meanings—both over the history of the museum institution, as well as in the space and time of a single individual’s engagement with a science center’s architecture, built spaces, and exhibits. As a result of its complex, layered nature, analyzing the relationship between science center exhibits’ techniques of multimodal communication and their immediate and wider cultural contexts requires the use of theoretical lenses from multiple disciplines. My work draws on theory from museum studies, architecture, rhetoric and composition, as well as social semiotic theory. Because each chapter of this study examines a different facet of meaning-making in science centers, each chapter employs a unique combination of those theories, which I use to scaffold my close readings of exhibits, architecture, and built spaces from my research sites. I also use evidence gleaned from institutional archival documents, newspaper articles, center websites, brochures, maps, and marketing tools to contextualize and corroborate my analyses of the rhetorical functions of the material and spatial artifacts comprising and containing these representations of science.

Each chapter of this project examines a different aspect of science centers’ visual and material rhetorics and their role in defining a public culture of science in their communities. Because my research assumes that exhibits are communicative media that have developed, over time, to serve the meaning-making purposes for which they are used, I first explore how the rhetorical tradition of science exhibits was established, historically, through a confluence of scientific objects and visual culture’s conventions
for understanding and valuing those objects within their unique museum context. I review museum studies literature through a rhetorical lens to explore how particular domains of response to science display arose and accumulated over time. The rhetorical tradition of exhibits produced in these contexts, I suggest, corresponds with conventionalized domains of response—the meanings and values connected to objects in their particularized contexts of display—curiosity cabinets, natural history catalogs, and taxonomic arrangements. Wider cultural assumptions about what science is and does and what the science center should do for a community are influenced by the accumulation and percolation of these domains of response into cultural consciousness.

In the following chapter, I use theory from architecture, museum studies, and rhetoric to read the exterior facades and geographic locations of my research sites within the context of their institutional histories. I show how their architectural and institutional faces are reimagined and transformed by stakeholders to address emerging educational, economic, and civic exigencies in the community. My fourth chapter examines the interior built spaces of the sites, combining social semiotic and rhetorical theory with data collected from interviews with museum professionals to demonstrate how these built spaces perform epideictic generic functions that frame the science inside its exhibitions as an engaging and exciting exploration, a vehicle of progress, and a process that is easily mastered.

My final content chapter uses social semiotic theory and rhetorical theory to analyze the multimodal exhibits themselves, arguing through close readings of three typologies of exhibits, that “hands on,” or what I term “haptic” exhibits, implicitly
instruct visitors to view science as a practice conducted by the “noble scientist,”
employing a “folk epistemology of common sense empiricism” that allows for facts and
concepts to be derived through pleasurable, enthymematic revelation. Ultimately, in my
conclusion, I suggest that the “folk epistemology of common sense empiricism” produced
through the rhetorical tradition of these exhibits—celebrated in the built spaces that
enclose them, and shaped by the constraints pressuring institutions to serve the
community—contributes to a wider phenomenon in the U.S. of the politicization of
science, and that failure to ignore how science centers participate in that politicization
may further attenuate our nation’s relationship with science.

My research questions follow:

1. In what ways do exhibits’ multimodal features function rhetorically to
   accommodate scientific concepts and principles for museum visitors? What
cultural conventions for understanding science are constructed or invited by their
arrangement, modes of display, and content? What narrative of science is made
available through the exhibitions?

2. What roles do museums’ built spaces and architecture play in shaping the visitors’
museum experience? How do they facilitate (or not) the taking up of scientific
identifications?

3. What are the identifications with science made available through built spaces?
   And how do the characteristics of the museum make certain ethical, pathetic, and
logical identifications\(^2\) with that narrative available? How do exhibits’ and built spaces’ multimodal terministic screens realize identifications with science?

4. What is the role of the museum within the community where it is located? How does the history of the museum influence its content and mission? What changes have occurred between the museum’s conception/development and its present in terms of how they conceptualize the museum’s audience—its desires, needs, and expectations?

Review of the Literature

*The Rhetoric of Science and Scientific Accommodations*\(^3\)

What was, until recently, a narrow subfield in the broader domain of rhetoric and composition, rhetoric of science has come into its own over the past two decades, with scholarship expanding in breadth and depth, overlapping the work in many other disciplines: philosophy of science, sociology of scientific knowledge, and history of science, to name just a few. The rhetoric of science emphasizes understanding the textual

\(^2\) In rhetorical terminology originating in Aristotle’s *On Rhetoric*, pathos and logos are part of the canon of appeals (which also includes ethos) from which rhetors can draw to make their arguments and persuade their audiences. Generally, pathetic appeals are seen as eliciting certain emotional responses from the audience, while logical appeals focus on their sense of what is reasonable and logical. In terms of the museum experience, I use “pathetic” to refer to all the emotions—excitement, motivation, inspiration, intellectual fatigue, boredom, etc.—that can arise during a typical visit and which, according to many museum professionals, is often the most memorable (more so than any learning of science concepts) aspect of the visitor’s experience.

\(^3\) “Accommodation” is a word used by Jeanne Fahnestock to describe the changes that occur in a scientific report when it is altered by a journalist for “lay” or public consumption. Other scholars refer to the product of accommodation as “popularizations”; throughout my research I refer to “accommodations,” “popularizations,” and “translations” as the product of an interchange between information and popularizer (e.g. scientist, journalist, museum curator) with the understanding that scientific discourse lies on a spectrum of other types of discourse. By using these terms interchangeably, I reference their use in popular culture and existing scholarship while acknowledging the artificiality of separating “expert” from “lay” discourses of science.
and contextual aspects of scientific argumentation, knowledge-creation, and communication and is particularly concerned with the intersections of the social and textual elements involved in these processes. My project locates itself at this intersection by examining the ways that scientific accommodation—a subset of scientific communication—is conducted through multimodal techniques for visitors at a variety of levels of scientific sophistication.

Foundational works in rhetoric of science have highlighted the importance of understanding the intersections between social relationships and purposes and the textual aspects of scientific writing and rhetoric (Harris, Prelli). And philosophical and historical examinations of texts, such those written by Alan Gross and Charles Bazerman, explore how texts and social constraints constitute and direct formation of scientific knowledge. However, the accommodation of scientific knowledge for the ‘lay’ public has just begun to garner scholarly interests in science communication, particularly in recent years. That this interest is so recent is particularly striking given the academic allegiances of scholars who study public understanding of scientific knowledge, many of whom overlap the disciplinary areas that focus on rhetoric of science (i.e. sociology of science, philosophy of science, etc.).

While interest in scientific accommodation is on the rise, Greg Myers’s and Jeanne Fahnestock’s research are early representatives of studies that examine scientific accommodations in relation to rhetoric. Fahnestock’s 1998 work, “Accommodating Science,” combines rhetorical and sociological approaches to the study of science by examining the ways that the rhetorical genre, scientific statement types, stasis type, types
of appeals, and word choices are changed in popularizations of science. By studying original scientific reports and their subsequent accommodations in popular periodicals, Fahnestock argues that the value of the science is understood for researchers, whereas lay audiences require explanation of the research’s value and relationship to their lives. She suggests that this distinction in uptake of scientific information explains in part why accommodations of science typically shift rhetorical genre from forensic—explaining past events or describing what was observed—to epideictic—celebrating the awesome discoveries of scientists and researcher or appreciating the enormity of how scientific discoveries have improved quality of life (333-334). Specifically, what is at issue for scientific audiences is not the same as for readers of scientific accommodations. As such, these genre shifts are also accompanied by changes in diction and in statement type—or degree of certainty expressed in a claim. The result of these journalistic choices is a qualitative change in the information that is presented, a changed that Fahnestock connects explicitly to the writer’s need to write a story that sells papers and grips an audience, a task best performed through “the work of epideictic rhetoric…[which] requires the adjustment of new information to an audience’s already held values and assumptions” (334). According to Fahnestock’s schema, the rhetorical decisions made by authors of popular works are dictated largely by pressures to please an audience and to fulfill employers’ expectations. As a rhetorical study of science accommodation, this project asks how science represented in science centers multimodal exhibits’ and built spaces’ is changed through that accommodation to serve the purposes of the institutions.
Like Fahnestock, Greg Myers emphasizes that an original scientific report and its popularization differ not only in word choice, but also in the subject emphasized within the text. He argues that scientific reports relate “narratives of science,” focusing on the actions and findings of the scientist, while popularizations offer “narratives of nature” focusing on the silent, “objective” processes of nature that happen outside of human observation. His analysis of these textual artifacts suggests that the impression or way of seeing science offered to lay audiences is a qualitatively different product than that understood by scientists. My project interrogates the nature of the science center’s narrative of scientific practice as it is realized through the material, spatial, and visual rhetorics of science centers, and attempts to trace that narrative to the community needs that such representation of science both reflects and serves.

In their textual analyses of scientific accommodations, both Fahnestock and Myers detail the qualitative shifts in content and diction that accompany accommodation, emphasizing how the artifact changes between its original instantiation (the scholarly article) and the accommodation (the popularization). In a more recent discussion of discourse and its relationship to the public understanding of science, though, Myers criticizes most dominant discussions of scientific discourse for assuming that accommodations vulgarize or oversimplify “real” scientific discourse, that the public is a blank slate for scientific authorities to “write” on, and that the content of science is simply an array of written statements (267). Instead, Myers argues, we should think of popularization or accommodation as a social process, one that sees science as a “terrain of competing discourses and practices” wherein “popularization is a routinized social
activity that has led to the creation of a number of fairly stable genres” (267). Understanding accommodations as part of a genre of social activity allows for us to view science centers, in particular as performing its own generic functions of popularization. The rhetorical functions which science centers share, then, become features of its generic performance, which allows us to view their constituent visual and material features as vital aspects of the genre.

Myers, too, encourages us to examine these non-textual features of popularization, arguing that “some of the most dramatic and memorable encounters with science are primarily visual, rather than verbal”; his claims about the importance of the visual and material aspects of accommodation are particularly pertinent to the genre of science centers. Myers aims to direct scholarly inquiry towards understanding ways that popularizations are conducted dialogically during the experience of reading/seeing—between individual and popularization—as well as how those interactions relate to the creator’s identity and credibility:

> Popularization is a matter of interaction as well as information; it involves persons and identities as well as messages…regardless of which scientific authority is at issue…it involves the active construction of believable or discreditable identities and alignments that might shift in the course of one interaction. (273)

Myers’ emphasis on the interactivity of popularizations as well as the role of accommodator identity and credibility suggests the science center is a prime subject for the study of scientific accommodation. With their characteristic interactive displays and
reputation for trustworthiness and credibility within their communities, science centers represent a genre of scientific discourse that should be of utmost interest to researchers interested in accommodation, particularly multimodal accommodation. My research embraces these multiple perspectives to elucidate the genre of science centers and clarify the interactions between scientific information and its consumers.

*Visual and Material Rhetorics and Scientific Accommodation: Visual Rhetorics*

Like Myers’s recent call for increased attention to visual popularizations of science, Fahnestock has also recently argued for the importance of better understanding visual rhetoric in scientific communications, specifically (“Enriching”). Rhetoricians and scholars of visual communication have attended to the argumentative and persuasive nature of images and visuals for many years. While earlier scholarship in argumentation and rhetoric focused on whether visuals could make arguments and the elements that affected their persuasive nature, more recent scholarship has focused on theorizing the meaning-making process of visualization. Visual media scholars Gunther Kress and Theo Van Leeuwen have employed social semiotic theory to articulate a “grammar of visual design” that aims to provide a schema for understanding how the elements of an image resolve themselves into a meaningful image for the viewer: “Just as grammars of language describe how words combine in clauses, sentences, and texts, so our visual ‘grammar’ will describe the way in which depicted people, places, and things combine in visual 'statements' of greater or lesser complexity and extension” (1). These scholars suggest that there are culturally-specific constants or “rules” to design and interpretation of images, but they also acknowledge that representation involves the creator’s interest or
purpose in creating, the context of creation, and his or her individual cultural and social history (6). While not explicitly rhetorical in their disciplinary training, Kress and Van Leeuwen’s emphasis on purpose, context, and elements of design clearly aligns with rhetoric’s allegiance to understanding the relationship between rhetor, message, audience, and context. My research embraces their theoretical perspective and seeks to understand how cultural conventions of looking at displays of scientific objects in museum contexts prescribes particular epistemologies for understanding those displays. Kress and van Leeuwen’s emphasis on the relationship between the creator’s purpose and cultural background with the intention of the visual bears strongly on curators’ choices and methods as they design museum exhibits with specific audiences and purposes for the information they hope to convey.

Rhetoricians of science have also begun to examine the rhetorical nature of visuals in science, in both professional/technical communications as well as accommodations for lay audiences. According to Fahnestock, the goal of a rhetoric of science is to understand the means by which scientific texts, arguments, or presentations persuade listeners of the validity of their claims about the world (“Enriching”). She argues that to understand and explain the means by which these claims are made persuasive requires “knowledge of the formal resources of argument, language and other modes of presentation or construction available to scientists” (“Enriching” 278). That is, rhetoric of science involves more than cataloging the persuasive strategies of speech and writing, but also understanding how images, graphs, and diagrams function to make scientific concepts and theories legible. Fahnestock argues that because visuals are such an integral
part of scientific practice and discussion, rhetoricians must better understand how they are used to generate evidence for argumentative claims (283). My examination of the multimodal semiotic function of exhibits aims to intervene, specifically, to understand how exhibits persuade visitors to accept their claims about the natural world as valid: those exhibits function to induct visitors familiar with the “everyday” conventions for establishing valid claims about the world to the conventions required for establishing a version of scientific validity. This work extends many studies by rhetoricians and sociologists of scientific knowledge detailing the characteristics, functions, and strategies of scientific representations and visuals (Baigrie; de Chaderevian and Hooper; Woolgar and Lynch; Gross; Shelley; Richards; Rudwick, among others).

In scientific communication and rhetoric more specifically, scholars have begun to piece together some useful theoretical frameworks to think about visual communication. However, the discipline-specific uses and practices of production (including variations of methodologies and practices within disciplines), as well as ever-changing technologies of production make theorizing this subject a shot at a moving target. As sociologists of scientific knowledge, Woolgar and Lynch argue that a heterogeneity of function and theory in representation is a result of their situatedness in time and within their discipline; they argue that representations are locally and socially produced, and are affected by the same issues as postmodern critiques of science and language and the issues that arise if there are no universal meanings or exact correspondence between word and object (1-3). Experimentation, discovery, replication, argumentation and representation are socially situated processes of knowledge-
production and are not exclusively methodological and epistemological concerns. Rather, the materials and objects that scientists “create, pick up, measure, argue about, and circulate are not 'natural objects,' but are manipulated, interpreted and become a repository of 'social actions'” (5). What follows from this condition, they suggest, is that the theory involved in representing is inseparable from the social context in which representations are composed and used, and that the theories informing the representation's composition are then bounded by the demands of the specific purpose of the creator (12). Because Woolgar and Lynch’s claims could be said to apply equally as well to texts as to scientific images, their theory provides a useful scaffold to my rhetorical analysis of both visual and textual aspects of museum exhibits. If both texts and visuals are conditioned by the media of their production, purposes of their creator, as well as the specific social contexts in which they are created and disseminated, then a rhetorical analysis informed by Woolgar and Lynch’s work seems particular appropriate for the specific genre of the science center, whose exhibits, especially, represent a rhetorical tradition where these factors are all significantly interdependent and in motion simultaneously.

Theory and practice of representing science are contingent upon the social contexts in which they are produced and executed and therefore understanding the rhetorical production and dissemination of visual accommodations of science requires studying them in situ as well as interrogating the practices behind their creation. By using Kress and Van Leeuwen’s theoretical frameworks to detail the ways that characteristics of scientific representation and accommodation in museums converge and diverge from
those of more bounded scientific disciplines, my research helps rhetoricians interested in science accommodation and visual rhetoric better understand the role of representation in the spectrum of scientific discourse and communication. Additionally, by interviewing museum staff who create and design these scientific representations, I also focus on the social processes involved in selecting media and shaping representations for specific audiences in specific locations, thereby contributing to visual theory but also retaining fidelity to rhetoric’s goals of understanding artifacts in relation to their creator, audience, and rhetorical situation.

**Visual and Material Rhetorics and Scientific Accommodation: Material Rhetorics**

In his discussion of visual literacy and scientific representation, Luc Pauwels argues that, given the “perceptual limits of human observers” and the “representational limits of any medium,” we must attend to “different types of media and different types of translations of and relations between a representation and whatever it seeks to represent” (viii). Pauwels is suggesting that choosing a different medium of representing a scientific phenomenon or concept alters the relationship between the representation and the represented, and also changes the nature of the output—the accommodation—as interpreted by a viewer or user. His assertion, while referring specifically to different technologies of visual production, should direct our attention to the product of that technology as well as to the material process of its production. While research in rhetoric and the field of science studies have addressed the ways that images marshal evidence for scientific claims and participate in the construction of scientific knowledge, understanding the *means of production* of the images and—more broadly—the material
nature of scientific objects, is vital for articulating their role in the rhetorical construction of scientific knowledge and its dissemination.

Pointing to the vivid images produced through fluorescent imaging microscopy versus fMRI and PET scanning technologies, Jeanne Fahnestock argues that the means by which images are produced can be as important for establishing the validity of claims made as the images themselves (“Enriching” 284). For example, fMRI scans often employ vivid coloring techniques that correspond levels of oxygen in the brain with different colors on the rainbow spectrum; a red amygdala may visually contrast with a blue or green portion of the occipital lobe, implying a significant difference in each structure’s activity for the casual observer. However, examination of the data used to produce those images may indicate only minute differences in levels of oxygen, conveying nothing definitive about brain activity more generally. But viewers may be mislead into believing more overstated conclusions or claims about brain activity because of the apparent “obviousness” of the differences in color (see Joseph Dumit’s study for an extended discussion on PET scans). Fahnestock would have us question the means of production in shaping scientific inferences made by viewers—is an fMRI scan the clearest way to convey that researchers correlate oxygen levels with brain activity? Might a chart that indicated levels of oxygen in each square inch of the brain provide a more nuanced—if less visually compelling—representation of the phenomenon in question? In the context of science centers, Fahnestock’s insights begs the question of the nature of the instructions or implications about how science is made or done that are embedded in the
built spaces and décor of the science centers’ exterior and interior façades, as well as the visual or material components of exhibits.

Bruno Latour and Steven Woolgar famously called attention to the social and material processes by which scientific evidence is inscribed, recorded, accumulated, and solidified into “fact”: “It is not simply that phenomena depend on certain material instrumentation; rather, the phenomena are thoroughly constituted by the material setting of the laboratory” (64). Latour and Woolgar argued that it was the combination of social processes involving laboratory apparatus and “inscription devices” (e.g. test tubes, labeling techniques, chemical assays, charts and graphs of change, scientific reports, and so on) that led to the “piling up” of the claims and statements that, eventually, may become accepted scientific “fact.” They assert that this piling up of processes and apparatus obscures the nature of science, erasing the socially contingent processes of “fact making” and leaving the impression that there was only ever a single logical conclusion to be derived from the evidence. Latour and Woolgar’s philosophy of scientific knowledge calls attention to the material apparatus and processes of science informing studies of material rhetorics influencing the development and communication of scientific knowledge. My research builds on Woolgar and Lynch’s by articulating the relationship between the sociohistorical contexts of museums and their impact on the ways that curators and exhibit designers use materials and visuals to encourage visitors to take on particular ideas, attitudes and language about science. For example, I suggest that the economic history of cities such as Pittsburgh, with its boom and bust eras, have influenced thematically the development of exhibits such as the Robotics exhibit at the
Carnegie Science Center. The city of Pittsburgh owes much of its economic rebirth in the latter portion of the 20th century to its robotics and advanced technology fields developed through public and private research institutions such as Carnegie Mellon University and the University of Pittsburgh; that the Carnegie Science Center would feature such exhibits speaks to the financial influence of these institutions, but also to the city’s overall attitude towards technology and its role in the community recovery and revitalization of the region. The relationship between the material reality of the exhibit—the sophistication of the robotics technology featured, for one—and the history of the city and its people is unmistakable, and a vital part of the message conveyed about technology at the Carnegie Science Center.

Other scholars of science and inquiry have recently pointed to the significance of attending to the influence of institutions and their material characteristics in shaping scientific knowledge and attitudes. Language, of course, remains of interest to rhetoricians, but more rich description of the material and visual aspects of scientific knowledge can contribute to a significant increase in the ways that these modes function together. In the introduction of her edited collection, Lorraine Daston provides a framework for understanding the role of scientific apparatus and phenomena in the generation and development of scientific fields. Arguing that both laboratory equipment as well as theoretical terms can be understood as scientific phenomena, she claims tracing their histories can help us understand the “historicity of scientific objects” or the process by which
…a heretofore unknown, ignored, or dispersed set of phenomena is transformed into a scientific object that can be observed and manipulated, that is capable of theoretical ramifications and empirical surprises, and that coheres, at least for a time, as an ontological entity. (5)

Daston provides theoretical terms for understanding how scientific objects come into being: through new interest in or perspective on a subject or idea (salience) and through discipline-specific cultural situatedness at a specific moment (emergence). The ontological “realness” of the objects is strengthened through the object’s productivity for the field (i.e. how useful it is for developing theories, conducting experiments, forwarding new knowledge claims) and by its embeddedness in a discipline and that discipline’s material practices and culture (e.g. how a technique develops into a standard practice involving standard lab apparatus, such as a biological assay or electrophoresis) (6-13). Museums’ exhibit display, significantly, experienced its greatest era of productivity during the nineteenth century; after science research migrated to universities (after about 1920), exhibits in science museums lose their embeddedness in the discipline of natural history. Daston’s schema helps us think of the meaning-making process of science as being both epistemological and ontological—about the cultural situatedness of concepts and material apparatus, which influence how ideas are shaped and received by auditors. Within the museum context we can also think of “material apparatus” as the resources that designers use to create exhibits to expose visitors to new ideas or to make salient a particular perspective on those ideas. For example, in an exhibit on resources, energy, and recycling, the Museum of Science at the Cincinnati Museum Center (CMC)
uses an object familiar to visitors—a bag of “trash” in a metal garbage can—but stacks eleven trash bags on top of the first to make salient the amount of waste produced by a single person in the course of a year. Visually, the stack almost reaches the high-roofed museum ceiling, creating new perspective and meaning to the term “waste” and connecting a physical referent to the text describing the number of pounds of waste produced annually by a single person. The physical representation makes salient the concept of waste by inviting the visitor to experience the concept visually and physically (you can walk around the tower of trash) and to position themselves in relation to this new perspective on the concept but also to their own relationship with waste.

The cultural situatedness of scientific objects and phenomena points to the significance of the cultural institutions that host and facilitate their development. Like Daston, Joanne Ploeger’s research calls to our attention the role that the material physicality of institutions play in shaping attitudes and ideas about science. Studying the high energy particle physics laboratory, Fermilab, Ploeger argues that the material characteristics of the lab—the internal and external architecture, fences surrounding the institution, and the interior décor and images—as well as the discourses that are deployed within and about the lab function as rhetorical boundaries that constitute its science, employees, and its publics. These rhetorics impact the economic, political and symbolic disputes circulating around Fermilab, but most importantly “these rhetorical boundaries help to determine the power and importance of the national laboratories as institutions, justifying their work and negotiating their symbolic importance in debates about the role and reach of science in society” (2).The mysterious presence of the institution and the
perceived inscrutability of the practices within impact the ways that high energy physics
is perceived by the public, an influence that extends to decisions to fund research (or
withhold funding) using tax-payer dollars. Through her analysis of Fermilab, Ploeger
asks us to consider the role of institutions in the interplay between social processes and
discourse, and individual personal experiences: “The social construction of scientific
institutions is a complex process involving many layers of meaning and interpretation
encompassing texts and performances and a wide spectrum of verbal and visual
rhetorics” (46). Rather than viewing institutions as separate from or communicating
unidirectionally with the publics they serve, Ploeger’s work emphasizes the multiplicity
of interactions and exchanges of meaning that happen when visitors engage with
Fermilab’s multiple modes of communication. Similarly, science centers as institutions
participate in a multimodal exchange of meaning with their visitors, employing visual,
verbal, and material rhetorics that shape individual experiences. They also occupy
distinctive physical structures, often located in the downtown area of cities, with their
very presence signifying the importance of science in the lives of their citizens. Ploeger’s
research is a useful case study for understanding the role of institutions in relation to their
surroundings, particularly the ways that material and visual artifacts inside the institution
combine or clash with verbal discourses about science to produce specific ways of seeing
science.
Multimodal Rhetorics and Scientific Accommodation

Within science centers, in particular, the line between visual and material modes of communication quickly becomes blurred as visitors look at and then interact with exhibitions’ exhibits and their component displays. A visitor might read about how steam-power was produced in the 19th century, and then press a button or turn a crank to watch a model steam engine power across a table. Or she might play a game of air hockey with a robot and then watch a video about the data sensing software that allows her opponent to react to the puck’s movement. The question of multimodality—or the use of many modes of communication simultaneously—and multimodal rhetorics, is clearly one that is integral to understanding scientific accommodation within science centers.

Multimodal rhetorics have certainly been of interest to rhetoricians for many years, but increased attention to the interplay between the institutions that employ them, and the use and uptake of these modes will enrich the rhetoric of science and extend our understanding of intertextuality as well as the role of multimodality in educational curricula, learning institutions, and, more broadly, in the construction of terministic screens and our understanding of identification. Multimodal texts require viewers to balance attention to several stimuli simultaneously or in sequence; understanding how this “all-at-onceness” functions and may be interpreted can also help museum professionals to design future exhibits and installations to suit their goals and purposes.

While science centers present informal opportunities for science learning, the role of multimodality in science education has been studied in the classroom by Gunther Kress, Carey Jewitt, Jon Ogborn and Charalampos Tsatsarelis. They argue that there has
been an excess of attention to language in the classroom, which assumes that it is the only mode through which meaning is made. They suggest that a social semiotic approach to the classroom context reveals that various modes of communication have developed according to sociocultural influences—specifically according to their social functions—as well as the individual characteristics of the media’s affordances. These influences and affordances then participate in the construction of meaning in representations and communications of scientific concepts and functions. They suggest that using different modes can lead to different meanings, that some are more accessible than others, and that modes can blend and interweave with language, resulting in more complex meaning (11). Their classroom research provides significant insight into the relationship between modes of communication: “our data reveals conclusively that meaning is made in all modes separately, and at the same time, that meaning is an effect of all the modes acting jointly” (1). By attending to the use of verbal, visual, and interactive/material modes in classroom instruction and learning, Kress et al. argue that modes create meanings individually and together simultaneously. Rhetoric, according to this schema, involves using the modes to suitably represent ideas or phenomena for a particular audience (4). According to Kress et al.’s schema, scientific accommodations in science centers would then be a product of the transformations accompanying accommodation of ideas into material displays, but also of the exhibit designer’s interest and affective orientation towards the subject and the audience. These influences suggest that science as represented in multimodal museum exhibits is necessarily different from “professional” science discourse, and that the form and content of the exhibits will be influenced by the
museum’s and the exhibit designer’s attitudes towards the material conveyed as well as the social world surrounding the museum and its visitors. My research suggests that this phenomenon is integral to the ways that visitors identify or align themselves with the scientific content represented in science centers, since they are being directed to attend to transformations of science that are shaped by museum professionals’ affective orientations to the field and the subject. Kress et al. argue that students’ views of the world are reshaped in the science classroom; I would argue that the science center offers similar opportunities for reshaping conceptions of science and its place in the world, as individuals interact with multimodal displays designed by motivated museum professionals and framed by the affective meanings available in the built spaces surrounding them.

Research in visual, material, and multimodal rhetorics of science has introduced helpful frameworks for understanding artifacts as socially produced and contingent on purpose and context of use. It has pointed to the significance of attending to the role of institutions in framing and shaping rhetorical meanings, as well as called attention to the ways that intertextuality between rhetorical modes of communication complicates and enriches meaning. By incorporating these perspectives, my research on multimodal exhibits within the rich context of science centers enriches our understanding of how scientific accommodations are produced through various individual and multiple modes. By studying this phenomena within the context of science centers, my research also helps us to consider how these multimodal accommodations frame specific cultural conventions for understanding science and aligning (or refusing to align) with specific
ideas, concepts, and beliefs about science as a body of knowledge and a process through identification.

*Ways of Seeing, Terministic Screens, and Identification in Science Centers*

In the previous section I reviewed recent studies of visual, material, and multimodal rhetorics of science. These studies are useful for understanding the ways in which creators use rhetorics to shape scientific meaning in contexts, but they do not provide an adequately rhetorical account of this process of meaning-making. Nor do they adequately describe the ways that these multimodal rhetorics cohere to rhetorically frame scientific concepts and ideas in ways that make them more or less available for viewers and users to take up and catalog or align with their existing beliefs, values, and ideas about science. In this section, I address the ways that verbal, visual, and material rhetorics establish *ways of seeing science*, or in more rhetorical terminology, the *terministic screens* created through the immediate context of the museum’s built spaces and their contextualization of its exhibits. I establish my theoretical frame through which my analyses are viewed, and offer a way of understanding ways of seeing science as lenses for identification with specific views of scientific processes, concepts, values, and beliefs which visitors to science centers may take up or refuse during their museum experiences. The application of this theoretical stance is then applied in subsequent chapters in my analyses of museum history and context, exhibitions, spaces and institutional characteristics; my research contributes to the ways in which we understand science centers’ construction of epistemological frames—ways of seeing science—that then
invite particular identifications with science that visitors then carry out into the larger public sphere: their homes, schools, city, region, and nation.

Michael Lynch and John Law have argued that novices bird-watchers are subject to “aspect blindness” and that these individuals require an apprenticeship in a social organization where they learn how to interpret what they perceive, and, in many ways learn how to see (270). Francoise Bastide argues that we must acquire “habits of thought” or patterns of viewing to correctly interpret meaning of an image (207), and Bert S. Hall suggests that all images contain features arising from expectations that the image-maker brings to the subject; portrayals are encodings that require a “set of conventions” (or “visual language”) common to both the representer and the viewer to achieve shared meaning (10). Soraya de Chaderevian and Nick Hopwood argue that mass production and distribution of three-dimensional models made them a vital part of developing a “visual language” for sciences as they served as a “key medium of traffic between the sciences and wider culture” (6). Each of these authors’ research suggests that visual and material artifacts have a vital epistemic capacity in scientific communication—they function as meaning-making artifacts for their users. Specifically, they indicate that viewers must acquire or possess a “set of conventions,” understand a “visual language,” groom their “habits of thought” to interpret the same meaning from scientific visuals as a member of the scientific community would. My project theorizes a particular “set of conventions” for understanding exhibits of scientific objects emerging from the unique relationship between the exhibits and the immediate contexts in which, historically, they have been used to make claims about the natural world. The rhetorical tradition created by the
recurring engagements with these displays then encouraged a particular set of responses—domains of response—to those exhibits, which then informs wider cultural ideas about science, objects, and their relationship to knowledge-making. In my first chapter, I theorize this relationship by reviewing a history of objects, display and their uses for knowledge-making in museum contexts.

Immersion in “visual culture” or “social organizations” can contribute to the development of these “ways of seeing” science. Kenneth Burke would argue that “ways of seeing” science are simply specific sets of *terministic screens*. For Burke, terministic screens are not just “sets of conventions” or “habits of mind” but are a filter through which we understand our surroundings. Burke argues that any terminology or use of symbols constitutes “a *reflection* of reality,” but also “by its very nature as a terminology it must be a *selection* of reality; and to this extent it must function as a *deflection* of reality” (1341). That is, the language and symbols we use to communicate in any given situation necessarily must direct attention to or “construct” some elements of reality while screening out our attention to others. Thus a museum exhibit that unequivocally celebrates the benefits of recycling may “screen out” nuances of energy consumption involved in recycling aluminum versus glass. A visitor leaves with the sense that “recycling is good” rather than understanding that the energy costs recycling of some materials may be “worse” for the environment than reusing them or dumping them in a landfill.

The terministic screens within museum exhibits therefore affect the “nature of our observations, in the sense that the terms direct the attention to one field rather than to
another” (1341); therefore what science centers do and do not include, in terms of content but also in terms of display techniques can constitute what people think of as “science” or “nonscience”. A science center that does not address evolution may perpetuate the controversy between creationism and evolution by its absence or silence on the subject, since according to Burke, “many of the ‘observations’ are but implications of the particular terminology in terms of which the observations are made” (emphases in original; 1341). Absence of exhibits on a subject may then convey meaning—especially attitudes, beliefs or values—about it; similarly, the modes through which an exhibit conveys information may in part constitute the message as “implications of the particular terminology”. While Burke was speaking of language, specifically when he wrote his theory of terministic screens, visual and material rhetorical theory demonstrates the symbolic meaning-making potential of these modes and should extend our use of Burke’s term to encompass them. Terministic screens may then be constituted verbally, visually, materially or multimodally as they are designed and deployed in museum contexts. My research examines the ways that science centers, through their multimodal exhibits, built spaces, and architectures, function as terministic screens, both explicitly and implicitly articulating and directing particular ways of seeing science that are integral to visitors’ museum experiences and which may impact their perception of science outside of the museum context.

Significantly, the ways of seeing science are not just epistemic—inculcating readers in the processes and phenomena of natural philosophy—they also encourage affective attitudes and orientations with the material observed and with science itself.
Kenneth Burke called the process of formulating these associated attitudes and orientations identification. In his discussion of terministic screens, Burke explains: “Within that [disciplinary] field there can be different screens, each with its ways of directing the attention and shaping the range of observations implicit in the given terminology. All terminologies must implicitly embody choices between the principle of continuity and the principle of discontinuity” (1344). Therefore the terms and symbols used to convey information align the viewer or reader with the phenomena (the principle of continuity), or fail to do (the principle of discontinuity). The museum visitor either accepts an account presented in an exhibit and associates it with their existing ideas, beliefs and conceptions about science and scientific content, or they do not. According to Burke, this work of alignment constitutes identification or becoming “substantially one” with the subject in question. In this way, “ways of seeing” science not only direct visitors to view the world and scientific phenomena and processes in specific ways, they also invite particular attitudes towards, beliefs about, and associations with them. My research examines not only the ways that multimodal exhibits, built spaces, and architectures function as terministic screens, it also investigates the ways that these features combine with the museum context—both internal and external—to shape the expectations and identifications with science that visitors bring to and take with them after the museum experience.

Visitors may carry with them identifications with science as projecting humans on a trajectory of progress, of learning science as a morally uplifting endeavor, or of a sort of secular aesthetic “worship” of the natural world. They may have gained these
identifications either through previous experiences with science exhibits, wider consumption of scientific texts or accommodations, or even simply through their immersion in the wider culture. These identifications then interact with the terministic screens—ways of seeing science—constructed by the centers’ exhibitions and installation, presenting visitors with new (or reinforcing existing) ideas, values, or beliefs which they may take up or reject. The association of science-learning with moral uplift with an aura of semi-religious awe is certainly echoed in the language used to describe the development of science centers like COSI in the 1960s. The physical presence of these buildings echoes the church-like awe associated with understanding “natural laws,” and the message of technological progress and teleology is everywhere celebrated in centers that point to past and current achievements—from celebration of the steam engine to the achievements of life-saving and -improving medical technologies.

Historically, science museums have accumulated these ideologies and orientations towards science. However science center educators, designers, and curators may attempt to shrug off or complicate these assumptions and identifications, they are still there, either carried by the visitors themselves into the museum experience or embedded in the rhetorical traditions of the exhibit. In this project, I explicate the complex relationship between visitors’ social milieus and existing expectations about science and the available identifications with science and progress made through the terministic screens of centers’ multimodal exhibits, built spaces, and architectures. By investigating this relationship, I complicate our understanding of multimodality and scientific accommodation, as well as the relationship between science centers’ terministic screens, and the ways that museums’
physical and historical contexts affect visitors’ identifications during the museum experiences.

As a child approaching a science center with my family, I carried with me my father’s reverence for nature and science, my family’s blue-collar beliefs in hard work and the benefits for society that science and technology reaped. Playing with bubble wands to learn about surface tension, I may not have been able to articulate these ideas, but they were reinforced by my parents’ presence with me in those museums. The exhibits reinforced these beliefs and ideas and directed my attention to displays that shaped my own fascination with the biological sciences, the environment, and the natural world, a fascination that remained undergirded by those cultural and familial values. These experiences shaped my sense of science as a process of discovery that cataloged the certainties of the natural world, a sense that was not shaken until the early years of my graduate education when I was exposed to new theories of epistemology. The identifications with and ways of seeing science that are reinforced in museums, particularly museums of science, are far-reaching and strong.

Science centers have yet to be explored by rhetorical studies of science; but, more importantly, the complexity of their multimodal exhibits, the relationship between those exhibits and their immediate temporal contexts—the built spaces and the needs of the surrounding community—as well as their participation in a rhetorical tradition of displaying science in museum contexts, each influences how science is articulated in wider culture today. This study begins to explore those layered relationships, and
concludes by sketching out a framework of artifacts and topics for future rhetorical investigations of science centers to explore.
The museum visit is a rite of passage for many school-age children in the United States, and has been for at least a generation. We may take for granted the dramatic appeal of a display of dinosaur bones, or the electro-static generator’s hair-raising effects. But how do we make sense of the dinosaur bones as evidence of a species that evolved and lived with other species of dinosaurs eons before humans stepped onto the scene? How do we reconcile the fear that the electro-static generator might shock us (if we were to remove our hands) with what it tells us about the movement of electric current? Does the proximity of the dinosaur to another imply a temporal relationship—that they both lived during the Jurassic? Or does it rather suggest they have the same habits of living—both predaceous, consuming other dinosaurs?
That we can probably answer these questions suggests that we have, at the least, an implicit awareness of conventions guiding our looking and our sense-making when we visit museums. The visual culture in which a viewer is immersed shapes both what she sees and how she sees when she looks at a scientific exhibit. Steven T. Asma calls attention to how such culturally-inflected looking functions both in time and across time: “A bird’s wing in a curiosity cabinet…signifies something quite different from what the same wing signifies in a homology exhibit” (Asma xiii). His example highlights two separate contexts—a curiosity cabinet, and a natural history exhibit on homology—occurring in two separate time periods. In a sixteenth century aristocrat’s curiosity cabinet, the cabinet itself frames the bird’s wing as one of many objects which may be understood in a variety of ways: as a beautiful, decorative object; a rare symbol of aristocratic power; or perhaps as a token of life’s ephemeral nature. Conversely, the wing might evoke all these meanings simultaneously.

This variety of conventions for understanding the bird wing was circulating in Europe’s wider visual culture during the eighteenth century. But for natural philosophers working at this time, such conventions for understanding natural objects like the bird wing, privileging beauty or sacredness, were being subsumed by others. The conventions that emerged were a product of a nascent visual culture of science: its disciplinary schemas privileged conventions of seeing a bird’s wing as a piece in a taxonomic puzzle. Its value became determined by what its appearance told philosophers about its structural function or avian evolution or its function as a type in a class of similar objects. The wing’s other potential meanings—aesthetic or religious—still circulate as responses in
wider visual culture. Despite this circulation and its influence on eighteenth century scientists, this example demonstrates how the epistemological value of aesthetic and religious responses began to diminish in these contexts of scientific display.

These changes in valued responses to the display of scientific objects are connected to changes in what counts as knowledge, as well as changes in the visual culture. Cara Finnegan defines visual culture as “an amalgam of our collective ‘ways of seeing,’ a set of ‘cultural conventions of vision’…” (135). Visual culture influences both the conventions for selecting and arranging objects as well as the conventions for responding to their display. Finnegan’s emphasis on an “amalgam” or “set” of perspectives in a given visual culture suggests there is a multiplicity of responses available in any act of interpretation, a set of conventionalized responses structured and constrained by a culture’s ways of knowing. David Birdsell and Leo Groarke contend that these “conventions of vision” include “what it means to see, or represent seeing, as well as changes in the meaning of visual vocabulary” (7). Birdsell and Groarke’s definition extends our understanding of visual culture to contain prescriptions or conventions guiding what “seeing” or “interpreting” an object means. To return to the example of the bird’s wing: “seeing” the wing in the context of the cabinet of curiosity was guided by different conventions for interpretation than the wing in an eighteenth-century homology display. The viewer of the curiosity cabinet engages in a different activity than the viewer of the homology exhibit, with different purposes and expected outcomes. Further, Groarke and Birdsell’s definition provides us with a structure for reading objects in a display as “words” arranged into “statements” understood by those who are fluent in the
visual vocabulary; accordingly, these statements may be composed and received
differently depending on the historical and social context framing the exhibit designer
and the exhibit consumer. To return to the first example: by the eighteenth century the
scientific revolution had expanded the visual vocabulary to incorporate more “words”
and a new syntax—to use a spatial analogy—for interpreting a bird’s wing.

These definitions of visual culture and conventions of vision help us understand
how exhibit displays may be understood as “compositions” comprised of artifact “words”
and “sentences.” These compositions are understood by individual viewers whose
looking is always structured by what Kenneth Burke has termed the “scene,” or the
location in which the rhetorical situation of looking takes place: both the immediate
context in which the display is installed, such as the interior space of a science museum,
as well as the more diffusely understood meaning of “scene” comprising the visual and
intellectual culture which frame museum practices. Eilean Hooper-Greenhill asks us to
consider, further, the role of museums, themselves, as *apparatuses* of visual culture, part
of that culture but also a unique material context through which exhibits may be
understood. As social institutions with their own conventionalized practices of showing
artifacts, museums “…act as visual apparatuses which frame those artefacts,” and as a
result, “vision [may be] analysed as a social practice rather than taken as a simple given”
(14). Hooper-Greenhill entreats us to think about how the practice of looking at
exhibits—compositions of artifacts—is shaped by the immediate museum context to
make ideas and concepts visible (and of course, as Burke reminds us of all terministic
screens, such visibility renders simultaneously other concepts invisible). As a “social
practice," looking at objects and arranging objects according to “conventions of vision” is done for the purposes of eliciting responses that are valued in a given moment, whether that response is appreciation, awe, instruction, inference, or inspiration. Science centers themselves, then, act as particular “apparatuses” framing their displays and directing the kinds of statements that curators and designers will make with their exhibit displays; the visual culture and the immediate institutional culture combine to shape how designers choose their content and the interpretive lens through which visitors are guided in how and what to see.

In this chapter, I conduct a critical literature review of the history of scientific displays in museums as they inform our understanding of the social practice of looking and the dominant culture’s ways of knowing. Specifically, I examine the changing cultural terrain of knowledge-making and its accompanying set of valued ways of reasoning or emoting (or both)—shaping the interpretation of these visual statements as well as the conventions of vision the statements themselves embody—for example, whether specimens are intended to be viewed as religious relics, scientific specimens, or objects of wonder. I introduce the term “domains of response” to denote a particular sense-making system in the visual culture of science: emerging from the uses to which scientific displays were put in the immediate context of curiosity cabinets and museums, these sets of conventionalized responses draw on the wider culture’s ways of knowing to make sense of science exhibitions. However, this confluence of museum context and the exhibitions it encloses recurs in descendent instantiations, concretizing this unique rhetorical situation into a tradition that constrains and directs how individuals may
respond to and make sense of objects. Each domain encompasses multiple spheres of response or “conventions of vision” simultaneously; I contend that visual culture does not shed one “convention of vision” for another, but that conventions accumulate and layer in the various contexts surrounding the museum “scene”; they combine to form different ways of viewing objects for different purposes and with differently valued responses. In subsequent chapters, I will demonstrate how layering conventions of vision complicate the rhetorical motivations and messages of agents involved in constructing community science centers and conveying the science in exhibits enclosed in these buildings.

Understanding this specific history of museum science display, its visual culture, and its corresponding conventions of vision, is invaluable for understanding the identifications with science made available in science centers today. Our present visual culture values specific social practices of looking and engaging with science and with the artifacts that index science; significantly, these contemporary conventions of vision are connected to the history of museum display and the domains of response to those displays as they changed over time. The conventions of vision are connected to one another temporally through the objects on display; these objects may even date back to moments when the visual culture privileged different domains of response, and which may affect the ways that objects are selected, arranged, or interpreted today:

…very many of these collections were assembled many years ago; the analysis of what is seen and known today must encompass the dimension of time. Objects in museum collections may embody the ideas and values of past social formations. In analyzing the interpretation of visual culture
during the present day, it will be important to consider how far, and in which dimensions, past interpretations, past understandings, are still being circulated. (Hooper-Greenhill 16)

As part of visual culture, museums are visual apparatuses whose displays are designed according to specific conventions of vision and also continually re-confirm the value of those conventions as they instruct us how to value science, and, perhaps implicitly, even how to do science. Science centers, in particular, tell us how to construe the world, and which ways of construing the world that we should value: those that enjoy cultural cachet by dint of their inclusion in the museum.

By tracing domains of response and their role in the development of privileged conventions of vision over time, I lay the groundwork for understanding the visual language used in structuring (and structured by) conventions of vision in science centers today, as well as the domains of response that inform decisions to build science centers, including how those centers architectures should appear. I argue that contemporary exhibits, reproduce a recurring rhetorical situation inviting the same set (or, rather, a descendent set) of domains of response—the same ways of knowing—that structured display consumption and composition in museums during the 19th century. Steve Conn has described the logic undergirding those exhibitions as an “object-based epistemology” or “naked eye science,” which may be correlated with what Michael A. Cavanaugh has deemed a “folk epistemology of common sense empiricism.” Taken together, these ways of knowing privilege the physical object as the source of knowledge—as both evidence and product of scientific and technological phenomena—and encourage a conception of
the scientific process as a simple one conducted through a combination of commonsense reasoning and induction.

The relationship between the history of display and the present domains of response that have, as a result, become available for visitors in science centers has a particularly complicated effect on these institutions’ missions: science centers aim to generate excitement about science, inspire children to pursue STEM careers, offer aesthetic, social experiences of science phenomena, and communicate basic scientific concepts with clarity. Yet, by reproducing historic techniques of display that embed implicit (and, now, outdated) theories of scientific inquiry, they may also reproduce the convention of vision that positioned scientific knowledge as certain and stable. In the chapters that follow, I explore the layering of domains of response engaged and deployed by different agents, at different scales of the science center “scene”; in doing so, I begin to demonstrate how these domains of visual culture simultaneously accrete and project epideictic inflections and meanings onto the subject of science, which is, by nature, a forensic genre.

**Visual Language in Visual Culture**

This present system of making meaning through display—of arranging these museum objects and features into intelligible narratives and ideas about science—has a history and has changed and developed over time. The early modern era in Europe is an important starting point because the roots of modern scientific display used in American science and technology centers reach back to this period, just prior to the western scientific revolution. For the purposes of this project, I paint this history with broad
strokes, dividing the time between 1550 and the present into four broad periods: 1550-1650; 1650-1750; 1750-1850; and 1850 to the present. Table 1 depicts each time period with its accompanying dominant domain of response, and it indicates the relationship between displayed objects, the responses valued by the surrounding visual culture, and religion’s influence on shaping visual and scientific conceptions of the natural world; much effort has been made in this history to align scientific theories of the world with biblical interpretation. Understanding the relationship between domains of response, visual culture, and museum display helps us to understand how science and technology centers and other scientific institutions have acquired, maintained, and reproduce their authoritative ethos, as well as how natural knowledge came to be seen as sacred, an aura it retains in scientific and religious institutions alike, even to the present day.

In reviewing this history as one of dominance and displacement, it is important to note that no domain of response is ever fully eclipsed by a new one. Potential identifications with visual statements and displays accumulate, overlap, and change over time. Exhibits, and the conventions guiding their interpretation change as users adapt them for emerging knowledge-making purposes, “reflecting different values, conditions of production, and habits of interpretation” (Groarke and Birdsell 7). Although they represent scientific knowledge, science museum displays experience the same adaptations and transformation as other “dialects” of visual language. The ways that scientific displays change over time are in part due to the ways that the ways that these particular “statements” made in the visual vocabulary are valued.
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<td><strong>Visual Culture’s Valued Domains of Response to Science Display</strong></td>
<td>Symbolic and Hermeneutic gives way to Wonder</td>
<td>Classification and Description</td>
<td>Causal Analysis</td>
<td>Experimentalism</td>
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<td><strong>Conventions of Vision in Visual Culture</strong></td>
<td>Objects are symbolic, unique; possessing a collection analogous to possessing the world in microcosm; response to unique objects as wonderful/awesome; bible and other authoritative texts direct how natural objects are understood</td>
<td>Objects to be observed and described in as much detail as possible; emphasis on understanding what is “essential” about a specimen; seeking natural laws of nature that are like natural laws of physics; focus on differences/identities between species</td>
<td>In natural history ‘Naked Eye’ science has cultural cachet; observing objects and comparing them helps understand how they came about; function and structure of natural objects to be understood through comparative analysis; science as agent of ‘progress’ emerges</td>
<td>Observation, analysis and manipulation of objects allows us to synthesize new objects and theories about the natural world</td>
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Table 1: Visual Culture and Domains of Response to Displays of Scientific Objects
### Relations between Visual Culture, God, and Cosmology

| | Objects symbolize God’s abundance and diversity; possession of collections; God’s/religion’s authority is ultimate way of knowing; understanding natural world bends to this authority | Providential philosophy says that natural laws placed by God in natural phenomena for humans to discover and to benefit from; search for natural laws that guide natural categories arises. | Evolutionary theories seem to align with God’s ‘design’ of natural phenomena; display takes on moral aura as belief increases that all knowledge can be arrived at with certainty and displayed with objects | Divine entity as causal agent for drops out of dominant scientific explanations of phenomena |

Table 1: Continued
Possessing the World, 1550-1650: Cabinets of Curiosity, Hermeneutics, and Wonder

In their mission statements, science centers often connect their educational goals with ones that are aesthetically- or affectively-inflected. For example, COSI provides visitors with “an exciting and informative atmosphere,” and hopes to “motivate a desire toward better understanding,” (“Our Mission,” COSI); the Carnegie Science Center “delights, educates, and inspires through interactive experiences in science and technology.” (“Mission,” Carnegie Science Center); and the Cincinnati Museum Center “inspires people…to learn more about world through science; regional history; and educational, engaging and meaningful experiences.” (“About,” Cincinnati Museum Center). All the institutions in this study cite such affective responses as a key element in their institutional missions. In 1969, Robert Oppenheimer, founder of the Exploratorium, one of the first science centers in the U.S., cited appreciation of the aesthetic beauty of “pure” science as being one of the primary aims of his center (Oppenheimer, “The Aesthetic”). Although contemporary science centers invoke these affective responses through uniquely 20th century modes of communication, a visual culture valuing awe, wonder, and delight in response to displays of objects dates back to the early modern period in Europe. Most museum histories point to the curiosity cabinets of the sixteenth century as the most recognizable predecessor of the contemporary museum. These collections, accumulated by aristocrats, were enclosed either in small rooms or wardrobes (hence the term ‘curiosity cabinets’), and consisted of objects secured from explorers of the “New World.” Examining this history reveals the roots of the contemporary motivation, in science centers, to invoke affective responses to scientific concepts and
phenomena and demonstrates how visual culture attached an affective response to the
unique aesthetic of the curiosity cabinet collection.

Prior to the European “discovery” and exploration of the New World, objects in
the natural world were primarily understood through the conventions prescribed by
hermeneutic texts. Books like the bible, bestiaries, and classical philosophical texts—
particularly Aristotle—were used to explain phenomena and read symbolic and mystical
meaning in plants and animals. David Freedberg argues that this way of knowing
involved warrants for knowledge based on relationships of “similitude” or “resemblance”
that were often supported by detailed drawings of collected specimens. This hermeneutic
framework supported reading the meaning or categorization of a plant or animal based on
its surface appearance—for example, if a root was covered with hairs, consuming it, or
perhaps rubbing it on the scalp, was thought to induce the growth of hair on the head.
Similarly, biblical interpretation and Aristotle’s treatise on natural categories were used
to explain natural phenomena.

During this time, books became cheaper to print, and more widely available,
resulting in an increase in the circulation of natural objects’ visual representation.
Stephen Greenblatt asserts that the early impulse to collect rare and beautiful natural
objects was paired with the desire to convey in vivid detail what one had collected in
written reports to others, as “textual records of wonders” (50-51). By circulating books,
individuals could make mobile the contents of curiosity cabinets, suddenly making
knowledge accessible to people unable to visit collections in person. According to Asma,
this circulation of objects in texts, facilitated by innovation in print and etching

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technology, also helped make strides in the “descriptive sciences” by standardizing descriptions of specimens and providing images of them for scholars abroad (95). But these texts also placed a limit on expansion of these fields, since misleading and erroneous representations were equally available. As written texts circulated new descriptions of objects, they were also increasingly used to understand natural objects.

This hermeneutic domain for understanding objects—according to the interpretive power of authoritative texts—was stretched to its limit by the introduction of natural and cultural objects, undocumented in any existing European texts, which explorers brought back from their travels to the new world. John V. Pickstone argues that the experience of curiosity and wonder elicited from viewing the cabinets of curiosity marked a bridge between the hermeneutic domain of response and the modern scientific view that was born during the 17th century. The “marvelous amount of stuff” from the New World and Asia could not be explained with the existing authoritative texts, a problem that led to questions about these books’ adequacy for understanding existence. Further, Pickstone argues that “natural objects” were actually created as a result of the onslaught of New World objects, since the existing paradigm for understanding the natural world could not adequately explain these phenomena. Since a previously “undiscovered” animal, such as a tapir or an iguana, had no textually determined symbolic meaning, the category of the “natural” was coined to describe it and many other similar specimens (60-62).

According to Oliver Impey and Arthur MacGregor, the Renaissance was characterized by a renewed interest in classical literature and exploration of the globe, two cultural movements which undergirded the development of the first cabinets of
curiosity or ‘wunderkammer’ (2). Classical literature invigorated a fascination with the peoples of ancient Greece and Rome. Highly valued paraphernalia from those cultures included coins, inscriptions, utensils, and other products of antiquity. Simultaneously, explorations from the New World, the Middle East and South and East Asia brought back with them all manner of natural and cultural objects. New specimens of fantastic animals, beautiful stones and shells, along with the cultural artifacts of the new people (and the people themselves) were accumulated and transported back to Europe for inclusion in these cabinets of curiosity (Impey and MacGregor 2).

Rather than the orderly displays of items behind glass that we associate with today’s natural history museums, these ‘wunderkammer’ were chaotic assemblages of objects with no common categorical relationship or arrangement (Figure 1). They ranged from what we would today associate with the natural historical—feathers, skeletons of tiny mammals, fossils and interesting rocks—to the anthropological—weapons, clothing, utensils, talismans—to the grotesque—women with horns growing out of their skulls, two-headed calves, and even preserved organs arranged into moralistic tableaux (Figure 2).

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4 Famous Dutch anatomist, Frederich Ruysch, described his preparation in this way: “Leg of a child, of a natural colour, under its feet is found a piece of the skullcap deformed by caries of a whore of great renown, her name is Anna van Hoorn, once known to all who loved whoredom, some of them still alive, as I was told. Why part of the skull were placed under the feet, one can easily guess, while this prostitute would not have this elend ailment, had not she practised her hateful trade: in such water one catches such fishes; this is all kept in clear liquor. I also kept the bones of one of her feet, it floats on water like a feather.”
Figure 1: Curiosity Cabinet of "Ole Worm," circa 1588

Figure 2: "Foot of a Child Treading on parts of a Skull" photo courtesy Library of the University of Amsterdam
The cabinets of curiosity of the early Renaissance era mark the transition period between the hermeneutic domain—where responses to natural phenomena were guided by religious or mystic interpretations and texts—and the nascent scientific worldview that scholars began to adopt after the scientific revolution of the 17th century. During this period, the types of objects collected and displayed changed, as did the logics for arranging and understanding them.

Interest and availability dictated the selection of objects for these collections, but the most comprehensive ones were displayed to inspire wonder in their audiences—wonder at both the aristocratic owner’s ability to acquire such objects, as well as at the marvelous diversity of God’s creation. Stephen Greenblatt describes the complexity of this “cult of wonder”: “The wonder derived not only from what could be seen but from the sense that the shelves and cases were filled with unseen wonders, all the prestigious property of the collector” (50). According to Greenblatt’s interpretation, the objects of wonder elicited this response for two distinct reasons: they represented a microcosm of God’s creation—its beauty and diversity—and they showcased the collector’s ability to possess that creation in microcosm.

Today in science centers and museums we can see both the principle of wonder and its attachment to collections of “science stuff” in operation today. Natural history museums seem to instill a sense of wonder analogous to the viewing of natural “oddities” that 16th century aristocrats enjoyed: “…no matter how ‘scientific’ the exhibits, most visitors will latch on to oddities and remember the museum for the great spindly spider crab that sat in a box at the top of the stairs.” (Pickstone 61). Science centers do not tend
to display the natural history “curiosities” that can be enjoyed in this ways, but they do make available other displays that elicit similar affective response, both visual features—for example, the “heat sensing” camera that reflects the visitor’s figure in swimming pools of rainbow colors—and engaging physical experiences—such as the electrostatic generator that makes your hair stand on end even as it threatens a jolting electric shock.

Additionally, science centers tend to have areas where visitors may view expansive “vistas” of people and exhibits, and the more closely packed together in space, the more appealing these vistas tend to be (Vice President of Experience, COSI). Part of why these vistas are compelling, I would suggest, is the lingering aesthetic appeal that harkens back to this era in science display’s history: the sense that the science center’s exhibits contain a vast array of “stuff” promising insight into the nature of the natural world. Additionally, museum professionals tend to see the elicitation of wonder that arises from these kinds of vistas, or direct engagement with the exhibits themselves, as being an agent of inspiration that motivates or leads to intellectual or educational pursuits or insights.

This association between affective response and its power to scaffold or direct intellectual knowledge construction has also been traced back to the development of the nascent scientific domain that replaced the hermeneutic as the dominant aspect of scientific visual culture during the period between 1500 and 1750. Philip Fisher suggests that curiosity was a vital aspect of Descartes’ ideas about inductive reasoning, and that its served as a vehicle for noticing novel phenomena that could then be integrated into existing explanations and ideas:
For Descartes, the pleasure and interest that we take in the rare and unusual is part of a purely intellectual curiosity that seeks to make sense of whatever is new within experience by means of understanding. Wonder, curiosity, and successful explanation notice the world and then renormalize that world, by fitting the exceptional back into the fabric of the ordinary. (Fisher 48)

Descartes’ sense that curiosity was a *vehicle* to be used in service of systematic, inductive understanding helps us understand how visual culture shifted to accommodate changing ways of valuing the same objects. Once collections were appreciated for their novelty, they could begin to be organized by logics that might help explain them as part of everyday phenomena. Collecting oddities for the sake of wonder soon gave way to the encyclopedic description and cataloging of those oddities to create taxonomies and systems to “fit the exceptional back into that fabric” of the everyday.

Throughout the 16th century the hermeneutic domain and the nascent scientific domain jockeyed for dominance in visual culture. Conventions of viewing natural objects as imbued with meaning gleaned from religious texts, as objects of aesthetic wonder, symbolizing wealth or divinity, as well the nascent scientific perspective grew and circulated together in time. But the domain characterized by careful observation and systematic inference began a steady climb beginning with the 1624 publication of *The New Atlantis* by Francis Bacon. This publication inspired the beginnings of an empiricist intellectual framework, the modern scientific revolution, inspiring the establishment of the widely influential Royal Society of England, and ushering in a new way of
conceptualizing collections. Significantly, Bacon’s argument for inductive reasoning included rationale against the explanatory power of the response of wonder encompassed by the hermeneutic domain. Stephen Bann explains:

For the scientific temper of a scholar like Bacon…the habit of ‘curiosity’ was offensive because it attached itself almost obsessively to the individual object, rather than using classes of objects to arrive at general conclusions which would have the force of law. Curiosity in sum was inimical to inductive reasoning. (24)

Bacon’s complaint—the obsession with individual objects rather than classes or taxonomies of objects—can be viewed as the pivot on which the visual culture as it related to collecting and display began to shift. Although the hermeneutic domain directing divine or mystical understanding of natural objects continued to circulate, the period between 1650 and 1750 was largely characterized by increased emphasis on descriptive and empirical observation of natural objects in collections. Significantly, this was the era in which taxonomies and classification systems emerged that were based on specimens’ “essential” empirical traits, rather than their relationship to classical texts; collections of objects and their proximity to one another became valued for their ability to help the new natural philosophers infer categories and families of relationships in ways that scaffold the analytical paradigm which rose during the period between 1750 and 1850.
John Falk and Lynn Dierking’s description of the museums as a “device” that can be used to “convey concrete facts of reality…real things from the real world” suggests the perception, among museum professionals, that science museums and centers “contain” the world, whether that means they contain a representative collection of its most important natural specimens, or they represent the abstract principles of science that explain and drive its workings. Some exhibits, particularly in art museums, call attention to the necessarily fragmented or partial nature of an exhibition of “French Impressionism” or “Bivalve Evolution.” However, the science center, with its vistas of “science stuff”—packed together in space—strengthens the impression that these places contain all the “stuff of science” or at least, like a true encyclopedia, all the “science stuff” American culture deems worthy of definition and description. This domain of response to visual displays—of seeing them as collections or representations of the “whole of the world” or the “whole of science”5—has its roots, I contend, in the emerging visual culture surrounding natural history displays in the scientific revolution.

5 It’s not necessarily important to ask whether visitors actually believe that science centers and science museums contain representative specimens of all of nature, or explanations for all of science; as I will discuss in chapter 3, the affective orientation towards science in response to its potential ability to do this encyclopedic cataloging is what is so compelling in these spaces, and, I would suggest, what connects the contemporary science center so closely to this 17th century domain of response.
In 1666, the recently established Royal Society published in their October edition of *Philosophical Transactions*, a call for aristocrats to donate the contents of their privately owned cabinets so that the Society could create a museum for study:

The idea here…was that aesthetically pleasing objects of the separate curiosity cabinets could reveal deep truths about causes once they were brought together and studied...Understanding causes, the logic went, leads to greater manipulation of nature, and in this manipulation lies the secret of humanity’s progress. The curiosity cabinets were being consumed and transformed by the scientific revolution. The act of hoarding things and displaying them in groups was changing its function. (Asma 72-73)

Paradigms for understanding the natural world through display were in flux during the period from 1650-1750. At the same time that aristocrats continued to enthrall their guests with their wonderful and spectacular catalogs of God’s creations, the western scientific revolution was underway. Enlightenment philosophy raised skepticism about the role of emotions in drawing empirical insights about phenomena; rather than reading objects’ symbolic meaning or reveling in aesthetic response, natural philosophers began to understand objects through a new set of conventions. Collections of objects were viewed as both natural and mechanical, as capable of being categorized according to essential traits, and as understandable through inductive reasoning scaffolded by systematic observation and description. Description and encyclopedic cataloging of natural objects for the purposes of classification emerged to scaffold the framework through which objects’ essential mechanical and natural traits could be discovered.
Scientists arranged displays to study specimens’ unique traits and to compare them one to another. Observing species side by side allowed natural historians to divide them into categories for the purpose of understanding God’s divine design.

Although authoritative texts were still used to understand natural objects, the domain of response valuing empirical and encyclopedic description that advanced during the period between 1650 and 1750 sought to understand natural objects by their observable traits. Freedburg suggests this era was characterized by a transition away from observing specimens according the hermeneutic principles of “similitude” and “resemblance” toward the descriptive and taxonomic principles of “difference” and individual “identity.” Careful observation, comparison, and description allowed natural philosophers to organize specimens in collections into categories determined by their “essential” qualities, though which traits were “essential” was a matter of rigorous debate. This transition to using surface appearances and identities of natural objects to infer their essential defining traits aligned with the empirical and descriptive impulse of natural historians adhering to Francis Bacon’s dictate in The New Atlantis.

In Bacon’s seminal treatise, largely considered to be the engine of the scientific revolution, he urged natural philosophers to use inductive, rather than deductive reasoning, in their study of the natural world. While using the theories of authoritative texts to guide observation and explain phenomena had been adequate in the past, Bacon argued that for new knowledge to be produced, practitioners of the new science would have to change their epistemological foundations. Rather than using existing theories and explanations, such as Aristotle’s categories, to explain natural objects, Bacon argued that
philosophers must conduct careful observations, record them with rich description, and compare those observations to formulate new theories explaining phenomena.

Significantly for understanding the role of collections in the scientific revolution, Bacon also described the object of this new lens of systematic study. In *The New Atlantis* he advised natural philosophers to assemble

> a goodly, huge cabinet, wherein whatsoever the hand of man by exquisite art or engine has made rare in stuff, form or motion; whatsoever singularity, chance and the shuffle of things hath produced; whatsoever Nature has wrought in things that want life and may be kept... (qtd. in Weschler 76)

In order to practice inductive reasoning and formulate new theories about phenomena, natural philosophers needed a collection of objects to observe, describe, catalog, and compare. *The New Atlantis* inspired formation of the Royal Society, one of the most significant and powerful scientific societies in Europe, which quickly established its own museum of natural objects to catalog and compare.

But natural philosophers, guided by Bacon’s prescriptions for inductive observation, were also influenced by the theories of philosophers attending to other nascent scientific disciplines, none of which were clearly defined and delineated as they are today. Importantly, during this same period Isaac Newton developed his theories describing the natural laws of motion. Published in 1687 in *Philosophiae Naturalis Principia Mathematica*, his theories of motion were undergirded by mechanical
philosophy and providential philosophy. Combined, these theories explained the natural world as the product of an anthropomorphized creator, a divine “watchmaker.” Providential philosophy suggested that this God had put in place laws governing natural phenomena; mankind could then discover, harness, and manipulate these laws to advance human progress. God’s “natural order,” Larry Stewart suggests, would be revealed, through systematic observation and experimentation, for human benefit (59). Newton’s theories seemed to confirm a God-engineered universe and spurred natural historians to seek out similar laws explaining natural history phenomena. Stewart argues that this marriage of providential and mechanical philosophy was also the logic that undergirded the use of technologies to advance economic development and progress in the United Kingdom during the eighteenth century, harnessing the conception of capitalist development to both “benefits for humankind” and to God’s “divine plan” for creation. We may trace to this time period the emergence of associating developments in science and technology with economic and social benefits to society.

The project of collecting objects and understanding their taxonomic relationship to one another suddenly gained urgency as scientists worked to infer a creator’s underlying logic for creating and categorizing natural kinds. According to Asma, mechanical philosophy was a key intellectual scaffold for this type of classification, since

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6 Mechanical philosophy was a vital lens for scientists’ understanding of the natural world in the seventeenth century; the theory held that organisms were composed of individual parts that functioned together as a whole according to physical laws of motion. According to David Schindler, after Descartes, philosophers subscribing to mechanistic philosophy saw nature as “…now absorbed into matter in this way, is whole (in any of its instances) only in the sense of being a collection which is exactly the sum of externally interactive parts” (Schindler “Introduction: The Problem”).

7 These identifications with science and technology persist today and still undergird rationales for building science and technology centers, as I will explore in the following chapters.
it suggested that living organisms were like machines, composed of parts in physical motion that could be understood in terms of their individual functions. Those parts and their functions were the “essential traits” that determined their membership in one category or another. Scientists believed that God designed each of these parts to create organisms perfectly designed for their environment and mode of living. Correctly classifying species into categories according to their functional parts then meant taking on a “god’s eye view” of nature, deducing characters that were divinely designed by the watchmaker and that separated species according to their “essential” traits.

Published in 1735, Carl Linnaeus’s *Systema Naturae* popularized the system of binomial nomenclature, and helped to standardize a system of classification for plants and animals; using reproductive organs as a defining trait to separate species into the taxonomic categories of variety, species, genus, order, and class, Linnaeus’s system was not the first attempt to develop a scientific system to classify nature, but it succeeded because of its brevity, clarity, and ease of use (Asma 115). Embracing this straightforward system of nomenclature that shrugged off anxieties about God’s “logic” for differentiating between species, Linnaeus’ followers eagerly set about describing and encyclopedically documenting natural specimens in their collections.

But the rise of microscopy ended the search for these “essential” traits, since this technology revealed that it was not essence that differentiated species but different arrangements of “particles”: “…everything from apples and oranges to chimps and humans no longer appeared to be homogenous material stuff differentiated only by immaterial forms…matter counted in a way it had not before” (Asma 108). While this
discovery displaced the goal of inferring God’s logic for structuring organisms, it led to the development of questions about what natural causes or forces might have led organisms’ structures to appear as they did, ultimately paving the way for the most seismic shift in the paradigm of natural history: Darwin’s theory of natural selection and its subsequent dissolution of the marriage between scientific and religious ways of understanding natural phenomena.

Describing and sorting collections of objects into categories based on their “essential traits” is the foundation of biological taxonomy; natural history museums today still organize their displays by taxonomy, grouping mammals, fishes, birds, reptiles, and other organisms by species, genus, and family relationships. Animals belonging to the same class are displayed side by side, suggesting both natural diversity as well as an encyclopedic knowledge of the organisms in taxonomic categories. Victor Danilov differentiates science and technology centers from natural history museums because of their emphasis on “contemporary rather than historic” themes and their “reliance on participatory exhibit techniques rather than objects of intrinsic value” (viii). Yet as a museum genre, science centers are indebted to natural history museums, and part of their authoritative ethos is derived through their association with other museum genres. Science centers present scientific principles as having universal applicability, explaining all things, if not representing them all; in doing so, they also value in their immediate contexts, the domain of response that frames science as both encyclopedic—able to catalog and describe all natural phenomena—as well as analytical/causal: able to explain all phenomena.

“During the last part of the nineteenth century an approach to the style of museum displays evolved which was based on how objects might be known and used in the production of knowledge. Objects were seen as sources of knowledge, as part of the real world that had fixed and finite meanings that could be both discovered, once and for all, and then taught through being put on show.” (Hooper-Greenhill 5)

“The modernist museum depicts ‘reality’ and shows ‘the way things are’ in an apparently neutral way...the texts next to the objects signal how the object should be viewed. Relationships between people, nations, and ideas are produced through the objects selected, the way they are displayed and the relationships between them. Hierarchies of value are constructed, inclusions and exclusions made, the self and the other separated...The modernist museum does this with things, which are understood as fragments of reality itself.” (Hooper-Greenhill 17-18)

Although displays in natural history museums still privilege an encyclopedic description and arrangement of their specimens into taxonomic groups, the biological scientists employed by natural history museums to study specimen collections—rather than curate museum exhibits—still research their taxonomic relationships. Specifically, they seek to understand the relationships among species that have come into being through pressures of natural selection, mutation, migration, and genetic drift: the mechanisms by which evolution has shaped organisms’ anatomies for functions appropriate to their habits of living. This form of research is based on inferential analysis, since, by its nature, evolution (for the most part) cannot be observed in real-time. Between the mid-eighteenth century and the mid-nineteenth century, the display of specimens in science collections was used more and more to make causal, analytical inferences that moved from describing the anatomical traits that defined a species type, towards explaining how and why organisms came to have those traits. An epistemological
shift that valued displays for their power to support analytical and causal explanations for observed phenomena—both in the laboratory and in nature—took place during this era.

The project of describing and arranging objects into taxonomies that proliferated in the period between 1650 and 1750 quickly exhausted the reach of 18th century science; scientists were no longer satisfied with description and began seeking underlying causes for the structures that they observed in their collected specimens (Asma 126). Displays of dissected animals in the museums of collectors, such as John Hunter, who prepared over 13,000 specimens over the course of his career in the late 18th century, were used not for eliciting wonder or cataloging descriptions of parts, but for conducting visual analysis and comparison to infer causal relationships (Figure 3).

“Hunter represents the flip side of the early Enlightenment’s hostility toward the senses. The rationalist distrust of experience was counterbalanced in the last half of the eighteenth century by a strong empiricism…Hunter wanted visually arresting images not for their own sake, but because they would give way under methodical study to the principles that underpinned all anatomical and physical phenomena” (emphases added, Asma 59).

The analytical paradigm Hunter drew from also allowed for an emotional response to displays of specimens, an engrossment that facilitated analytical observation and theorizing about the relationship of structure to the functioning of organisms’ physical traits. Hunter’s museum was arranged and displayed according to the principle of natural history to which he subscribed; displays were meant to show metaphorically the
theoretical causal relationships being sussed out with the transition from descriptive natural history to causal, evolutionary based ideas of natural history. Hunter’s practice demonstrates, too, the accumulation and layering of responses to scientific displays over time. While the “visually arresting images” were not appreciated primarily for this effect, the response was seen as a vehicle towards more analytical inference: the wonder of looking sparked inferential musings about carefully documented and described phenomena. Each of the dominant domains of response served an underlying purpose in Hunter’s project.

Figure 3: Left and Right are the "Electric Organs" from Torpedo Marmorata Specimens; Center shows a Specimen Dissected to Display the Electric Organs in situ © Hunterian Museum at the Royal College of Surgeons
The example of Hunter’s displays and his belief that careful observation would “give way” to the principles “underpinning all natural and physical phenomena” also gestures towards the “techniques of the self” that were emerging at this time and which dictated what individual practices constituted legitimate scientific inquiry. Lorraine Daston and Peter Galison characterize the traits of the scientific practitioner in this emerging analytical domain as one whose powers of observation could sift through details and infer plausible explanations to account for existing phenomena:

“Only neophytes and incompetents allowed themselves to be overwhelmed by the variety and detail of natural phenomena. To register experience indiscriminately was to be at best confused and at worst indoctrinated. The true savant was a “genius of observation” whose directed and critical exercise of attention could extract truth-to-nature from numerous impressions as the smelter extracts pure metal from ore.

(203)

Scientific practice at this time, then, involved the individual scientist’s practice of accumulating systematic, detailed observations of arrangements of specimens in order to infer relationships and postulate causal explanations for how their forms and structures came into being. I argue that this “technique of the self,” to use Daston and Galison’s terminology, by which careful, embodied engagement with visual displays gives way to intellectual insight or knowledge, becomes vital to the project of interactive science center and its methods of display. I take up this subject in more depth in chapter four of this project, but this conception of individual scientific practice is central to
understanding the implicit messages about scientific practice that are valorized in the science center’s epideictic atmosphere.

The period between 1750 and 1850 marks the time when the domain of response privileging comparative analysis and observation in natural history began in earnest, although of course the other domains were still operational, and often useful. John V. Pickstone defines the analytical domain of making meaning in this way: “…analysis seeks order by dissection….analysis comes into play when objects can be viewed as compounds of ‘elements’, or when processes can be viewed as the ‘flow’ of an ‘element’ through a system” (11). Mechanical philosophy had allowed for natural historians to view organisms to be seen as the sum of their functional parts; now provenance of those parts—the why and how these traits separated organisms into species—became the driving question of natural history. Jean-Baptiste Lamarck’s “transformist” theory was the first to provide a comprehensive answer to that question, and it played a major role in how the display and analysis of natural history exhibits were conceived and understood in the 19th century.

Lamarck’s theory of evolution was considered comprehensive in that it explained how traits of organisms came to be and suggested a mechanism for their transmission to offspring: over time living creatures evolved into higher orders, trending towards greater complexity; changes acquired by individuals during the course of their lives could be transmitted to offspring. His ideas about biological evolution were informed by the
philosophy of the Great Chain of Being, which envisioned species in the natural world as each representing a ‘link’ in a series of descending order: from God and the angels, to humans, animals, and plants. Lamarck’s theory took the concept of a sequential relationship between adjacent species and overlaid on it a new relationship to time, which was informed by emerging geological theories that projected the age of the earth as being much greater than previously believed. Each “link” in the chain resembled its immediate neighbors, but also departed from them in meaningful ways. Lamarck’s theory suggested that it was organisms’ physical changes over that deep time, rather than divine intervention, that resulted in different species. It was assumed that complexity increased as one ascended up the chain, but the nature of the driving force behind that ascension was the primary analytical question driving evolutionary scientists at this time.

The analytical approach to evolutionary theory that began between 1750 and 1850 precipitated a revolution in the biological sciences, particularly ones influenced by evolutionary theory. The same transformation in visual culture that changed how displays were viewed as instruments of analytical meaning-making for scientists also change the relationship of museum displays to their other, diversifying audiences. According to Tony Bennett, Lamarck’s transformist theories, published between 1802 and 1822, were important for the development of museums as educational institutions in the 19th century. Lamarck’s idea that the individual could change himself during his lifetime was compelling for social progressives who were attracted to the idea of transformation and

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8 The Great Chain of Being dates back to Aristotelian and Platonic theories of the natural world and its hierarchical organization, demonstrating that the hermeneutic paradigm, while in some ways displaced by encyclopedic and analytic ways of knowing in science, was still important for directing the domains of response that scaffolded analytical observation and description.
improvement of the individual self. An important aspect of the mapping of the Great Chain of Being onto the history of life on earth is that, “Such a temporality links together the stories of earth’s formation, of the development of life and its development from ‘primitive’ to ‘civilized’ forms, into a single narrative which posits modern Man…as the outcome and, in some cases, telos of those processes” (Bennett 39). The “natural order” of the world, then, seemed to involve both the human ability to use knowledge of natural laws to manipulate nature, and humanity’s seemingly inevitable drive toward perfection.

It seemed natural to assume then that man would continuously improve, through scientific and technological progress, both his mode of living and the human being itself. Bennett argues that, particularly in post-revolution France, Lamarck’s ideas coalesced with the values of liberal government, leading to the belief that the “lower” classes of society could be uplifted through moral and intellectual education, although these principles of display cohere most clearly in the U.S. and Britain later, around 1875 (39-41). Museums were the institutions of informal learning where these ideas about natural history and the “natural order” could be put forward, popularized and celebrated.

As public education became a museum goal, the question of what to teach and how to convey knowledge to “common” audiences came into question. While scientists were seeking answers to their analytical questions, it was assumed that public audiences required instruction in understanding the simple descriptions and traits of species as well as explanations for how the species were related to one another. Theory at the time suggested that visitors could infer relationships between organisms based on simple looking: positioned as they would be in terms of their taxa and their relationship to one
another in the Great Chain of Being, Steven Conn asserts that these first displays for public consumption conveyed a “naked eye science.” This mode of looking to learn would enrich the public through a marriage of moral and intellectual uplift accessible “at a glance”: curators and scientists believed they were moving towards perfectly understood and organized classificatory schemes of organisms; through correct organization, arrangement and representative display visitors could immediately understand and internalize the natural order. Eilean Hooper-Greenhill summarizes neatly the relationship between objects and the epistemological frameworks guiding how curators believed knowledge could be built through looking:

If laid out in the correct way, both the meanings of the individual objects and a substantive body of information about particular disciplines would be explicit in the relationships between the objects. Knowledge was imagined as a classificatory table, on which all living things could find their correct position. The experience of the world could be analysed in terms of order, identity, difference and measurement. Analysis, comparison, enumeration, and classification were essential strategies for knowing. Finite schemes of knowledge were thought to be possible.

(Hooper-Greenhill 127)

This “naked eye science,” by which it was believed that proper arrangement rendered certain knowledge immediately legible, was based on what Conn calls an “object-based epistemology,” “predicated on the assumption that objects could tell stories ‘to the untrained observer’” (4). The object-based epistemology functioned in two ways: through
the selection of representative objects, and through the classification system in which they were placed. Curators conceptualized objects as functioning *synecdochally*—individual specimens represented their entire species—and *metonymically*—objects’ organization stood as part of a larger body of natural history knowledge. Meaning was thought to be made in museums visually, by a twofold process of selection and combination, where visitors would move horizontally, forming “coherent visual sentences” around objects “selected and ordered like words in a text” (5). As individuals in the museum moved *through* the exhibition’s displays, the experience simultaneously constructed the evolutionary narrative of “natural order” created through God’s plan for the universe and emphasized its completeness, rationality, and systemic ideals (Figure 4).
According to Conn, “this faith in objects as the source of knowledge lay at the center of how Americans in the late Victorian period understood the world, and it lay at the center of the whole museum enterprise” (9). For museum-goers, visits became educational and moral experiences bordering on the sacred. As nineteenth century museums revealed God’s plan for the world, both scientific practice and collections acquired an aura of moral purity, and museums became seen as “temples of naturalism in which visitors could worship science’s understanding of the creation” (Conn 42). By extension, “mid-nineteenth-century natural scientists served…as moral teachers, and in
their hands the carefully arranged objects that filled their museums thus became moral objects as well” (Conn 42). Beliefs in the morality of scientific work contributed to progress in the natural sciences, but also offered consumers of this brand of museum science with a sense of reassurance that the world could be encyclopedically understood in full, even as scientific uses of such displays moved towards deriving analytically and causally grounded explanations for existing phenomena.

In this fusion of scientific practice and aims with moralistic praise for the fruits of scientific labor—scientific certainty sanctioned by divine authority and purpose—the immediate visual context in nineteenth century museums was infused with epideictic energy. Later, this assumption that scientific inquiry would arrive at certain knowledge began to erode, and the supremacy of museums as locations for knowledge production declined in kind as experimental laboratory science replaced museum science. But the aura of moral authority in science museums persisted in the material displays and spaces of the science museum and emerged again in the science center, perhaps because of the decoupling of museums from the project of scientific practice. Science museums made little alteration to their display techniques, despite the fact that the scientific practices and theories that had once supported their logics had changed. If, as Marshall McLuhan has suggested, the “medium is the message,” then even after the broader message about science had shifted, the older message about the ability of objects to convey truth about the natural order would persist in the form of the exhibit. Additionally, it would embed and project the moral aura associated with the “truth-to-nature” narrative of that order, valorizing the ability for objects, arranged correctly, to reveal that narrative.
The object-based epistemology theorized by Conn also depends on what Michael A. Cavanaugh, writing about creation science, has termed a “folk epistemology of common sense empiricism” (189). This theory assumes that the seventeenth and eighteenth century models of empirical observation, common sense, and rationalism are the primary philosophical components that underlie scientific practice and knowledge-making (Cavanaugh 187-188). Cavanaugh explains why this theory is so compelling to the public:

…science and commonsense are not totally antithetical, for in a knowledge-based society, commonsense is increasingly tutored by “packed-down science.” Thus the man on the modern street “sees” the roundness of the Earth, and his common sense “knows” that the heart is not the seat of emotion and that werewolves do not exist. Such “conventional wisdom” is primarily a fact, not of individual psychology, but of membership in a certain kind of society. The organized process of gaining, and warranting, knowledge, differs from the ability to use it in packed-down form, or the ability of Everyman individually to validate what he knows. (emphasis added, 186)

Eighteenth and nineteenth century museums instructed visitors to rely on their visual powers of observation to infer relationships that curators had already sussed out and organized for them. Curators avowed the epistemological power of objects by positioning them as the “words” in these visual sentences, which visitors could infer with enough careful observation. I suggest that the progressive era’s urge to “uplift” the public in
museums popularized this “folk epistemology of common sense empiricism” and promoted a view of scientific knowledge as being accessible (and generated) through looking and inferring, and then was decoupled from the actual practices of science that began to transition out of the museum, which I take up in the next section. “Membership in a certain kind of society,” as Cavanaugh terms it, also means immersion in the visual culture that values those ways of sense making. Science centers are institutions that both contain evidence of a past visual culture’s valued domains of response and are evidence of such valuation. By using exhibits, media of communication that embed the “folk epistemology of common sense empiricism,” science centers reproduce the rhetorical situation of those nineteenth century exhibits and valorize those implied ways of looking and knowing.

A final note about scientific display in eighteenth and nineteenth century museums is that these meaning-making practices—undergirded by object-based epistemologies and folk epistemologies of common sense empiricism—are forensic in nature. As Jeanne Fahnestock reminds us, science as a genre is primarily concerned with explaining past events and validating those explanations:

Scientific papers are largely concerned with establishing the validity of the observations they report; thus the swollen prominence of the ‘Materials and Methods’ and ‘Results’ sections in the standard format of the scientific paper and the prominence given to tables, figures, and photographs that stand in as the best possible representation for the physical evidence the researcher generated (“Accommodating” 333).
Up until the nineteenth century, science displays were used by natural philosophers to make inferences about past relationships and causes, with how visual displays of specimens, in their arrangement in relation to one another and individual could be used to explain the origins of phenomena. In the twentieth century, museums see a major shift in their generic purpose, as scientific practice migrated out of museums and into university laboratories, and their missions turned toward the celebration and praise of the fruits of rapidly expanding scientific fields.

Diverging Institutions with Diverging Purposes, 1850-Present: Science Finds a New Home and Museums Seek a New Mission

“The present is deeply influenced by the past, thus the interpretation of objects and collections in the past affects how they are deployed today.” (Hooper-Greenhill 19)

“...by the end of the nineteenth century specific pedagogic approaches had been developed. These pedagogic approaches operated through concepts and technologies that would remain in place until the last quarter of the twentieth century, and which would become curatorial orthodoxies, some of which remain current today.” (Hooper-Greenhill 126-127)

The moment of certainty for American museum scientists was to be short lived. Beginning in the last decades of the nineteenth century, science in the United States shifted in both its epistemological assumptions as well as in the physical location of its production. Steve Conn suggests there were two primary catalysts that drove these changes: Darwin’s theory of evolution, and America’s adoption of the German model of the university, along with the fragmentation of higher education into distinct disciplines that accompanied that model. Together, these movements altered the ways that broader visual culture made sense of displays in science museums; specifically, this transition
precipitated a decoupling of the visual culture of science from visual culture and practices of science and natural history museums. Exhibits could no longer persuasively be framed as apparatuses supporting experts’ analytical inferences, and curators struggled to contextualize displays of specimens in a broader visual culture where experimental laboratory science was leading to rapid expansion of scientific knowledge. Science centers emerged decades after Darwinian theory and the German university model wrought their changes, but I contend that their methods of display—both during their inception and now—are indebted to this particular moment in the history of science and science display in natural history museums. Specifically, through their immediate visual and verbal contexts and methods of display, science centers invite visitors to reproduce the domains of response—wonder, symbolic meaning, encyclopedic cataloguing, and analytical inference—accumulated in the visual culture surrounding the museum phenomenon.

Although natural historians shunned it initially, the explanatory power of Charles Darwin’s theory of evolution and its widespread acceptance dealt a heavy blow to museum science, the effects of which reverberated well into the 20th century. Specifically, Darwin’s theory of natural selection suggested that the natural environment, undirected by the hand of any supernatural creator, was the force shaping the forms and structures of species over time. The assumption that a benevolent creator had established a “natural order” which careful scientific investigation could uncover was increasingly attenuated by the same investigations which, in previous eras, had seemed to corroborate divine providence behind natural laws. Acceptance of natural selection redirected
scientific inquiry, and during those same decades research programs began to migrate their physical homes out of private laboratories and natural history museums and into university laboratories. As early as the 1870s American universities began adopting the German model of the research university; although many of the most eminent universities had established natural history museums for research, many began building laboratories for experimental research. By the 1920s, Conn argues, “academic science had replaced museum science as the vanguard of new knowledge,” and by 1939, analytical, object-based epistemology had been almost entirely displaced by a new way of knowing that embraced theoretical and experimental science (246).  

With this out-migration of research from museums to universities, museums and the people who worked in them cast around seeking new purpose and direction; curators and other staff struggled to redefine museums’ relationship to science and the public. As the experimental domain gradually displaced the analytical in scientific disciplines, a smaller and smaller percentage of the overall biological research was conducted in museums. Professionals working in museums faced diminishing financial resources and the increasing perception, among experts, that their research agendas were obsolete. An

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9 The project of natural history—documenting and explaining the origins of and relationships between the biological and geological worlds—did not die with broad acceptance of Darwin’s theory; to the contrary, his insights fueled the development of many scientific fields we recognize today: biology, cladistics, ecology, genetics, embryology, and many others. Scientists in natural history museums continued (and still continue) to use specimens and data to make analytical inferences about the relationships between species structures/functions and their modes of living. This research is often supported by, and also leads to, experimental research and data drawn from laboratory and field research. The visual culture of science still values and requires the descriptive and analytical domains of response, but these are often used to develop experimental apparatus or interpret experimental results that are evaluated through trained disciplinary judgment, rather than any universal criteria. Despite the fact that many scientific disciplines incorporate each of these domains of response, science fragmented in the twentieth century into the multiplicity of disciplines we recognize today.
additional consequence of this transition was that, as science became increasingly specialized in experimental laboratories, its products and processes grew increasingly esoteric and inaccessible to the public. Some curators believed that a solution was to embrace and develop museums’ potential for public education and entertainment, but, according to Conn the “baggage” of their histories as intellectual leaders in science made these early attempts appear clunky and haphazard. I suggest that part of this difficulty was the extent to which the logic of the museum displays was interwoven with the object-based epistemologies warranting that logic. Indeed, Hooper-Greenhill reminds us that in some museums these implicit theories about objects still inform and structure display techniques today, and are

…based on an understanding of objects as sites for the construction of knowledge and meaning; a view of knowledge as unified, objective, and transferable…and the conceptualization of the museum and its audience as separate spheres, with, in addition, the museum as a place for learning that was held apart from the popular culture of the everyday…These approaches to knowledge…were to remain largely in place until very recent years. In some places they still persist. (127)

In the chapters that follow, particularly the last in this project, I examine specific elements of science centers’ visual display that preserve this approach to sense-making. Even in museums and exhibits where the explicit verbal message about science presents it as a set of practices carried out by experts to arrive at contingent knowledge, I show how haptic, or “hands on” exhibits and the material elements in science centers may
function to undermine those messages by hearkening back to the persistent, and compelling, conception of science as produced through enjoyable—and “wonder-filled”—visual (and physical) engagement with objects, made more resonant by science centers’ insistence that the experiences they offer for visitors are not, as Hooper-Greenhill suggests, “held apart from the popular culture of the everyday” but a necessary and inextricable part of daily life.

Conn argues that the antecedents to today’s science centers emerged during these fraught decades of intellectual and institutional transformation. The Franklin Institute and the Chicago Museum of Science and Industry opened in the 1930s, and both were devoted to presenting applied science and technology through exhibits reminiscent of the haptic, or “hands on,” activities that are a defining feature of science centers today. These early institutions also aimed to amuse and to show the relationship of science to the everyday, educating through visually and physically exciting experiences: “visitors were no longer to be taught through the careful systematic presentation of objects, but they were to be dazzled instead and offered the opportunity to play with exhibits rather than study them” (Conn 249). These kinds of institutions were rooted in both technical and skilled trade schools (which was how the Franklin Institute began, in 1824) and the kind of trade shows that were found at exhibitions such as the World’s Fair in Chicago in 1893. In such contexts, new technologies were unveiled to the public, who were invited to marvel at the new technologies as they experimented with their operation (Ogawa et al. 271). Although these instances of display were not explicitly tied to natural history museums, they were indebted to the object-based epistemology that invited viewers to
make sense of their world through the objects accumulated and presented to them as tokens of civilization’s achievements. The interest in “playing” with exhibit elements that was sparked in the Franklin Institute and the Chicago Museum of Science and Industry aimed to inspire an emotional response—excitement, wonder—and attachment to science and technology. This explicit turn to connecting science and technology to the “dazzle” factor, which I read as a descendent of the domain of wonder from the sixteenth century curiosity cabinets, is important for understanding how the domains of response in visual culture come to accumulate and layer one on top of another in the immediate visual context of the science center.

In contrast to Conn’s account of science center origins, Richard Toon and Rodney T. Ogawa, Molly Loomis, and Riannon Crain contend that science centers are a unique product of the post-World War II culture in the U.S. These scholars characterize science centers as part of the education reform that arose in the wake of the Second World War and the subsequent Soviet launch of Sputnik. In the years after the war ended, public belief in the “moral certainty about the social importance and efficacy of science” was at an all time high for the nation, and scientists were enjoying unprecedented cultural prestige (Lewenstein qtd. in Ogawa et al. 270). This moral certainty in the efficacy of science was due in part, to public perception that American achievement in science and technology was, to a great extent, why the U.S. won World War II (Wissehr et al. 369). It was onto this national scene that Sputnik entered, undermining Americans’ certainty that their recent achievements signaled permanent international prestige, and provoking swift government action. Cathy Wissehr, Lloyd H. Barrow, and Jim Concannon emphasize
how significantly the “blow to national pride” shaped the urgency of those government responses:

Even if the public did not know much about rocketry, satellites, or space, they did understand a perceived blow to national pride. Until that time, the United States stood at the forefront of medical research, automobile design and manufacture, and electronics. The launch of Sputnik changed all that. The United States was suddenly seen as having fallen behind, and the focus was now not on catching up but on surpassing her adversary.”

(Wissehr et al. 368)

To boost America’s competitive edge the government matched the perceived public urgency with concomitant action: funding for the National Science Foundation was increased, science curricula were overhauled, and increased cooperation between research scientists and school teachers was facilitated through the National Defense Education Act of 1958 which “encouraged the development of high-quality science and mathematics programs to encourage scientific careers” (Wissehr et al. 368). The goal of many of these programs was to address the national shortage of science and technology professionals; science curricula designed for this purpose emphasized “thinking like a scientist” by cultivating individual skills such as “observing, classifying, inferring, controlling variables, etc.” (DeBoer qtd. in Barrow 266).

It was in this “Golden Age of Science Education” that science centers proliferated and were popularized. Ogawa et al. suggest that the climate of reform characterizing these years opened up the exigency for a new kind of educational institution: the science
center. These scholars view the science center as a radical break from both from an entrenched American educational system as well as the institutional genre of the science museum; this institution, in their view, responded to “calls for innovation in science education, democratic access to information and a widening political interest in popularizing science” (271). Science centers were able to adopt unique and compelling techniques for communicating and teaching science because, unlike schools that were bogged down by their origins in the 19th century, they were unencumbered by such institutional roots, and so could embody the mid-century’s new vision for science education (Ogawa et al. 273).

Ogawa et al. concede that science museums have “deep historical roots,” but argue that science centers are fundamentally different institutions. Since, they contend, natural history and science museums focus on “displaying artifacts in glass cases and discrete galleries and modeling scientific processes in static exhibits” science centers were vastly different because their exhibits presented “natural phenomena and scientific processes” using techniques that “encouraged the visitor to be a part of those phenomena” and which aimed to “present the physical world as it was perceived by scientists and artists...[to inspire] visitors to discover the nature of nature for themselves” (Ogawa et al. 272). I contend that Ogawa et al.’s characterization actually demonstrates the continuity between natural history museums, science displays, and science centers. While nineteenth-century natural history museums had invited visitors to infer God’s divine order by organizing arranged objects into coherent visual “sentences,” science centers invited visitors to “be a part of those [natural] phenomena” by inviting visitors to
view those phenomena “as it was perceived by scientists.” Scientific knowledge and the agent responsible for driving natural phenomena had changed, but the implicit instruction in how to derive that knowledge remained largely unchanged. Additionally, although visitors were still invited to experience (divine?) wonder and awe in the face of natural phenomena, this aesthetic experience was achieved through an individual’s manipulation of physical objects, rather than by simply viewing them.

Richard Toon, too, emphasizes science centers’ aesthetic qualities to differentiate them from natural history museums. He describes Frank Oppenheimer’s establishment of the Exploratorium in San Francisco in 1969 as response not only to the wave of science enthusiasm and reform following Sputnik’s launch, but also to the shock reverberating internationally in response to the atomic bomb’s destructive force. In the period between 1964 and 1971 American feeling toward science and technology was complicated by “rising fear of nuclear proliferation, and feelings of insecurity evoked by the potential of an atomic Cold War” (Ogawa et al. 271). These tensions stoked suspicion about science and technology as it was being used for political ends. Oppenheimer, who worked on the Manhattan Project, is reported to have established the Exploratorium because it represented the opportunity to display universal principles of science apolitically, inviting appreciation for their aesthetic value and potential for facilitating individual self-discovery (Toon 106).

Basic science, rather than applied science, was the focus of Oppenheimer’s center; basic science, he reasoned, was more aesthetically pleasing and could be
appreciated more readily than applied science, which was symbolized with iconic resonance in the case of the atomic bomb:

“The phenomena of basic science which have become the raw material of invention are not easily accessible by the direct and unaided observation of nature yet they are natural phenomena which have, for one segment of society, become as intriguing and as beautiful as a butterfly or a flower” (Oppenheimer, “Rationale” 206).

Other science and technology centers that opened during the period after Sputnik’s launch also embraced the aesthetic quality of basic or “pure” science as a way to direct attention away from the destructive force of applied science. But they also recommitted themselves to presenting industrial achievements that signaled America’s investment in capitalism and positioned U.S. achievements as the end point of science’s teleology.

Although Toon and Ogawa et al. draw a distinctive line separating the history of science centers from natural history museums (calling science centers “undisputedly a product of the 1960s”), their similarity, in form if not in purpose, to the new 1920s-era science museums described by Conn is striking, and Toon’s line may represent a semantic distinction rather than a hard and fast one in the minds of museum visitors. It also seems reasonable to infer that the aura of divine moral “purity” science acquired in nineteenth century natural history museums with their object-based epistemologies, are comingled with the aesthetic “purity” of the basic science presented in contemporary science centers. This is a particularly compelling interpretation if we accept Conn’s ideas about the formation and existence of science museums featuring interactives as
contemporaneous with the decline of natural history museums’ intellectual significance. This moment of overlap when knowledge-making in natural history museums was migrating to universities may have perpetuated public conceptions of science as “pure” and object-based, since museum-goers could easily have visited “outdated” natural history museums in the same week they visited technology museums inviting interactive participation in “everyday” science, resulting in two competing but related narratives. The first, and older narrative: that science is the process of looking carefully at marvelous, natural objects in order to infer how God, in his divine plan, shaped their forms for their functions and environments; the second, rising narrative: that science is a process of arriving at a set of stable, basic concepts knowable through scientists’ “experimentation,” characterized as analogous to the process of careful study and manipulation of objects in exhibits. The rise of the rhetoric of the “purity” and aesthetic beauty of basic science that arose could easily be viewed as melding together these two narratives, placing the “divine” scientist in the role of creator who “discovers” the concepts to be explored through exhibits. While museum professionals view these two kinds of museums and their contents as drastically distinct, it is possible visitors saw natural history museums and science centers as simply “about science,”—natural, basic, divine, applied—transferring the dying institution’s aura of divinity to the excitement inspired by the embodied experiences of the rising institutions.

The relationship between scientific displays of objects, natural history museums, and science centers should not be viewed as a direct lineage; the influence natural history museums have had on sense-making in science centers is diffuse, not direct. But based on
this review of the history of scientific display and visual culture, we cannot accept
without qualification Ogawa et al. and Toon’s assertion that the interactive science center
is a novel organizational form. Both natural history museums and science centers employ
the display of science objects to effect their educational goals. Although science centers
have been framed as privileging physical engagement, particularly touch, exhibition in
both institutions is based on physical engagement with material objects. Through their
similitude, natural history museums transferred onto science centers their ways of seeing
science. Since then, science centers have proliferated and became a recognizable feature
of the American landscape; in turn, that ubiquity makes them increasingly available and
“legible” as apparatuses of a particular identification with science. Whether the visitor
studies a diorama representing a sloth’s habits of living or manipulates a pulley system
exemplifying simple machines, these exhibitions reproduce rhetorical situations that
invoke the same set of valued domains of response. And, further, they convey the same
implicit message about how science is done.

In this light, the dates that Toon and Ogawa et al. set out as boundary lines are more
usefully read as indicators of a shift in the visual culture’s logics of interpreting and
interacting with displays of scientific objects—the valued domains of response—, rather
than a fundamental change in the nature of the museum institution itself. I am suggesting
that that shift ought to be primarily characterized as a shift in the visual culture that has
cycled back to valuing science displays for their comingling of the affective experience
of wonder in response to some representation of cognitive content. Visitors to these
institutions—either natural history museums, industrial museums, or interactive science
centers—can and must draw from the same domains of response in order to make sense of displays of scientific phenomena.

Positioning Conn’s account for the emergence of science centers along with Toon’s and Ogawa et al.’s is also useful for articulating the important relationship between scientific display, broader visual culture, and the immediate visual contexts of buildings designed to convey science through visual experience. What is vital to take away from these decades, is that a new institution arose in response to broader national beliefs and ideas about science and technology and the ways that America wanted to present itself globally in relation to these endeavors. But the visual culture informing the ways that science was presented inside those new institutions—and how those institutions fashioned themselves both inside and out to reflect that culture—was itself formed through the accumulation of domains of response to science, each subverting the others in dominance, but never fully retreating from the culture’s scene of available sense-making schemas.

Conclusions

Critics have noted the importance for the museum of this ‘adaptation to changing circumstance and to the requirements of the time’. In a European context, at least, this is seen in the manuscripts in the medieval library, the curios within the cabinets of the Renaissance, the paintings within the picture galleries of the Baroque, the specimens within the cases of the Enlightenment and the intangibles and e-tangibles in the databases of modernity. However, equally significant within this process have been the changes in ways of seeing and ways of knowing that each society has built for itself. As disciplines, discourses, and taxonomies change so do museums.—Andrew Barry and Ross Sawyer

In the science center of today, all domains of response to displays of science may be engaged simultaneously. Children and adults marvel at natural phenomena—we gasp as centripetal force presses us against the wall of a spinning drum—we internalize the
ways that exhibits describe, catalog, and organize our lives, dividing our selves into “mind, body, spirit” our modes of being into “sensing, thinking, acting,” among others. We are presented with narratives describing how scientists manipulate laboratory conditions to explain phenomena—how we use carbon dating to age mummies or dinosaur bones, often the exact same bones that puzzled nineteenth century natural historians. The genre of the museum exhibit and our interactive displays of scientific concepts are contextualized by these domains and each one is available in the visual culture and can be activated individually or together in the visitor’s museum experience.

But different stakeholders have also engaged these domains of response at different moments, for different purposes and motivations in the history of science centers’ institutional formation and physical construction. In the centuries where these domains of response were conventionalized, they changed the ways that people used objects to make meaning as well: in the early modern era, objects that were unique, grotesque, or wonderful, were grouped together to embrace god’s diverse universe in microcosm; during the sixteenth and early seventeenth centuries, objects were appreciated for their ability to represent a species and divulge the essential traits that made it a species; objects in the eighteenth and early nineteenth century were compared and analyzed, arranged to help derive the theories that explained their forms, functions and relationships. Now our relationship to objects is fraught: we still use them for these purposes—all of them simultaneously, even. For example, the Hall of Diversity in the American Museum of Natural History functions to evoke all of these responses through
its scope and beauty, and its spatial organization of representative specimens to realize their taxonomic relationships (Figure 5).

The Parry and Sawyer epigraph, reproduced here at the ending of the chapter, tells us that museums are an adaptable medium, an apparatus that changes as the disciplines and discourses inside it shift and reframe what visitors have come to learn and look at. But in this chapter, I have attempted to show that while museums may change, the visual culture within and around these physical spaces accumulates and layers domains of response. This is not to suggest that the wonder we experience when we feel our hair
stand up when touching an electrostatic generator is the same wonder that sixteenth
century aristocrats felt when they beheld a rhinoceros horn. Or that when we compare the
bones of a whale flipper to a bat wing, we can infer the evolutionary homology implied in
their similar structures in the same way that eighteenth and nineteenth century natural
philosophers did. But most science centers do seek to inspire awe and wonder through
their exhibits and through the experience of being in a museum’s space, set aside from
everyday life. They do invite visitors to learn new concepts and taxonomies and to make
analytical inferences about the relationship between concepts and ideas defined and
grouped into those taxonomies. I have demonstrated that these domains of response have
historical roots and are still valued responses for making sense of science displays in the
museum context today. Further, I have shown in the final section of this chapter that the
break between museums and mainstream science that occurred between 1870 and 1920
rendered these domains of response to science display as the most accessible and
coherent associations with science available in museums today. As experimental science
increased in specificity, it became more difficulty for visitors to access and understand
the results and implications of scientific research. Because museum exhibits were
decoupled from the scientific enterprise at this vital moment, they preserve the
combination of “object-based epistemology” and “folk epistemology of common sense
empiricism” that was embedded in their logics of display in the ‘naked eye science’ of
the nineteenth century arrangements. While visitors may now touch and manipulate
exhibits in interactive science centers, the objects that comprise exhibits retain
communicative functions and purposes similar to those of their antecedents. And in doing
so, they preserve the messages about science embedded during those moments. Science center exhibit display has traits of a genre that was designed to encourage forensic inference—causal analysis of past events to explain present conditions. As such, the medium itself, because of the domains of response underlying its sense-making potential, contains a connection with the forensic genre although it is primarily used now in service, at least in science centers, of epideictic purposes.

In the chapters that follow, I explore how the visual aspects of science centers capture and embed these cultural and social identifications with science. I demonstrate how science center buildings, geographic sites and surroundings, interior spaces, architecture and ambience, as well as the exhibits themselves, capture and project forward in time particular associations with science: science as an economic driver and agent of civic and cultural revitalization; science as nationalistic achievement and agent of (ongoing and uninterrupted) progress; and science as a body of content that is knowable, worthy of celebration, and, if careful observation and inference are applied, revealed through viscerally-felt enthymeme-like epiphanies. In the process, I will explore the nature of science centers’ terministic screens, the identifications with science they make available, and the consequences of those identifications for museums, for science, and for understanding the relationship between epideictic and forensic genres as they co-exist in physical places. By reading carefully the history of science centers and their present modes of operation and existence, we can better understand the nature of the identifications with science they make available, as well as the broader nature of how
science centers use material modes of display to realize epideictic genre conventions about a (primarily) forensic subject.
Chapter 3: Particularities of Place and Face: How Science Centers Respond to Shifting Rhetorical Exigences

The roots of our contemporary situation are to be found in a material history of practices and understanding will have to emerge from a recognition of the historical depth of current dilemmas.

- Carla Yanni

The institutional goals of the science centers in this study, emerging in different moments in U.S. history, align with one another insofar as they aimed to popularize scientific knowledge and educate the general public in their historical contexts and communities. For example, the Western Museum, forerunner of the Museum of Natural History and Science in Cincinnati, was founded by Daniel Drake in 1818 to establish a relationship between the regional landscape and the people of Cincinnati; according to M.H. Dunlop, it “was intended to answer to modern needs for scientific knowledge, for general civic improvement and, overriding all, for an orderly and rational approach to the environment…” (526). The “orderly and rational approach,” positioned God as the source of all things “natural” and his Great Chain of Being as the logic behind the order and rationality. The “identity” work that M.H. Dunlop identified as a primary goal of the museum was to connect visitors to that order by positioning them as a part of their region’s natural history (525). By 1920, research science had almost entirely migrated to university laboratories. Although its collections were maintained by the Cincinnatus Foundation, the Western Museum closed its doors to the public in 1868, perhaps an early
a casualty of this transition: Indeed, Emanuel D. Rudolph shows that Daniel Drake’s interests were diverse and inclined to support (and initiate) emerging institutions of higher education and research; he was involved in the founding of the Ohio Mechanics Institute and the Medical College of Ohio, among several others. As a founder of several educational institutions each with a slightly different emphasis, it is perhaps unsurprising that Drake’s interest shifted from the museum to the rising institution of the university. While its closure in 1878 speaks to that era’s rising interest and emphasis on universities and experimental research, its re-emergence as a public museum with a new name—the Museum of Natural History and Science—in 1931 demonstrates the continuity of its nineteenth century purposes with its early twentieth century ones.

In his justification for re-opening the MNHS, President of the Cincinnatus Foundation, Robert M. Senior, asserted that a museum of natural history still offered the public a valuable educational function by connecting past natural events of the region with the community’s identity and its future:

…[It] stimulates an understanding of the past and develops in the community an interest in the future. Though on the one hand it caters to the specialist and the research student, on the other hand it promotes in the school children, and in the general public, an understanding of the world of nature—a love for the out-of-doors—a keener enjoyment of life. (Dean)

These goals echo the “public uplift” purpose of science education in nineteenth century museums. The forensic purpose of the museum exhibit is harnessed to one that is both deliberative and epideictic: explaining how past evolutionary events lead to the present
forms of animals and natural features is framed as invoking, in both the “research student” and “school children” an “interest in the future” inspired by a more complete “understanding of the natural world.” The present moment of learning is framed as one that both argues for future actions and connects those actions to pleasure and quality of life. These themes of “public uplift,” “interest in the future” and “understanding of the natural world” are echoed in the purposes and goals of science center institutions opening later in the century; these motives, as well as the recurring use of science exhibits to effect them, threads together the institutional and rhetorical practices of these earlier institutions with science centers as we know them today.

The late nineteenth and early twentieth centuries mark a period of transition for science in the United States; migrating the majority of experimental science into university laboratories and out of museums meant that museum exhibits were decoupled from the epistemological enterprise, preserving in their form of display the combination of “object-based epistemology” and “folk epistemology of common sense empiricism” that undergirded the logics of display in the nineteenth century. In doing so, they also preserve the messages about scientific “facts” and methods embedded during those moments. During the same period that science was transitioning in its epistemological methods and locations of practice, Steve Conn argues that science centers were emerging as new institutions on the scene, entering the same visual culture inhabited by the struggling natural history museums. While visitors were delighted to be allowed to touch and manipulate exhibits in interactive science centers, the objects that comprised the exhibits operated according to the same epistemological assumptions and invited the
same domains of response as those in natural history museums: “look, touch, and know scientific marvels,” they exhorted visitors.

Science centers’ exhibits share the display traits of natural history museum exhibits, designed to encourage forensic inference—causal analysis of past events to explain present conditions. As such, the medium itself, because of the domains of response underlying its potential for sense-making, contains a connection with the forensic genre. Each encounter with a science exhibit reinvokes a rhetorical situation that participates in this tradition of sense-making. But science centers also emerged in response to their own set of exigences, and have had to adapt to changing rhetorical situations as their original exigences mature and fade away. Science centers now frame their exhibits in terms of their epideictic purposes—to “inspire” to “excite” and to “motivate” learning, rather than to realize the construction or transfer of knowledge. I suggest that this transition in science centers’ primary genre, from forensic to epideictic, may be better understood by studying the institutional and architectural histories of the science centers in this study. By fleshing out the exigences to which stakeholders intended for science centers to respond, we can better understand how the rhetorical constraints influencing decision-makers—the beliefs, interests, motives, and attitudes connected to science and technology—were embedded in the science center architectures and projected in their material forms to constrain and influence museum professionals working in the present.

Peter Galison has described architectural forms containing scientific practices in terms of how they “…concentrate the meanings crystallized around the science of a time”
He encourages us to consider how the buildings that contain scientific activities function to “...help us position the scientist in cultural space...” because buildings serve both as active agents in the transformation of scientific identity and as evidence for these changes” (Galison 2-3). And Carla Yanni has demonstrated how, in the nineteenth century, natural history museum architecture was designed to represent, iconically, the theories of nature being developed by the scientists within. She argues that we ought to attend to the ongoing rhetorical force realized through architecture, since through the durability and prominence of their material forms, highly contextualized ideas about nature have continued to be “projected in western society since the nineteenth century” (3).

Galison’s and Yanni’s descriptions allow us to piece together a framework for understanding how the attitudes and beliefs about science are embedded in architectures’ material forms: Galison highlights how architecture functions as “active agent” and evidence of change in scientific identity, by physically positioning scientists, their work (both its practices and its products), and the public in relation to one another; Yanni emphasizes how the durability and persistence of a building can project the notions and conceptions of science embedded in its exterior façade and in its geographic location into the future. Trends in architecture no longer dictate that science centers’ exterior façades relate iconically to the subject matter inside, but the buildings that first served as the homes for the science centers in this study certainly did have indexical or symbolic relationships to their subjects and purposes. Their current buildings also index their relationship to science, but, as Galison suggests, they serve as evidence of
transformations in attitudes regarding the purpose and value of science and science centers in the communities of this study. Buildings are redesigned and repurposed, and institutions are relocated in new homes to address changes in attitude. Through their existence, buildings also precipitate new changes in scientific identity for the community. The science centers in this study have experienced at least two eras of conceptualization, construction, reconceptualization, and redesign that both reflect and precipitate changes in attitudes and beliefs about science and technology in their communities.

Galison and Yanni’s insights also suggest the importance of the temporal modes of being in a science center’s institutional and architectural history; the social and cultural changes that transpire during the passage of time influence changes in attitudes and beliefs about science realized by science center architecture. Schroeder-Gudehus’s characterization of the science center building as a “historical artefact” suggests we understand its architecture and location as reflections of its context (1). If we accept that buildings and institutions are material statements that are designed to address a need emerging from a particular confluence of factors in the “social, economic, and political context,” we can also view these “historical artefacts” as rhetorical statements addressing a need or demand that emerges from a particular rhetorical situation. From the social, economic and political context, an exigence emerges, which, according to Lloyd Bitzer’s description, is an “imperfection marked by urgency; it is a defect, an obstacle, something waiting to be done, a thing which is other than it should be” (6). Stakeholders recognizing the exigence—for example, the need for improved science education—and wishing to address it, are constrained by their perceptions of what science is, what it can be used for,
how it can be learned, and why it is valuable (among many others). As I illustrated in the last chapter, those identifications with science have been shaped by the history of visual culture and science display. For example, stakeholders who perceive science as a set of marvelous, stable facts and methods of observation which are valuable because they can be applied to product saleable goods will be likely to produce science centers that function as communal spaces making available those facts and methods, and praising their application in producing goods and services. The stakeholders’ constraints in these rhetorical situations are then characterized, in part, by the historical domains of response to science display that they then embed and reproduce in the institutional missions, exterior architectures, and geographic locations of the science centers.

Viewing the contextualized meanings of science center institutions and buildings as rhetorical statements that emerge to address a particular exigence (or set of exigences) goes beyond the agenda-setting function Carole Blair has described: “Architecture, like natural language use, expresses degrees of significance not just through its symbolic substance but by its very existence…when a memorial (or any other text) appears on the landscape, it is thereby deemed—at least by some, and at least for the moment—attention-worthy” (34-36). Science centers, by emerging in particular geographic locations in particular moments, certainly represent the stakeholders’ assertion that the science is worthy of attention. But by addressing their community’s exigences, they also make statements about what science is and about how it ought to circulate in communal spaces to meet demands for knowledge, for education, and for entertainment. They enclose and reproduce the rhetorical tradition of displaying science in physical places,
thereby reproducing a recurring rhetorical situation and the corresponding values and epistemologies of the domains of response exhibitions have supported: wonder, encyclopedic knowledge, and analytical inference. I take up discussion of the exhibitions themselves in more detail in the fourth chapter. But here it is worth noting that Bitzer has described such recapitulation as realizing a powerful tradition: “The situation recurs and, because we experience situations and the rhetorical responses to them, a form of discourse is not only established but comes to have a power of its own—the tradition itself tends to function as a constraint upon any new response in the form” (Bitzer 13). Bitzer’s characterization also suggests that past instantiations of science centers and past experiences of visitors inside them will influence how they are experienced in the present.

Carole Blair, Greg Dickinson, and Brian Ott have theorized the relationship between places of public memory and the temporal contexts into which they intervene meaningfully. While they suggest that the project of collective memory positions visitors uniquely in relation to the past, I would suggest that science centers, museums, and other buildings working in a historic tradition that includes representing the subject’s value for the community, function similarly:

A memory place proposes a specific kind of relationship between past and present that may offer a sense of sustained and sustaining communal identification. By bringing the visitor into contact with a significant past, the visitor may be led to understand the present as part of an enduring,
stable tradition…the apparent immutability and permanence of place are important here. (Blair, Dickinson and Ott 27)

Specifically because the science centers in this study are now part of an institutional genre with its own history, each science center institution, its building, and its geographic site will interact to perpetuate and project a sustained communal identification with science. Because science centers are also part of a larger museum tradition, which shows the past so that we can better understand our present, they (re)present an “enduring, stable tradition” that changes with cultural attitudes and beliefs about science, but not in the same fashion that, say, scholarship changes. The science centers contain modes of display that reproduce encounters with science that value and evoke outdated theories of scientific knowledge. In doing so, the centers set up a dialectic relationship between the rhetorical situation produced by visitor’s interaction with the science exhibit displays inside, and the manner in which the durability or alterations to buildings’ exterior façades or geography reassert or re-imagine the value or truth-status of the identifications with science produced inside.

Carole Blair, Greg Dickinson, and Brian Ott argue that a “memory place”—a memorial or museum built specifically for commemorating a past event—has its own history, which is often just as important as the historic event it represents. They quote James Loewen to theorize how a built structure might be understood as accumulating meanings in three distinct temporal periods: 1. the moment of the event or person being commemorated; 2. the “story of its erection or preservation…[which] reflect[s] the attitudes and ideas of the time when Americans put them up…”; and 3. the moment when
the contemporary guest visits the historic site. They argue that the story of the memory place’s erection “accounts for the place’s particular modes of existence and invention” (30). Although they are not explicitly about memory, as historical artefacts, science centers also have different “modes of existence” in the moments when they are constructed, re-imagined, and experienced by a contemporary visitor. Each of the institutional buildings in this study has multiple historic contexts that inflect how its architecture positions the public in relation to science: 1. The moment of their institutional conceptualization and establishment and the construction or selection of their original buildings in particular geographic locations; 2. The periods in which the buildings containing science centers were redesigned, relocated, or revitalized; and 3. The present moment, in which museum professionals work inside the (relatively) static spaces.

In this chapter, I examine the first two temporal periods of two mid-western science centers, examining stakeholders’ motives for building a science center, their rationale for selecting a particular geographic site and one particular architect or architectural design. By tracing these decisions, we can observe how the centers functioned rhetorically to address the exigence in a particular moment. Such a narrative also provides a snapshot of stakeholders’ attitudes and beliefs about science, and shows how they were realized in the institutional plans and building architectures, suggesting how transformations in those attitudes and beliefs affect the institutions and buildings’ abilities to effect the same rhetorical functions. I use photographs and descriptions of the contemporary and historic buildings to conduct rhetorical “readings” of the architectures and I use primary source research from newspaper articles, informal museum history
documentation, museum archives, and museum staff interviews, to support my analysis of the ways in buildings embed attitudes and beliefs about science, *evidencing* changes in attitudes, and well as *precipitating* changes. Constructing this narrative provides insight into how science centers intervened rhetorically to fulfill needs based on how science and technology were understood and valued in a particular historical moment; further, I believe it suggests how changes in attitudes and beliefs about science may have precipitated changes in institutional mission and emphasis that gradually changed science centers’ generic purpose and function, influencing how curators and exhibit designers working in these places present science to the public in the present.

**Definitions and Demarcations**

I take my definition of “institution” from scholars Rodney T. Ogawa, Molly, Loomis and Rhiannon Crain, who study intersections between educational history and institutional theory; they define an institution as an organization with structures developed for the purposes of realizing a specific goal, such as public science education (273). The Museum of Natural History and Science at Cincinnati Museum Center (1818), the Carnegie Science Center (1939), and COSI (1964) were all founded as organizations with goals of “improving” public science education or “expanding” scientific knowledge. Their common goals were influenced by the contemporary notions of education, knowledge, and science, as well as how “improvement” and “expansion” were conceptualized and framed in each period. Despite their distance from one another in time and space, a key commonality among these institutions is their exhibition of scientific objects and phenomena to educate the public.
I use the term “architecture” broadly throughout this project, aligning my use with Suzanne MacLeod’s definition, which includes the building’s “physical structure, the layout of functions in space, the layout of collections in space, the management, the programming and so on…”; this definition emphasizes the building’s purpose, place, and meaning (MacLeod 20). This breadth of definition also allows us to articulate a relationship between the institution, its primary stakeholders, and the production of its architecture, since “social organization, government and professional bodies and the motives of individuals [are all] involved in the production of museum space at specific historical moments” (MacLeod 20-21). In this chapter, I focus primarily on the institutional history, and specific architectural elements of a building’s external features, particularly its “place,” the geographic location within the city in which the building resides, and its “face,” the building’s exterior façade and any of its surrounding grounds. In the next chapter, I explore how building architecture realizes contemporary articulations of interior space in the present.

Blair, Dickinson, and Ott’s suggestion that buildings occupy different “modes of existence” during each period warrants dividing the histories of these institutions and their architectures into two periods: the first dates from 1933 to 1964 and traces the exigence for and construction of the Carnegie Science Center’s antecedent, Buhl Planetarium and Institute for Popular Science, and COSI: Center of Science and Industry. The second period dates from 1980 to 2000, when the buildings housing both of these institutions, and the purposes for which they were originally put, underwent radical transformations.
Hereafter, I limit my analysis in this chapter to COSI and the Carnegie Science Center (and its antecedent, the Buhl Planetarium and Institute for Popular Science). The anecdote about the Western Museum’s goals for its community used to begin this chapter demonstrates the similarity between that institution, founded in the nineteenth century, and the two founded in the mid-twentieth century; those continuities draw the thread from the nineteenth century institution’s motives and modes of exhibition display to those in the twentieth century, demonstrating the persistence of the rhetorical tradition of science exhibition. However, the institutional and architectural history of the Museum of Natural History and Science and its present home, Cincinnati Union Terminal, spans a longer period and demonstrates complexities that warrant individual treatment elsewhere. In the interests of concision, in what follows I narrow my focus to the Buhl Planetarium/Carnegie Science Center and COSI.

Science Institutional Goals in Context: Locating Informal Science Education in the Twentieth Century Optimism

“Today our nation is committed to unprecedented research expenditures in space exploration and the results are issues of international concern. Not only scientists, but all of our citizens need a basic understanding of space.”

- “Planetarium,” Center of Science & Industry

The beliefs in science education as a vehicle for “public uplift” and a means of demonstrating one’s “interest in the future” that the Museum of Natural History and Science embraced during the late 19th and early twentieth century still circulated in public culture even after World War I, informing how natural history institutions conceptualized their missions. But significant developments in technical and industrial growth as well as the potentially destructive consequences of their application in World War I had shifted
public attention and interest to machine technology and industries, as well as the
importance of medical and basic research. The Buhl Planetarium and Institute for Popular
Science opened in 1939, one of the first five such facilities in the United States, and
embraced an optimistic view of science and technology’s potential benefits to the
community. Focusing on astronomy, rather than natural history, the Buhl encouraged
“young people to explore the world of science,” and, to facilitate this exploration,
focused a planetarium using the state-of-the-art display technologies, a “Model II Zeiss
Star Projector that could accurately display 9,000 of the brightest stars in the sky.”
(Carnegie Science Center, “About Us: History”). In addition to its focus on astronomy
and technology, it used its planetarium and hands on exhibits to encourage visitors to
consider not only the beauty of nature, but also the technologies man had developed for
studying it, and the potential for studying and applying natural phenomena as a career.

The building that housed the Buhl Planetarium and Institute for Popular Science
captured the popular visions of technology and industry as a powerful force for American
progress. The original Buhl building was constructed in the Art Deco style, which Linda
Oliphant Stanford has described as a synthesis of old and new, Beaux-Arts and modern
styles of architecture (20). This “ideal of a marriage of fine and applied arts and industry”
was believed to result in buildings that symbolized the city’s tradition of urban of
sophistication and, though its streamlined masses and “curvilinear” lines, its path to
modernity, achieved through technological and industrial progress (Stanford 12).
Architects trained in this style also often subscribed to the “form follows function” theory
of design, and buildings were intended to symbolize or suggest their purpose through
their exterior forms. As the one of the first of five planetariums in the United States, the building’s exterior façade and ornamentation aim to make its purpose clear: the curving mass of the planetarium’s dome—the institute’s main purpose—is prominent above the exterior façade of the building’s entrance, which is unadorned by windows, or other ostentatious structures that might take visual attention away from the dome (Figure 6). The names of famous astronomers and scientists, including Galileo, Newton, Kepler, Copernicus, and Ptolemy, are engraved into the walls supporting and surrounding the dome; each name is flanked with floral ornamentation (Figure 7). As you move closer to the building, large bas-relief sculptures personifying “The Heavens,” “The Earth,” “Day,” and “Night” are visible (Figure 7). Each sculpture is labeled as well, requiring no sophisticated art interpretation skills to understand their meanings. As they entered the front doors, visitors proceeded underneath sculptures of “Modern Science” and “Primitive Science,” who face one another with the implements of their “practice” (Figure 8).
Figure 6: Front of Buhl Planetarium Exterior Facade

Figure 7: Ornamentation on the Buhl’s Exterior Facade; "The Heavens" Bas-Relief (left) and Illuminated "Copernicus" Engraving (right)
The building’s architectural style suggests the themes of progress and the marriage of fine arts with industry, and this overt ornamentation captures clearly the institutional goals—to facilitate and promote the exploration of science—and projects the building’s rhetorical function: to improve the community materially, through the building’s function as a communal space for learning about astronomy, and to promote the future career development of young Pittsburghers. Located in the North Side of Pittsburgh, which was suffering urban decline at this time, the building also symbolized
the hope that scientific and technological learning would uplift individuals, as well as the entire city, through its expansion.

A More Urgent Exigence: Sputnik and its Role in the Transformation and Creation of Science Centers

Examining the shift in emphasis of the Buhl’s programs during the Cold War era reveals how attitudes and beliefs about science and technology changed in the United States after the Second World War and also contextualizes the goals and mission of COSI when it opened in 1964. During WWII, the Buhl was used for explicit forensic and deliberative purposes; the planetarium was used to training the military in “celestial navigation,” how to determine from the location of stars the direction they ought to follow. Later, in 1958, the Buhl introduced its “Junior Space Academy” “as a local response to the launch of Sputnik and the dawn of the Space Age” (Carnegie Science Center, “About Us: History”). Descriptions of this program in local newspaper advertisements reflect the contemporary beliefs, ambitions, and anxieties circulating about science and technology education at the time. Courses in “physics, the ocean, mathematics, the weather, genetics, chemistry, art and nature, crystals, telescope making, insects and geology” were all available (“Space Academy Countdown”). But featured classes highlighted in advertisements focused on space exploration and travel and how scientific and technical developments evidenced progress:

‘Journeys’ to Jupiter, living on an asteroid, and man’s evolution will be among new courses offered this year to some 1,000 youngsters in Buhl Planetarium’s summer space academy.

An investigation into the possibility of colonizing the moon or living on an asteroid.
A study of primitive man’s march through the ages, his ways of life in precivilized times, and the changes in his body through evolution. (Space Academy Countdown)

Sputnik’s 1957 launch had a nationwide impact on attitudes and interest in science and technology. A climate characterized by “incredible intensity” of anxiety, optimism, and urgency, spurred federal increases in funding for science and technology research and a nationwide demand for improvements in science education curricula (Dean “When Space Suddenly Mattered”). It is no surprise that science centers proliferated during this time, as the National Science Foundation supported the expansion of informal learning experiences offering greater depth and quality of learning. The Buhl’s “Junior Space Academy” highlights how science centers and their missions were conceived as rhetorical responses to those exigences and demonstrates how science centers emerging at this time functioned as both a reflection of cultural fears and hopes and an intervention addressing the perceived need for improved and expanded science education. These courses were not only aiming to convey through their knowledge transmission “a keener enjoyment of life”; rather, Young Junior Space Academy participants were explicitly acquiring, through explanations of natural phenomena, the knowledge they would require when they were to “live on an asteroid” in a future that must have felt imminent.

The goals that stakeholders aimed to realize in COSI’s establishment were conceived to address the same exigences as the Buhl did in the Cold War era. The Buhl focused the deliberative rhetoric of its programs on preparations for the future, vetting the young for competition in the Space Race by introducing the requirements for sustaining human life in outer space. COSI’s mission was also deliberative, focusing on the future,
but emphasizing economic, rather than intellectual, gains to be made. Its stakeholders conceived of “…an organization dedicated to the understanding of science and its application in our daily lives.” (“The Beginning and the Realization “ in *Center of Science & Industry*). In 1957, local business people, nonprofit organizations, government officials, and board members of cultural institutions came together to create and fund an institution focused on the *application* of scientific and industrial developments for financial gain: In addition to fulfilling “the civic and cultural need for such a center…to meet the needs of young people and adults,” one of stakeholders’ main goals for COSI was to “stimulate and encourage a better understanding of research, development and the American System of Free Enterprise” (“The Beginning and the Realization” in *Center of Science & Industry*). Learning about science in COSI, these goals suggest, addressed the Cold War exigence for improved science education, but also assumed those improvements would be used to stimulate America’s capitalist aims, thereby besting the Soviets through economic, as well as intellectual and scientific, achievements.

The founders of COSI envisioned science as a resource that could be wielded to address the civic and economic needs that Sputnik’s launch had brought into being; applied to produce new goods and products, the science made available through COSI’s educational exhibits and classes would stimulate American capitalism. Stakeholders with this view of science—a process with concrete products that could be bought, sold, and valued on the market—framed COSI’s institutional purpose as both forensic and epideictic: past scientific and technological achievements were displayed and explained in classes in order to praise American achievements and inspire individuals to emulate
those behaviors, thereby instilling in visitors belief in the value of capitalism and the importance of American technology and industry in perpetuating its vigor. An editorial published in the *Columbus Dispatch* in 1962 supports reading the center’s purpose as focused on education and celebration:

> “Even though the Columbus area has excellent educational facilities…it needs an installation such as that being planned to *promote and encourage* science education among children and adults. We are living in an exploding technological age where science no longer can be learned by memory. The sum total of all scientific knowledge doubled from 1900 to 1950. It doubled again between 1950 and 1960. A museum of science and industry with provocative exhibits both *inspires and teaches* children to think…. A museum of science, industry and history is truly a magnificent *investment in the future*” (emphasis added, “The Beginning…” in *Center of Science & Industry*)

The editorial highlights public perceptions of science centers as functioning in the epideictic and forensic genres—the center *aims* to praise science, to “promote and encourage” science education among both children and adults through the presentation and explanation of past events to “tell a story of the development, operation, and scientific significance of a business, industry, association, educational institution, research organization or governmental department.” (“The Principle Areas” *Center of Science & Industry*). The editorial also demonstrates the explicit deliberative purpose of the science center: to learn in the museum today is to invest in the future tomorrow. In the
rhetorical situation following the launch of Sputnik, Americans were fearful and anxious about the nation’s future. By emphasizing the changing nature of science—how it “no longer can be learned by memory”—and the rate of change, the writer also alludes to the rhetorical situation surrounding science and technology opened up by Sputnik and harnesses its urgency to advocate for education and inspiration, which together realize the “magnificent investment in the future” and demonstrate the means by which that future can be achieved.

As it was originally conceived, COSI was intended to serve as an informal extension of school education for both adults and children. Educational programs were intended to be hands-on and focused on conveying relevant information to both children and adults; courses were offered on a range of subjects and difficulty levels, from elementary to advanced: “Courses will be planned to appeal to students and adults with special science and hobby interests and for those who wish to pursue advance [sic] courses of research and study.” (“Classrooms and Workshops” Center of Science and Industry). Seven classrooms were made available for workshops and a darkroom was available to both “staff and students.” COSI’s administrators recruited teachers from a variety of backgrounds to align with the rigor of the courses as well, from university professors and schoolteachers to business volunteers and even high school students. The course offerings are representative of the contemporary developments in science and technology COSI hoped to address: “Beginning Radio, Beginning Science, Electricity and Magnetism, The Slide Rule, Speed Mathematics, Microscope and Slide Making, Rocks and Fossils, Amateur Radio Code and Theory, Chemistry and Preservation of
Historical Materials” (The Center of Science and Industry). Classes were offered with the intention of instructing individuals at all levels of ability and interest, a practice generally unheard of in science centers today but which highlights the unique role COSI stakeholders imagined for the science center during the 1960s. The role of the science center in the city and its audience was broader and in many ways more diverse than its current function; visitors were expected to visit COSI regularly and individuals of all ages were intended to benefit from immersion in science-related courses, exhibits, and films.

The exigence for establishing COSI, then, was clear and nearly unanimous; its educational and inspirational purposes would be achieved through the informal learning opportunities available in exhibits and classes. The urgency for an institution like COSI is evidenced in the national anxiety and pride that characterized the rhetorical situation in the post-Sputnik era. Businesspeople, local politicians, indeed, the whole of the U.S. seemed unanimous in its support for institutions that would promote science education, and they aimed for those institutions to get up and running quickly. After visiting centers in Oregon, Chicago, and Philadelphia, the museum’s early founders presented a report to the Franklin County Commissioners, who allocated $502,000 of tax revenue in 1962 to renovate Memorial Hall. The hall had been constructed in 1903 to serve as a convention center, but had fallen into disrepair in the years leading up to COSI’s birth. The Greek-style building had been used to host community events, such as the local high school’s annual prom, but also attracted high profile performances by figures including Marion Anderson, Rachmaninoff, and William Jennings Bryan (Figure 9) (“Franklin County
Memorial Hall”). After the Veteran’s Memorial, now located on the Scioto Peninsula, opened in 1955, Old Memorial Hall lay vacant, save for the Franklin County Historical Society, which immediately proposed COSI as the new occupant.

The decision seems to have been motivated, primarily, by the historical society’s desire to avoid leaving vacant a historic building in the heart of downtown, but the haste with which Memorial Hall was chosen and renovated speaks to the urgency felt by stakeholders to get the institution up and running as quickly as possible (“Franklin
County Memorial Hall”). Although it was in desperate need of renovation, its low cost made it attractive to stakeholders, and rather than spending time and money arguing with donors about what an science center should look like, the committee was able to focus on developing the programs and exhibits that would realize their primary educational goals. Despite the rather utilitarian logic for installing COSI in Old Memorial Hall, its location in the heart of downtown and its former use as an important communal space for the community enhanced the impression that the new institution inside it would also be of value and significance to the city.

Nine years later, the center had begun to prove its worth in the community, and in 1973 the “solar front” was added to the Old Memorial Hall building (“COSI Timeline”). This modern exterior façade disguised the neoclassical columns and stairway which had lead up to the front doors, protecting Old Memorial Hall’s façade, and creating additional exhibit space. More importantly, though, the solar front’s sleek, geometric panes of black glass and brick lent COSI a “modern” appeal that symbolized the stakeholders’ aspirations for how “improvements” in science and technology education realized in this place and its programs might similarly transform the “face” of the local—and by extension, the national—economy (Figure 10).
The exigence for the establishment of COSI was tied intimately to U.S. concerns about international competitiveness in the STEM fields, which were both economic and nationalistic in nature. Politicians, corporate representatives, and the public seemed united in their support for building a science center for the specific purpose of educating the public, promoting capitalist endeavors through scientific and technological achievements, and attaining these goals in a timely and cost-effective fashion. COSI opened in the heart of downtown, just seven years after its original conception, in a building that was hastily selected, symbolizing the urgency with which the stakeholders believed the mission ought to be pursued. Later, once the value of the center’s intervention in the community was no longer in question, it was made-over with a “modern” façade to symbolize and allude to the modernity of the scientific education happening inside its walls. The speed with which the project was established, the content
of its programs, exhibits, and curricula, and its geographic site in the heart of downtown and demonstrate the complex of social and cultural forces cohering to shape COSI’s original rhetorical purpose and informing design choices for the architectural and intellectual spaces realizing that purpose.

Examining the exigencies for opening the Buhl Planetarium and Institute for Popular Science and COSI side by side demonstrates how each institution and its building was conceived as an intervention in an exigence emerging from each city’s unique rhetorical situations. Those rhetorical situations were influenced and inflected by the larger national climate and the concerns and ambitions for science and technology emerging after the First World War. After World War II, those concerns and ambitions redoubled in intensity and urgency following the launch of Sputnik. The Buhl building captures the exuberant, 1920s optimism about science and technology through its Art Deco façade. Its installation in a location in the heart of the North Shore neighborhood, a promise to the community that astronomy and scientific study could uplift the citizens intellectually and improve the neighborhood materially. The façade’s ornamentation personifies the objects of astronomical study, rendering scientific practice into a mythic pursuit—a pursuit that takes on an even greater intensity when Junior Space Academy classes begin to frame science learning as essential preparation for a definitive future of living in space.

COSI’s exigence is less diffuse than the Buhl’s initial mission and purpose, which were sharpened by the intensity and urgency of the U.S.’s Cold War era anxieties. Unity of purpose—enriching science education and generating enthusiasm and excitement
around that intellectual pursuit—drove COSI to quickly develop innovative programming for an institution that could quickly be installed. Its home, a building that, through its location in the heart of downtown and its history as a gathering place for important events, co-opted for the subjects of science and industry the community’s existing sympathies and sense of value connected to the building. Once COSI had developed its own ethos and reputation as a pre-eminent science center focused on education for the future, the solar front was installed to represent that goal and to index the high-tech nature of the science and technology being learned inside.

These buildings emerged on the scene (or were repurposed within the scene) of their downtown areas and functioned, as Carole Blair has observed, to call the community’s attention to science, technology, and industry, as subjects worthy of value and interest. They also intervened during a particular national rhetorical situation as statements about American supremacy in science and technology development and the urgency with which those fields needed to be nurtured and promoted for the nation’s future economic and intellectual success. The Buhl’s exuberant Art Deco style captures the post-WWI optimism for science and industry. Its mythic personifications of the objects of scientific study and practice symbolized the significance of the endeavors conducted inside the institution and rendered them part of the “mythology” of Pittsburgh’s history of science and technology. The Cold War climate in which COSI emerged attached to the institution’s mission an urgency that was realized materially in the haste with which Columbus’s Memorial Hall was repurposed to house COSI; the addition of the solar front then symbolized the institution’s success and symbolized its
purpose of transmitting to visitors the most up-to-date science knowledge, persuading visitors that the explanations of phenomena within would be the path to future science careers worthy of celebration.

By their very existence, by these symbolic allusions embedded in their exterior facades, the science center buildings in this study construct “a cultural and institutional identity” for the social practices and subject matter of science represented inside their walls (Galison 16). By emerging when they did with the architectural style and forms that they did, the buildings serve as a daily reminder of the significance of the subject matter for the city—located in the hearts of the city they seem to represent themselves and their subjects as being at the heart of the city’s future success. By visiting these institutions, visitors could weave their experiences of science learning into that promised future.

Galison has suggested that “buildings serve both as active agents in the transformation of scientific identity and as evidence for these changes.” (Galison 2-3). In this section, I have demonstrated how the COSI and Buhl institutions and buildings emerged as evidence of changes in the nation’s scientific identity, and how, during the Cold War era, new interest and significance were attached to science and science education. The subsequent demand for improved science education was partially addressed through the assertion of these buildings and institutions into the local communities. In what follows, I demonstrate how the role of these institutions within those communities were further reconceptualized by stakeholders, who themselves responded to shifting attitudes and beliefs about science and industry. Those institutional revisions then precipitate changes to the institutions’ architectures and geographic
locations. These histories suggest how changes in the physical buildings also precipitate changes in their institutional missions and the means by which those missions are pursued.

**Addressing Economic Recession and Urban Decay: Science Center Architecture and Location as Agents of Urban Renewal**

The Sputnik era was characterized by a united and intense belief in the value and significance of scientific research, which bolstered enthusiasm for expanding and improving science education. The exigence for improved education was addressed in many ways, one of which was the assertion into local communities of science center buildings and the institutions and programs they housed. Federal increases in research funding and national improvements in education gradually began to increase the number of STEM professionals; consequently, the *urgency* of the demand for science education began to diminish, as did enthusiasm and support for these kinds of educational programs. During the recession era of the late 1970s and early 1980s, economies in midwestern cities, especially, suffered decline or all-out collapse as industries that had previously sustained them, including steel and automobile production, shrank in scale. Urban decay and infrastructural deterioration followed economic decline, and policy-makers and stakeholders who had influence over science center institutions began to prioritize new exigences emerging in their communities. In particular, it became clear that immediate action to diversify the economy and revitalize urban neighborhoods was necessary for the community’s future success and well-being.
In Pittsburgh and in Columbus, Ohio, stakeholders began to reconceive institutions like COSI and the Buhl Planetarium and Institute for Popular Science as vehicles that could function to addressing those new exigences. Between 1987 and 2000, the Buhl and COSI were subject to major institutional, architectural, and geographic changes, changes stakeholders made not to improve science education, but rather to facilitate the economic and civic expansions they believed their struggling cities required. These changes also mark an important transition between the 1960s and the 1980s in how the communities in Columbus and in Pittsburgh were invited to identify with science and technology: as the exigence for science education receded in significance from the larger national context, stakeholders repositioned science and technology centers in the community, holding them up as valuable for their ability to act as one of many cultural institutions with economic and civic power. Rather than framing science as a set of valuable intellectual methods and concepts applied in future careers or current everyday activities, the new buildings performed epideictic functions—aesthetic creation of beautiful façades symbolized the scope and value of scientific and technical achievements; their buildings preserved past achievements in industry, and their refurbished exterior and interiors promised that affective celebration of science might benefit the city in the future.

The case of Buhl Planetarium and Institute for Popular Science and its merger with the Carnegie Institute demonstrates how redesigning and relocating a science center building both reflect and effect changes in institutional purpose and function. And analysis of the Carnegie Science Center’s location and architectural style demonstrate
how material and geographic changes in a building can reposition the community in relation to science. According to Roy Lubove, Pittsburgh’s economy was heavily reliant on the steel industry up until the 1980s, when the recession prompted companies like U.S. Steel to close their local plants, leaving thousands jobless and precipitating a “social tragedy” in addition to an economic one (7-8). As the steel mills closed their doors and eliminated jobs, they also withdrew the social and community services on which many Pittsburghers had become dependent. Critical concerns included the loss of gainful employment and health insurance, a public education system ill-equipped to prepare students for college, and an exodus of the young and educated (Lubove 13).

To address these issues, city and state officials agreed that they needed to encourage new public and private partnerships between corporations, government, and nonprofit organizations. Between 1982 and 1992 the city worked to diversify its economy through the development of advanced technology research, and medical, health, and educational services. Universities, especially Carnegie Mellon University (CMU) and the University of Pittsburgh, played a major role in this expansion, and federal grants allowed for universities to partner with corporate sponsors, linking businesses and universities and establishing research institutes and advanced technology centers. Favored areas of research and development included “new computer applications, biotechnology, advanced materials, robotic and intelligence systems, [and] environmental technologies” (Lubove 43).

Diversification through advanced technology, medicine, and research buoyed the failing economy, but it did not address the abysmal quality-of-life and urban decay
brought on by the steel industry’s collapse. Public officials feared that even with state and local support, the nascent technological and medical industries might fail if the city proved unable to attract and maintain a workforce to fill the new positions. Educated professionals, doctors, nurses, scientists, and engineers have great flexibility in choosing a region to live and work, and to sustain this new professional workforce, public officials had to re-envision the city as a place that could be attractive for its “recreational and aesthetic” assets and cultural opportunities (Lubove 186).

Policymakers also realized that, in addition to enhancing Pittsburgh’s quality of life, cultural institutions might also contribute to the city’s economic growth. Many local theatres were refurbished during the 1980s and resources were poured into the symphony, ballet and opera to establish a Cultural District in the city’s Gold Triangle: “The performing and visual arts, recreation, and historic preservation nurtured tourism, provided jobs, increased the tax base, and ‘averted social costs’ caused by the absence of ‘lively streets and vital neighborhoods’” (Lubove 31). Projects to beautify downtown neighborhoods accompanied these cultural developments, and local restaurants, bars, and nightclubs also benefitted from the rising number of cultural patrons visiting the area. The construction of the Carnegie Science Center on the North Shore and its opening in 1991 fits neatly into this development pattern; examining how the Buhl was reconceptualized and redesigned as the Carnegie Science Center demonstrates how its subject matter and educational function were reprioritized below the new economic and civic functions stakeholders conceived for it.
Revitalizing the Buhl institution was certainly, in part, related to its history as a pre-eminent science and technology institution in Pittsburgh. During the 1970s, Buhl Foundation trustees had discussed plans to repair and refurbish the original Art Deco structure. Reviewing the Buhl’s history and its state of disrepair in 1979, journalist Peter Leo argued that a science center symbolized the city’s value and respect for the benefits reaped from science and industry, and that a revitalization of the Buhl might propel those benefits forward into the future: “The drive for change at the Buhl stems in part from the conviction that a city whose economy owes so much to science and technology should have a pre-eminent science center” (Leo 1). But ultimately, the small endowment on which the Buhl operated could not support the large-scale improvements required, and in 1987 the Buhl Foundation’s board of trustees partnered with the Commonwealth of Pennsylvania and the City of Pittsburgh to plan a new building for the Buhl on the North Shore of the Allegheny River. However, the new project also required greater numbers of building personnel and services, as well as staff trained in science education and public relations, all of which had a price greater than the Buhl Foundation could afford. Rather than re-imagine or scrap the project entirely, the Buhl’s board of directors opted to merge with the larger and more established Carnegie Institute, which was also backed by a much larger endowment (Gangewere 46). In doing so, the exigence for science education in Pittsburgh was not removed, but it was held up alongside these other, more immediate needs:

The role of science education was linked in vital ways to the future of the city. Thus there were a variety of reasons for creating a new freestanding
facility. Pittsburgh’s tourist industry could be aided by the proven ability to draw travelers to a city. City, county and state officials saw the wisdom of supporting science education in a city that was dealing with the consequences of losing its industrial base. (Gangewere 21)

The “variety of reasons” for building the new structure indicates the institution’s transition away from a primary focus on science education and towards a combination of purposes addressing the demands for it to contribute to the community’s economics, entertainment, and education.

The new Carnegie Science Center was dedicated to serving the science education needs of a diverse community. That diversity was reflected in the range of experiences they offered, including exhibits and demonstrations offering initial “acquaintance” with science and technology, programs and classes to develop and deepen those initial experiences, and even “opportunities for excellence” for those who were “serious about careers in science, engineering and related fields” (DeSena 22). At the same time that the institution’s new director was focused on how the science center would realize these varied educational functions, the science center’s physical location answered demands for the more overt (because they had greater visual prominence for the casual citizen observer) epideictic functions for the subject of science.

By merging with the Carnegie Institute, the Carnegie Science Center received more funding, but it also put science and science education on the same cultural level as the other Carnegie institutions dedicated to art and natural history. These other institutions, focused on aesthetic experience, preservation, and celebration functions,
contributed to shifting perceptions of the Carnegie Science Center’s purpose, as did its geographic location. Situated on the North Shore of the Allegheny River, the new center was built on the grounds of a razed factory that had been used for iron smelting. Pittsburgh sold the land on this geographic site for a single dollar, a site that had been selected, in part, to honor the city’s industrial past and project forward its advanced technology future. By occupying that location the building would perform functions similar to a memorial: to both celebrate and preserve the city’s past technological achievements and to provide a communal place wherein a bright future based on science and technology could be envisioned through the range of experiences offered inside.

In addition to symbolizing the city’s past achievements and future ambitions for science and technology, the center’s location on the North Shore was also intended to frame it as an “anchor attractor” to draw visitors from out of town. It shared riverside real estate with another attraction, the nearby Three Rivers Stadium (now Heinz Field) and is just blocks from Rivers Casino and PNC Park (Figure 11); if acquiring the cultural cachet bestowed on the Carnegie Institute’s organizations was one effect of the institutional merger, perhaps an equally significant effect was realized by locating the science center alongside these sorts of attractions. Carole Blair has noted how the buildings in an area may jockey for public attention: “Texts compete, not only for attention by virtue of their existence or proximity, but also on more specific levels of materiality” (44). Positioning the science center as being one of several of the North Shore’s leisure activities also positions science education as an activity in competition with sports and gambling, activities focused exclusively on pleasure and entertainment, with no affectation of
But the Carnegie Science Center’s geographic site on Pittsburgh’s North Shore was not sufficient in itself to attract visitors to the area; stakeholders believed that its modern architectural design, particularly its visual emphasis of the state-of-the-art OMNIMAX theatre, played an important role in its ability to compete with these other...
activities. Fans arriving to watch a baseball game at Heinz Field park in the science center’s lot, and cannot miss observing the OMNIMAX theatre as they cross Allegheny Avenue to the stadium: its cylindrical shape and enormity of scale differentiate the theatre from the angular cubes and pyramids of the rest of the building’s façade (Figure 12). Its volume and its significance for the building and the institution are further emphasized by two crowning features that draw visual attention and contrast the heavy gray mass of the majority of the exterior: the institution’s name marching in large red letters (which are multi-colored at night) around its roof, and the ethereal “e-motion cone,” floating above the letters, illuminated with colored lights that change with predicted weather changes (“About Us”) (Figure 13). These features also index how the OMNIMAX theatre functions inside the center, presenting entertaining films about science that are unique for the all-encompassing and viscerally-felt visual and auditory experiences they offer. Like the other leisure attractions on the North Shore, the OMNIMAX theatre promises an affective experience, but with the advantage of the cultural cachet attached to science and the institutions affiliated with the Carnegie Institute.
Figure 12: View of Carnegie Science Center Exterior Facade from Parking Lot Approach

Figure 13: Carnegie Science Center OMNIMAX Theatre and E-Motion Cone
The Carnegie Science Center’s exterior façade—really two façades since the building is observable from across the river as well as from the approach across the center’s parking lot—was intended by the architect, Tasso Katselas, to realize the building’s “three primary components: the OMNIMAX theater, the planetarium/auditorium space, and the exhibit space” (Katselas 38). Despite Katselas’s intention for the façade to indicate a relationship between form and function, and although the Henry J. Buhl Planetarium is the historic antecedent, the planetarium space is obscured in the exterior façade. From the river view of the CSC, one can see on the far left the planetarium’s volume, but it could easily be mistaken for exhibition space, since the exterior façade in that section is marked by a flat plane, not a cylindrical form like that of the OMNIMAX theatre, whose shape suggests both its purpose and its significance (Figure 14). The difference between the overt form of the OMNIMAX theatre and the subtle plane covering the planetarium suggest that, at least architecturally, stakeholders aimed to foreground the OMNIMAX theatre—the tourist attractor—rather than the historic connections to scientific developments and public education represented by the planetarium. While one might speculate that Buhl Institute’s museum professionals were not keen to downplay the planetarium’s role in the new institution, it is likely that economic concerns of the state and city funders—as well as those of the Buhl Foundation—won out. As Lubove reminds us, “… the Carnegie Science Center could [not] have been funded without an economic, utilitarian rationale” (194).
Stepping back to examine the center’s exterior façade and grounds as a whole further suggests that the building functions to reposition science in terms that reflect city officials’ and museum professionals’ desires to make science education a leisure activity, an economic stimulus, and a realization of past and future ambitions for intellectual and economic progress and development. Built in an abstract modern style, the exterior façade symbolizes Pittsburgh’s ambitions for its high-technology future, but like the Buhl’s Art Deco home, this architecture in its geographic location also captures the particular aesthetic of the moment of its construction: a “high technology” aesthetic of
the 1990s that valued science education as an attraction and entertainment, but also as preparation for an imagined “future.” According to architectural critic Patricia Lowry, the building is constructed from Albucon (bonded aluminum and plastic), synthetic stucco, glass, and cement; together their overall effect in the completed form is, according to Lowry, an “industrial aesthetic befitting its site and surroundings” (C1). The building’s external façade is, predominately, gray, although the windows are accented with bright red. The façade’s form is not symmetric, but composed of a variety of geometric figures: cylinders, rectangular prisms, and triangular prisms. Katselas argued that the asymmetric volumes and masses suggest the building’s educational function and that it “makes no pretense at being anything other than an environment for science exhibitions” (38). He describes the exterior façade as capturing the excitement of the inside through the “motion” it depicts outside:

“On the riverside façade, the earth swoops up to the entry and the sculptural massing unfolds—revealing the volume of the Omnimax theater to the east, and the ramp atrium and auditorium to the west, connected by sweeping diagonals, and the audacious use of texture, color, walks, and bridges.” (Katselas 38)

While Katselas emphasizes how the building is meant to signify the energy behind science education in the way it “swoops” and “sweeps” as it “unfolds,” Lowry reads its “abstract Modern” style as analogous to “a high-tech research center” (C1), supporting the suggestion that the building itself is meant to memorialize Pittsburgh’s industrial past while encouraging an association between the center and the future of Pittsburgh’s own
advanced research facilities. Further, her analogy also suggests that this type of architecture—abstract modern—was associated, at the time of her writing, with a particular aesthetic association with science and technology. While this version of the “International Style” of modern architecture aimed to be “ahistorical,” Darryl Hattenhauer reminds us that its impulse to marry form and function is a product of its time, which “represented what its proponents imagined functionalism to be” (75). This modern aesthetic, evidenced in particular by the use of concrete as a material for the external façade, is one firmly situated in the early 1990s, and now resonates less with “high technology” than it does that era’s notions of efficiency and a functionalist, imagined, “high technology” future. The clutter of gray cement shapes contrasts sharply with, to cite a recent iconic example (sure to itself become equally dated), the sleek crisp lines and vivid combinations of silver, white, and primary color motifs popularized in the early 21st century by Apple Corporation.

Notably, Lowry contrasts what the Carnegie Science Center’s 1990s modern aesthetic seems to say about science and technology with what she perceives as being the goal of the science center: fun. Lowry laments that the high-tech aesthetic does not do enough to indicate the building’s leisure function:

“Clearly the building needs some visual excitement…one can't help wishing that the building weren't so very ... well, gray. The purpose of the center is to ‘educate, excite, entertain and inspire.’ Its building should aspire to the same goals. It should look like a place where interesting and fun things happen, a place where children and adults alike will see things
they've never seen before.” (C1).

Lowry’s implication, while perhaps unintentional, is that a high-tech research facility is not exciting, neither is it entertaining or inspiring. One infers from this comparison that the serious work of scientific researchers is not interesting or fun but serious, and, like the exterior of the building, gray and drab.

The building’s exterior façade presents an overall aesthetic that concretizes a moment in architectural history when asymmetric combinations of volumes and masses, combined with particular building materials suggested to audiences that “high technology” activities were happening within. Lowry suggests that this aesthetic does not do enough to represent the “interesting and fun” things—education, excitement, inspiration, and entertainment—happening inside. But I would suggest that the prominence of the OMNIMAX theatre and the building’s geographic site, situated among the other North Shore entertainments, makes clear the stakeholders’ intention for the building and the institution to function primarily as an economic engine and participant in Pittsburgh’s urban renewal. Science education is certainly still an exigence that the institution inside the building addresses, but the rhetorical purpose of the building seems less to prepare visitors to learn a set of concepts and methods than it does to position science as a vital engine of the city’s past and future economic success and development, and one that should primarily be experienced as an entertainment on par with a baseball game. The Carnegie Science Center, as new physical structure, became part of stakeholders’ response to a tripartite exigence: practical needs for managing, funding, and running a large-scale institution; the need to boost the economy and develop the North
Shore region; and the need to represent the role of high tech and research as the way forward for Pittsburgh. By re-envisioning the building and the institution to address this exigence, the center acquires a multi-tiered function itself: to increase science education; to celebrate science and technology’s role in Pittsburgh’s cultural and economic development; to attract and maintain a workforce to support the new high tech industries.

Shifting from a primarily educational purpose, the Carnegie Science Center was reconceived to celebrate a vision of Pittsburgh’s future, to stimulate the economy by providing jobs and attracting tourists, and to preserve a romanticized version of the city’s industrial past. Similarly, COSI stakeholders in the late 1980s and early 1990s “pitched” a relocation and new architectural design for the institution as the best of many possible solutions to a multifaceted problem Columbus faced. Stakeholders in Columbus aimed to achieve similar economic and civic results to those in Pittsburgh by situating a new building for COSI on the undeveloped Scioto Peninsula. Like Pittsburgh, and other cities in the “Rust Belt” at this time, Columbus was experiencing economic difficulties and looking for creative ways to diversify its economy; COSI’s redesign falls into the scheme of “urban revitalization” through cultural development. Its case differs from the Carnegie Science Center in that the move to a new building was not precipitated by an institutional reorganization (although the new building did itself precipitate some changes, as I will discuss in the next chapter). COSI is also unique in its demonstration of the means by which a building’s epideictic purpose is realized as an aesthetic creation by an elite architect, and its preservation of an existing historic structure.
Opened to the public in November of 1999, stakeholders framed the rationale for constructing a new home for COSI in terms of the building’s potential to function as an “anchor attractor,” stimulating tourism and encouraging further cultural and commercial development of Columbus’s Scioto riverfront area. This new civic and economic exigence into which a redesigned COSI could intervene is evident in newspaper coverage of the plans. According to local development journalist, Steve Wright, a primary motive in establishing the new building on the Scioto Peninsula was to transform it into a “downtown destination” (“Many Hopes and Plans,” 3). Ralph Smithers, the executive assistant for Mayor Greg Lashutka (1992-2000), made a statement that reflects the same faith in cultural revitalization demonstrated in Pittsburgh’s construction of the Carnegie Science Center:

Cities kind of change. People go out into the suburbs, then they like to come back…But they want arts, culture, a vibrant riverfront, restaurants on the street. For the first time in many years, it's all fitting together . . . COSI is the first step.” (qtd. on Wright page 3)

As a beloved fixture of the city, officials hoped that relocating COSI in a relatively undeveloped section of the city would open the door for other beneficial civic projects, including a pedestrian bridge, parks, and paths connecting COSI to other downtown destinations, such as the Veterans Memorial and the Arena District, venues for

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10 To date, there has been little success in attracting additional businesses or cultural institutions to the Scioto Peninsula. However, that may soon change: on August 13th, 2013, the Columbus Dispatch reported on a plan to raze and redesign the Veteran’s Memorial (located just north of COSI on the Scioto Peninsula) to incorporate a veteran’s museum with “an emphasis on interactive exhibits” and an outdoor, open air amphitheatre. The proposal includes opening a branch of the Columbus zoo south of COSI, “interactive indoor displays and an outdoor animal-themed playground” further enhancing this cultural district and aiming to attract more visitors and more businesses to the Scioto River area (Jarman).
sporting and musical events surrounded by restaurants and bars. COSI’s new geographic site represented a new era of cultural development for Columbus, providing “a vision of the future” that was both “dramatic and monumental...” Enthusiasm for this possible function was bolstered when the announcement that world-class architect Arata Isozaki would design a new exterior façade for the western face of the new building, a façade that, stakeholders hoped, would generate the oft cited “Bilbao Effect.” Following the announcement of Isozaki’s agreement to take on the project, Dimon R. McFerson, co-chairman of the COSI trustees' building committee, proclaimed his hope that COSI would be Columbus's “St. Louis Arch,” “Eiffel Tower” or “Statue of Liberty” (“Building a New COSI” 9A). McFerson’s enthusiasm reflects stakeholders’ ambitions for Isozaki’s design to attract tourists from across the country and the world to see the “monumental” design of a world class architect.

Significantly, the relocation of COSI on the banks of the Scioto River and the choice of a world-renowned architect for its design were not ideas proposed originally by COSI’s museum professionals. In 1989, Franklin County Commissioners purchased land east of the downtown location (further away from the river) for a $39 million expansion, but that same year several members of the Greater Columbus Chamber of Commerce proposed instead to build an entirely new structure on the Scioto Peninsula (“Building a New COSI” 9A). Embracing the proposal, COSI trustees moved forward in 1990 with an 18-month plan for a completing a new building on the Scioto River. However, the proposal met resistance from the Committee to Save Our City, which protested plans to move COSI, revealing the diversity of opinions and attitudes toward relocating COSI and
developing the Scioto Peninsula (“Building a New COSI” 9A). Stakeholders were pressured to demonstrate not only how resituating and redesigning COSI would address the economic and civic exigences, but also how those material changes would address other civic concerns, such as the desire to preserve Central High School, a historic building also located on the Scioto Peninsula.

Isozaki’s proposed design was remarkable in that it was the first to be accepted by multiple stakeholders with competing interests and concerns. In addition to conferring the considerable ethos of his architectural acumen, Isozaki’s proposal mollified groups concerned that a new COSI would mean the razing or, at least, the overshadowing of the former Central High School building:

“Isezaki’s design, incorporating the façade of the former Central High School, is the first to address the broader considerations inherent in the COSI project. It has found acceptance among the Central High alumni, Franklinton residents and those who vehemently—and with good reason—opposed the movement of COSI to the Veterans Memorial site.” (“COSI Can Do” 8A).

A seemingly resounding success, Isozaki’s design married the façade of Central High School with a new modern façade. This choice was seen as respecting Columbus’s educational past, and delighted politicians, members of commerce, a committee of Central graduates, representatives from Columbus Public Schools and the Franklin County Commissioner as well as other invested groups (Blackford “COSI Plan” 1A).
In newspaper reports published at the time, the stakeholders most pleased by the
new geographic site and the famous architect are local interest groups, politicians, and
COSI’s board of trustees; interestingly, the opinions of museum professionals responsible
for designing the exhibits, programs and content for COSI are not considered
newsworthy. The exterior façade’s union of the historic Central High building and
Isozaki’s new design aligns with Dale Sullivan’s definition of the epideictic functions
performed to realize a rhetor’s ethos, in its confluence of educational, preservationist, and
aesthetic functions (116). In interviews, Isozaki indicated his awareness of the social and
political significance of incorporating Central High into his plan. He emphasizes how his
design addresses this significance, as well as the local geographic features—the existing
skyline, the river, and Franklinton’s expanse of flat land—but barely acknowledges the
scientific educational purpose of the institution contained inside of the building:

“I have designed a building with two faces…The eastern face matches the
old, the scale of the little row of skyscrapers across the river. The scale of
the west face matches the flat land around—it doesn’t have windows, it
has tall curves of precast concrete highlighted with shining stainless steel
ribs. The old is more purely historic, the new is pure contemporary. Inside
the design is one meant to inspire a hyper experience” (Isozaki qtd. in
Wright “Japanese Architect” 4D)

Acknowledging the local social and geographic context, Isozaki also “chose a curve for
the building, because the river curves to create the peninsula…The building is very long,
but it responds to the gentle curve of the river.” (Wright “Japanese Architect” 4D). The
building’s design responds clearly to the city environs and the geographic site, but it does aim to represent the project of science within its walls (Figure 15).

Further, Isozaki’s description of the building in another interview suggests, on the part of the architect, an odd misunderstanding of COSI’s mission and its role in the community:

I was talking about what kind of building COSI is, and I thought, ‘It is not a museum. It is not a research center. It is not a performance hall. It is not a school.’
Even in all of Japan, we have no similar facility. I decided this is a cultural institution of the second half of the 20th century. (qtd. in Wright, “Kudos for Architect”)

Isozaki’s characterization of COSI as a “cultural institution of the second half of the 20th century” is surprisingly contained in the duration of its impact, particularly since Isozaki’s building opened during the last months before the 21st century began. Isozaki’s ignorance of COSI’s purpose, even after the dedication of its new building, suggests that Isozaki does not subscribe to modernist, “form follows function” architectural theory; it suggests further that the stakeholders who selected Isozaki and, along with him, his design, privileged a building that would address the exigence for urban revitalization and sophistication that an elite architect would convey, over and above a design that would echo the function of science education within.

Examining the building’s exterior façade reveals these beliefs and motives as well as the disconnect between those held by various stakeholders as they have become embedded in the structure as well. Isozaki’s style has been associated with the “metabolism” movement in architecture, a style emerging in Japan during the post-World War II era when the urgent need to rebuild entire Japanese spurred debate on the relationship between city life and its architecture. Architects engaged in “…heated debates over their conceptions of the ideal city and planned a great deal of experimental architecture and cities based on ideas of lifestyles and communities for a new era” (Mori Art Museum 1). Metabolism proposed to unite social and economic purposes and uses
with the environment, analogizing the ways that an organism’s parts work together in harmony:

As its biological name suggests, the Metabolism movement contends that buildings and cities should be designed in the same organic way that the material substance of a natural organism propagates—deftly adapting to its environment by changing its form in rapid succession. (Mori Art Museum 1)

COSI’s design is, as Isozaki states, “pure contemporary,” the Western half a definitive product of the modern architectural tradition popular in the late 1990s. The contemporary half of the building is 960 feet long—longer than three football fields—and 75 feet high (Blackford “COSI Plan” 1A). The exterior façade is comprised of 157 curving concrete and stainless steel panels to reflect the sun; these panels are “almost like a banana peel bent into a ‘clothoid’ or a ‘segment of a spiral’” (Wright “COSI’s Riverfront ‘Monster’” 1A). The overall effect is of an enormous gleaming battleship, looming windowless and inscrutable as one approaches from the parking area (Figure 16).
Significantly, one cannot actually see much of the building’s Central High School façade during a visit to COSI. One can exit COSI from the mezzanine floor out into Genoa Park, which spills out into the Riverfront Amphitheatre. From this view, Isozaki’s contemporary façade is almost imperceptible, and the Central High façade has visual prominence (Figure 17). However, the above-ground parking area for COSI, which most visitors use, lies on the building’s western side and Isozaki’s design dominates the visual field in the approach to the main doors that funnel the visitor in to the ticketing area. Visitors to COSI’s Big Science Park may trickle out on either side of the old school’s
façade, but neither Genoa Park nor the Big Science Park are likely be the primary destinations for COSI visitors. While Isozaki’s design marries the 1920s era Central High building with his Metabolist battleship, the combination embodies to a far greater extent the city’s ambitions to be augmented with this “cultural institution of the second half of the 20th century” and its reverence for its historic educational past than any explicit aims to promote science education.

Figure 17: COSI’s Central High School Facade Viewed from Genoa Park

COSI’s case is unique in its demonstration of the means by which a building’s epideictic purpose is realized through aesthetic creation. By prioritizing economic and civic functions of the new building, stakeholders repositioned science education as a
lesser priority and of lesser value in the community. Making these choices realized similar effects to those in Pittsburgh, encouraging the community to view science as a vehicle of entertainment and economic revenue, and revaluing the center not for its educational functions but for its ability to delight and contribute to the financial well-being of the city. In doing so, though, the building may also have pressured COSI to adopt institutional changes to how it represents science inside in order to accommodate and align with the building’s epideictic functions outside.

Conclusion: What Happens When Architectural and Geographic Changes Repositio

In this chapter I have demonstrated how stakeholders’ attitudes and beliefs influence how institutions are brought into being, and how those identifications with science and technology become embedded in the architectures of the buildings that enclose them, projecting forward to influence future stakeholders and visitors. In the post-Sputnik era, an exigence arose in the U.S. for new and improved science educational programs (Ogawa et al.) as well as a corresponding need to increase numbers of science professionals to regain and maintain U.S. intellectual and economic dominance in an increasingly globalized world (Wisser et al.). Science centers like COSI and the Buhl Planetarium and Institute for Popular Science were inserted on the scene as unique material responses to that educational exigence, symbolizing Columbus’s and Pittsburgh’s commitment to science education and its role in securing national economic and scientific success. Art Deco buildings, such as the Buhl Planetarium and Institute for Popular Science, symbolized the 1920s optimism and enthusiasm for the future of science
and technology, which took on a new aura of unified purpose and direction during the 1960s when the Buhl instituted its Junior Space Academy. COSI emerged during the height of Cold War anxieties, and so stakeholders captured the urgency and significance of its institutional purpose by installing it in an existing building in the heart of downtown, a place that already possessed cultural significance and authority within the community. COSI’s science courses, like the Buhl’s, aimed to transfer knowledge of basic science principles to visitors who could apply them to situations such as building their own ham radios, or mixing their own photographic chemicals. The value of science was evident in these institutions’ missions and programs, but their treatment of science was also focused on instilling in visitors explanations for phenomena that could explain past experimental results—the forensic genre—and predict their result in future applications—the deliberative genre. Each of the three rhetorical genres theorized by Aristotle were employed to instruct visitors about science.

But by the 1980s, the demand for improvements in science education programs had receded in prominence, and enthusiasm for science and science centers ebbed in kind (Dean). At the same time, industry across the U.S. was in decline, especially in the “Rust Belt,” in which the Midwestern centers in this study lie. Stakeholders, including politicians, law- and policy-makers, and local businesspeople aimed to diversify economies in their communities to address the economic fallout following industry’s decline. They turned to economic diversification through urban and civic revitalization as a new and more pressing exigence to which science center institutions could also respond, often through new geographic locations and new exterior façades that captured
the belief that science education and increased access to scientific knowledge could realize and precipitate economic progress and urban development. The diffusion of the exigence for improved science education in the Sputnik era left science as simply another cultural product and institution, like art or music, and during this era the recession spurred stakeholders to re-imagine all cultural institutions as both civic quality-of-life enhancers as well as sources of economic revenue and jobs.

When science centers are repositioned in the community to compete with other institutions performing quality-of-life functions, then their institutional missions and means of executing those missions are pressured to change in kind. As rhetorical statements made to address an exigence in a rhetorical situation with different constraints, redesigning these science centers’ buildings to address new exigences also asserted a new set of epideictic purposes for the science center that took precedence over (and constrained) the educational practices inside. COSI and the Carnegie Science Center were reimagined to function as “anchor attractors,” and to realize these economic and civic functions stakeholders contract with famous architects (in the case of COSI) or incorporate novel technologies (in the case of CSC’s OMNIMAX theatre) to entice and attract tourists from within and beyond the local community. At the same time, COSI and the Carnegie Science Center also preserve and celebrate the past through their honoring of a particular geographic location (in the case of Carnegie Science Center) or a particular architectural design (as in COSI’s marriage of Central High with the new façade) to satisfy local stakeholders’ definitions of civic enhancement while simultaneously realizing the desired “Bilbao Effect.” These various purposes may be recognized as the
“locus of characteristics” that Dale Sullivan has described as realizing an epideictic ethos, through a “constellation of purposes: preservation, education, celebration, and aesthetic creation” (116). By extending the purpose of science center buildings beyond the educational function, these buildings and situation in particular geographic locations increase the number of purposes that reposition science as an epideictic subject. In the science centers’ realization of each of these purposes, they attach the epideictic functions to the existing science education exigence, suggesting both how and why these science centers may have shifted from a balance of forensic, deliberative, and epideictic rhetoric to focus primarily on epideictic rhetoric in their exhibits and programs. Rather than presenting science as a set of methods used to explain past events or a set of concepts by which we might make predictions about future events, these buildings encourage visitors to appreciate past scientific achievements and basic concepts as engaging entertainments. They allow for pleasurable visions of future possible careers, but in a single visit they offer no substantial means of pursuing those visions.

Additionally, through these changes, the institutional purposes and missions of the science centers, often guiding and created by museums professionals, persisted in addressing the exigence to educate the public; they did not seamlessly mesh with the new functions proposed by other stakeholders for the buildings to perform. Positioned as sites of urban culture, the re-imagined science centers had to compete with other cultural and leisure institutions, while still accomplishing their missions as institutions of science education. By responding to external pressures to compete for visitors, centers like COSI and CSC are also pressured to enhance the entertainment function they perform inside, to
design the experiences in exhibits, demonstrations, and programs inside to match the epideictic functions performed outside. These competitive constraints have pressured science centers to make their science experiences as much fun as a day at an amusement park. Shrinking tax dollars and public financial support have only increased the pressure on institutions to entertain, since science centers have become increasingly dependent on admissions to generate funding for general operations, requiring that they make their exhibits even more appealing to guests if they wanted to remain solvent. In recent years, families and schools have been the only dependable audiences for science centers, which, in the competition model, requires that exhibits be designed, more and more, for younger and younger audiences.

The cases of the Carnegie Science Center and COSI demonstrate, too, how science center buildings themselves become more than just the scenes of rhetorical exchanges. Rather, if we read these buildings’ rhetorical functions according to Kenneth Burke’s dramatistic pentad, I suggest we also understand them as both agents and acts that realize the motives of stakeholders involved in decisions about these institutions. Indeed, in the case of COSI, in particular, hiring Isozaki and relocating the center on the Scioto Peninsula had little to do with the center’s institutional mission. Rather, the new architectural design and geographic site for the building realized stakeholders’ economic and civic motivations over and above any motives for science education; this emphasis on scene over educational message is evidenced by their emphasis on the building as an aesthetic creation of a famous architect, on their focus to preserve the old Central High School building, and on their drive to attract economic and civic development to the
region. As we will see in the next chapter, the decisions may have benefitted the city (although this is debatable, as the Scioto Peninsula remains relatively free of development, even 15 years after the move), but they have constrained significantly the work of museum professionals working to present science inside the museum.

These functions outside will certainly influence how visitors approach and are affected by the interior spaces of the centers. To be recognizable as science centers, these institutions still incorporate exhibits, which reproduce the rhetorical situations surrounding exhibits in the 1960s, and as I have suggested, by extension, the 1920s and late nineteenth century. As a result, exhibits reproduce the rhetorical situations, thereby and invoking the same accumulated domains of response to science display. This recapitulation is further clarified by returning to Bitzer’s characterization of how rhetorical situations may recur again and again, forming into traditions: “The situation recurs and, because we experience situations and the rhetorical responses to them, a form of discourse is not only established but comes to have a power of its own—the tradition itself tends to function as a constraint upon any new response in the form” (13). The domains of response that arose during the history of science display “…exist as rhetorical responses for us precisely because they speak to situations which persist,” and are persistent in science centers (Bitzer 13). They also constrain how visitors may respond to any exhibit that uses the modes of display that have become associated with these domains of response.

The repositioning of science performed by building geography and location may complement or contradict the valued domains of response invoked in exhibits. Mainly,
though, it encourages the visitors to see those responses to displays—the experience of wonder in the response to a taxonomy exhibit—as part of the entertainment, and as a way to make knowledge for (and in) the future. In the next chapter, I explore how decisions about architecture that reposition visitors in relation to science outside also constrain and influence the exhibit composers who represent science inside. I will demonstrate how the dominance of science centers’ function as both scene, act and agent in the visitor experience affects exhibit composition and prompts visitors to view science as an aesthetic experience, rather than a primarily intellectual or methodological one.
Chapter 4: Affecting the Exhibit: How Science Center Spaces Shape (and are Shaped by) Museum Experiences

The histories of these science center buildings and institutions reveal a diverse complex of stakeholders involved in choosing their geographic sites and shaping their exterior architectures. The buildings’ exterior architectures and geographic locations address exigences in a particular moment shaped by a city’s beliefs about and ambitions for science and science education: to stimulate the local economy and landmark the city, to draw visitors and development to particular locations within the city, and to symbolize past achievements in science and technology and inspire more. More explicitly, transformations in these buildings’ external architecture and geographic sites crystallize stakeholders’ attitudes and beliefs about the value of science education in a particular moment and project them forward: as I demonstrated in the last chapter, shifts in the wider culture’s assumptions and beliefs about science prompted stakeholders to make material changes to the Carnegie Science Center and COSI that pressured the institutions inside to serve, primarily, epideictic functions for the community. Once those decisions about architecture and location have been made, the museum professionals inside must navigate and work within the built spaces of the science center. Their work developing exhibits and educational programs continues after the buildings’ material changes have influenced, in the wider community, changing expectations about what science education ought to be and how science will be represented within.
Exhibit and program designers’ choices about what topics to display and how to display them are shaped by a complex of issues; visitor expectations and interest are key, especially as science centers strive to compete with other leisure activities in their locales. But museum professionals must balance community demands with expectations of public and private funding organizations, finite financial resources, institutional goals and missions, and time, among others. While working to accommodate these other constraints and affordances, exhibit designers are further influenced by the science center’s internal built spaces themselves, those that have been determined and shaped by the external architecture as well as the stakeholders’ visions for the interior. An important outcome of these decisions for all museums, and this study’s science centers in particular, is the space’s degree of plasticity or changeability. Science is a subject in constant motion, and in order to match that trait, built spaces must allow for flexibility in the material shape, size, and style of exhibits that they can accommodate. In turn, that degree of flexibility also dictates, to a certain extent, the content that may be presented. The lobbies, exhibition galleries, hallways, theatres, cafeterias, lighting—even the plumbing and heating and cooling requirements—of these buildings influence how exhibit designers conceptualize exhibits and their hopes for the outcome of the visitor’s museum experience.

Scholars in museum studies and architectural history have focused on the ways in which museums’ spatial characteristics intersect with exhibit content, as well as the social practices and experiences of museum professionals and museum visitors alike. John Falk and Lynn Dierking have theorized the effects that space may have on a visitor’s
experience: “Placing oneself in a particular setting is an active process. Some of what happens once one is in that setting is active, but much is passive and strongly influenced by the setting itself” (Falk and Dierking, *The Museum Experience* 63). They call attention to the relationship between museums’ physical spaces and the phenomenon of museum fatigue\(^{11}\), the difficulty children may experience learning new concepts in novel museum spaces, and the differences that experienced and novice museum-goers demonstrate in their patterns of movement through museum spaces (57-61).

Richard Toon extends the discussion of intersections between space, intellectual, and affective experiences. Focusing on science center spaces, he argues that their climate- and light-controlled environments contribute to a representation of science that invokes the “technological sublime” and separates scientific practice from its human practitioners and the lay community through a “double disconnection” (“Black Box” 28). Peter L. Galison expands the aperture beyond science centers to theorize a more general relationship between architecture and science, contending that “…space is manipulated to concentrate the meanings crystallize around the science of a time” (3). His perspective adds to those of Falk and Dierking and Toon to emphasize the *temporal* relationships between space and science representation. He suggests there are a number of ways by which architecture and science co-mingle their influence in a given moment, through the ways that architectural features are engaged in “…appropriation, adjacency, display, and

\(^{11}\) Recurring in museum studies literature for the better part in the twentieth century in museum studies, the phenomenon of museum fatigue has been characterized as the combination of mental and physical exhaustion experienced by visitors consuming large volumes of information while standing in galleries with hard, often stone floors. The incorporation of amenities such as cafeterias, carpets, benches, water fountains, and a higher volume of restrooms all may be read as attempts to ameliorate museum fatigue and extend the possible duration of a museum visit.
symbolic allusion…” (Galison 3). These practices of appropriation, symbolic allusion, adjacency may be taken up differently by different stakeholders and spaces to construct what Galison calls a “cultural and institutional identity” for the subject matter displayed.

Suzanne MacLeod, too, embraces a temporal perspective on architectural meaning: she asserts that museum spaces, through their material flexibility, can be adapted to realize a culture’s identity with a museum’s subject in different time periods. MacLeod’s view also highlights the manner in which spatial uses influence museums’ meanings. As much as we attend to the architect’s design, she contends, we should consider the ways the uses to which visitors and staff put a space continually remake that museum space and, I suggest, its available meanings (“Rethinking” 10). If we accept MacLeod’s perspective, then we ought to move beyond Falk and Dierking’s and Toon’s unidirectional focus on how the building affects its visitors, to embrace also how uses to which they put the spaces reshape and redefine them as well.

Despite the richness of scholarship in museum and architectural studies on space and science, there are far fewer rhetorical studies on the subject. Recently, Carol Blair, Greg Dickinson, and Brian Ott have intervened to address this gap, exploring the ways that material and spatial aspects of memorials and museums affect the rhetorical project of remembering and forgetting. In particular, they are invested in exploring how “…public memory is typically understood as relying on material and/or symbolic supports—language, ritual performances, communication technologies, objects, and places—that work in various ways to consummate individuals’ attachment to the group” (10). Memorials and museums provide those material memory supports to invoke group
identification; monuments memorializing the Vietnam War or the Civil Rights Movement, for example, resonate with us as places that realize this rhetorical work. Blair, Dickinson, and Ott suggest it is the very physical nature of experiencing such a place—traveling to and moving through it—that “…predisposes its visitors to respond in certain ways, enthymematically prefiguring the rhetoric of the place—at the very least—as worthy of attention, investment, and effort” (26). Although they are not places of memory, science centers function similarly to other museums and memorials: planning a visit and touring the center in and of itself frames the science within as being “worthy of attention, investment, and effort.” Memory may be central to sustaining the meanings made during a science center experience, but I suggest that these sites’ spaces function somewhat differently than those of memorials or museums dedicated to preserving past events. Most science centers aim to show unchanging principles of science, but often such institutions serve a variety of roles in their communities; their hybrid nature, in turn, affects how these places function to make particular associations with science available.

In this chapter, I use a social semiotic theoretical lens to read these science centers’ spaces themselves, examining how available meanings are shaped by exhibitions’ spatial arrangements and characteristics, their position in relation to one another, the general characteristics of the interior spaces’ overall aesthetics (including lighting, colors, materials, maneuverability, navigability), and the relationship between the exhibits and other integral elements of the museum (theatres, cafeterias, gift shops, other institutions, etc.). I then use data from interviews to explore how teams of museum professionals collaborate to compose exhibits within the physical, social, and financial
constraints inherent in the science center institution. From this analysis, I offer several conclusions: 1. Exhibit designers and the exhibits they compose in these spaces—including the meanings they can or cannot make available to visitors—are profoundly (and intentionally) influenced by epideictic functions realized in through the spaces that enclose them. The experience of the science center—its exhibits, programs, and all its constitutive spaces—is intended primarily to facilitate positive and memorable social experiences; 2. Spatial flexibility within these science centers, particular their gallery spaces, is vital for accommodating a variety of exhibit themes and styles that match the pace and volume of content produced by contemporary science; 3. Paradoxically, no matter how nuanced an exhibit’s representation of scientific practice or findings, the epideictic functions of the spaces surrounding it and other museum functions in these centers invite visitors to embrace an aesthetically and affectively satisfying narrative of science and technology as both vehicle and evidence of human progress. As exhibit designers are pressured to accommodate their work to changing attitudes towards science and education in the wider culture, it may be more difficult to do so if they do not acknowledge the meaning-making influence of the built spaces that contain their exhibitions.

Defining and Reading Science Center Spaces

In this section, I lay out the framework for analyzing the relationship between the constraints the buildings’ spaces impose on exhibit composition and the financial and social factors that engage and exacerbate the effects of those constraints. These interior spaces make available meanings that may conflict or complement the scientific meanings
available either outside the museum or inside specific exhibits. Whatever explicit messages about science are presented in exhibits’ content, the museum’s built spaces influence the visitors identifications with those messages. Yi-Fu Tuan elaborates:

“Architecture continues to exert a direct impact on the senses and feeling. The body responds, as it has always done, to such basic features of design as enclosure and exposure, verticality and horizontality, mass, volume, interior spaciousness and light” (116). This analysis describes those “features of design” and attempts to characterize the nature of their “direct impact” in forming attitudes about science.

As a starting point, I use Maree Kristen Stenglin’s definition of both “space” and “building.” In her framework, the term “space” is understood broadly, referring to both indoor and outdoor spaces; when I refer to a science center’s interior spaces, though, I focus on ones recognizable as “built spaces.” A built space is “a three-dimensional structure that comprises three intersecting planes: an overhead plane consisting of a roof and/or ceiling, a wall plane and a base plane comprising a floor” (37). The resulting space is defined and delimited by those planes. Built spaces within a science center might be as unremarkable as a fire-escape stairwell or as intentionally awe-inspiring as the massive rotunda at Cincinnati Union Terminal (Figure 18); built spaces are varied in character and purpose, and can be changed through temporary (e.g. putting up folding walls to create a private booth or stanchions to shape a waiting line) or more permanent means (e.g. tearing out a wall to create more space). The science center building, is composed of its constitutive built spaces, a whole that defines and encloses its parts: “either a single space, such as a rotunda or hall, or a series of interconnected spaces, such as the
apartments in a block of units. These in turn are comprised of numerous smaller spaces such as corridors, bedrooms and so on” (Stenglin 37).

Figure 18: Rotunda at Union Terminal

Stenglin’s analysis of a history museum complex in Australia demonstrates the use of social semiotic theory for analyzing the meanings embedded in three-dimensional spaces. Her schema extends the existing social semiotic theory used to analyze textual and visual systems of communication (Kress and van Leeuwen; Halliday and Martin; Kress, Jewitt, Ogborn and Tsatsarelis). According to social semiotic theory, written and verbal language, photographs, diagrams, and illustrations, as well as gesture and action,
each are systems of meaning-making resources; these resources each perform meaning-making functions—representational, social, and textual.

According to Stenglin, the *representational function* of a built space—what the space *construes or represents*—is manifested in both the *activities* individuals are intended to pursue in the space as well as in the space’s *structure*: how the individual is meant to construct meaning by moving through the space. In the science center, such activities might include touring an exhibit (learning), buying a souvenir (shopping), watching a scientific demonstration (learning/being entertained), or lunching in the cafeteria (eating). The cafeteria’s representational meaning, for example, is manifested in its intended activity, eating, which is specifically located and approved in this space. Importantly, though, Stenglin relates the *activities* that individuals do in a space to the institutional purpose of the building in which they do the activity (38). If the primary purpose of the science center is to educate its visitors with exhibits, that purpose should be apparent in the way that the space organizes the activities in which it invites visitors to participate. If its purpose is something more abstract—“leisure” or “inspiration,” or perhaps even all of the above—education, leisure, and inspiration—then these activities ought to be realized in the building’s spaces.

In addition to the institutional activities for which a space is designed, the space’s representational meaning is also dependent on the space’s *structure*. For example, the cafeteria may be recognized as place for eating because of its collection of grouped tables and chairs, and the presence of a formally directed line—often controlling traffic with stanchions—through which customers must proceed to select and pay for their food.
Stenglin argues that the spatial meaning can be partially derived through its structure of sequencing, either serial or orbital: meaning either accrues serially as visitors proceed through a space in time, or it is presented in an “orbital” structure, where a space’s meaning is represented through a central “nucleus” around which “satellites” may be approached, “contextualizing, elaborating, explaining and/or appraising…the nucleus” (41). She suggests that either structure may be used to organize space within a whole building or “to pattern the interconnected spaces of an exhibition” (40). For example, an exhibit on evolution—a process that proceeds through time in one direction—would likely organize its spaces and exhibits serially, proceeding in a chronological order to structure the narrative of organismal change over time. By examining the intended activities and structure manifested in science centers’ built spaces, their individual exhibit galleries as well as their series of constitutive hallways, atriums, lobbies, galleries, we can infer attitudes and ideas about science that are represented in the three-dimensional space.

Stenglin’s schema suggests that three-dimensional spaces also perform a social function, invoking individual emotional associations of security or insecurity, as well as communal feelings of association and belonging. Stenglin calls these meaning-making functions, respectively, binding and bonding: “Binding is concerned with the relationship between space and emotion while Bonding explores the patterns of interaction between the occupants of a space as well as theoretical resources for solidarity building and affiliation” (42). Either extreme of boundedness—either too constricted (as in a dark, narrow cave) or too expansive and unbounded (such as a perch on the top of a high cliff)
can make individuals feel insecure, although Stenglin suggests that “school children, in contrast, find these levels of Binding to be exhilarating and exciting” (43). But most adults feel secure in spaces that make them feel comfortably enclosed or free to safely explore, “spaces in which users feel...comfortable, safe and protected...[Spaces] do this by clearly delineating the boundaries...” (44). Safe enclosures that permit freedom to explore have specific traits that invite these feelings of security. The degree to which a built space is permeable to light and air—specifically through how the building materials and space control these elements—impacts these emotions, as does a space’s ambience:

Colour, light, texture and pattern also play a very important part in making spaces feel more or less enclosed. Light colours, up-lighting and shiny textures can considerably open up a space by making it feel more expansive; while darker hues, dim lighting and coarse textures can work together to make a space feel more firmly enclosed. (Stenglin 46)

Within three-dimensional spaces, these individual emotional responses to how the space binds visitors is also connected to another social meaning produced by the space: the degree to which the space invites bonding, or “…the attitudinal disposition of visitors in relation to spaces...its basic function is to align people into groups with shared dispositions” (Stenglin 50). Of course, rhetoricians are familiar with the concept of bonding, since it resonates strongly with the rhetorical concept of identification.

Stenglin’s schema is useful for systematically examining identification within three-dimensional built spaces, since she offers a simple, but clearly not exhaustive, catalog of four “tools” that “…materialize Bonding in the third dimension: Bonding icons,
hybridization, as well as classification and framing” (50). Bonding icons are categorized into two groups—those that “rally” and those that “privilege”: rallying icons gather people around “shared communal ideals” while privileging icons index shared meanings and “intertextually reference other people, places, values, and ideals” (50). An exhibit such as Carnegie Science Center’s Miniature Railroad performs such a rallying function. This model of an early twentieth century Pennsylvanian town displays, on a scale of 0.25:1, people at work mining coal, flying hot air balloons, playing baseball, and farming, to name just a few activities. The model functions both to rally visitors around a nostalgic representation of past local industrial achievements and privileges viewers in the present as, potentially, the descendants of those past achievers, but certainly benefiting from those past efforts. These kinds of icons, in all three centers, work to connect the space of the science center with the local communities, thereby connecting the emotions and knowledge associations inside the science center with the city itself.

Rallying and privileging icons such as the model railroad are often intentionally designed and produced aspects of a built space. But another function built spaces perform may be less intentional and more a matter of happenstance or institutional need: “hybridization” refers to the layering of meaning accrued when one space serves multiple functions. According to Stenglin, “Hybridization is very important to Bonding as it not only impacts on the ways people interact with the space but it serves to ‘recontextualize’ the values of one field to another and, in doing so, aligns people into a complex communality” (51). This significance of hybridization seems to apply particularly to museums like the Museum of Natural History and Science, which occupies Cincinnati
Union Terminal, a functioning train station that embodied an unfulfilled narrative of technological and industrial progress for Cincinnati. Although its use as a transportation hub has almost stopped entirely, the scale of the building and its 1920s architectural style project those dreams of progress onto all three museums now housed in the complex.

Hybridization is produced by the ways that multiple institutions and purposes engage together in a space. When an existing building is altered for new purposes, often construction is done to alter existing spaces or build new ones; these can then be more or less permanent and permeable. Classification and framing refer, respectively, to the degree to which a built space keeps things or people together or separate, and the strength of the physical barriers that separate or retain them (54). This aspect of science center spaces, is particularly significant for COSI as well as the Museum of Natural History and Science: COSI wrestles with the constraints of operating in a building too spacious for its needs, while the Museum of Natural History and Science operates in a historic building that cannot be easily altered. The Carnegie Science Center’s recent self-assessment and subsequent changes to their space reveal the degree to which space’s permeability and permanence impact the emotional associations with science available to visitors.

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12 In 2011 the Carnegie Science Center commissioned a self-assessment of visitor experience; rather than asking visitors to complete questionnaires about their visit after the fact, the study aimed to measure visitor response in real-time. A group of about 400 visitors were fitted with baseball caps containing sensors that would measure and record fluctuations in visitors’ alpha, beta, delta, theta, and high beta brainwaves as they navigated their visits, including the approach to the building across the parking lot, purchasing tickets, and actual experiences inside the exhibitions. Brainwave patterns were matched to emotional oppositions, such as “happy” versus “sad” or “inspired/engaged” versus “demotivated.” The brainwave measurements were then consolidated and mapped onto the locations in which the visitors experienced the fluctuations, mapping in aggregate the group’s emotional response to specific spaces (Carnegie Science Center, “Visitor Experience”).
In addition to the representational meanings and the social meanings that buildings can make available to individuals, Stenglin points to a third aspect of social semiotic meaning available in three dimensional built spaces: its *textual function*, which is “…concerned with the organization of information into a meaningful whole. In particular, textual meaning is concerned with how information is patterned so that a text ‘hangs together’. Buildings, like written and spoken texts, unfold in time. They also unfold in space” (54-55). As we will see in the analysis of museum spaces, the textual meaning of spaces and of specific exhibit spaces is highly dependent on factors and decisions that are often beyond the composing team’s control, and which nevertheless impact the associations with science made available. For reference to Stenglin’s taxonomy of spatial semiotic functions, see Table 2.
### Representational Functions

*Portraying Institutional Activities*: processes and objects; specifically, for science centers, functions are: educational, recreational, cultural,

*Activities realizing function*: learning, interacting/manipulating (in exhibit spaces), eating (in cafeteria), watching (throughout museum), learning (throughout museum?), resting (benches, cafeteria, hallways), etc.

### Social Functions

*Binding*: invites emotional responses of security (comfortably bound) or insecurity (too bound or too unbound)

*Spatial Resources affecting Binding function*: Permeability and Ambience.

### Textual Functions

*Information Value*: ways a space’s organization conveys meaning about content—ideas, objects, processes.

*Resources for realizing information value*: patterning of given and new information, impressions of what is real and what is ideal, and that which is central and peripheral

### Structure

*Structure*: The patterning of representational meanings.

*Structure* patterns content to be either:

- Serial—accruing meaning sequentially—or Orbital—where satellites elaborate, contextualize, or explain the nucleus.

*Spatial Resources affecting Bonding*: Classification/Framing Hybridization Rallying and Privileging Bonding Icons

### Bonding

*Bonding*: how space invites attitudes towards other people

### Cycles of Theme-Rheme

*Framing*: Related to the social function

*Resources realizing function*: the degree to which elements in a visual composition are connected

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**Table 2: Spatial Semiotic Functions, Resources and Available Meanings**
The social and textual functions of science center spaces are the ones that realize their epideictic functions and most directly influence the affective meanings that are made available to visitors in the museum experience. In what follows, I apply Stenglin’s schema to photographic evidence and data from interviews with museum professionals to show how these built spaces function to make available affective and intellectual associations with science. Using Stenglin’s taxonomy allows us to conduct a systematic and fine-grained reading of three-dimensional spaces in science centers; that systematically-revealed nuance help us understand how profoundly built spaces function, in Burkean terms, as both “scene” of exhibit composing processes and “agent” of epideictic rhetorical functions that further enable and constrain composing processes and available exhibit meanings. Composing processes themselves also shape and remake built spaces of the science center and their available meanings. For this reason, science centers must privilege flexibility, to allow for change and development of their spaces and exhibits in alignment with the changing and developing field of science and technology practice and content.

**Exploring Science “Stuff” in Comfort: Space’s “Binding” Function and the Science Center Experience**

Whether a science center’s space makes available feelings of security or insecurity, the degree to which it binds its visitors is, perhaps, a function that we take for granted. Until we are exposed to extremes that make us insecure—claustrophobia-inducing elevators, or the dizzying view from a mountain-top—we may not attend to how a space elicits feeling. A space’s impact on affective associations is made more salient when that space is drastically changed; for example, negative public response to COSI’s
new building was magnified by its contrast to the old one, particularly the new facility’s immense size and visual aesthetic inside. In particular, people noticed the high-ceilinged hallways: painted white and stretching the building’s entire length of the building—a building longer than three football fields—they connected space between exhibition halls with little visual adornment. A guest proceeding down the length of a hallway in 1999 saw few visual cues to indicate what exhibits she might visit until she had almost reached a gallery entrance. Visitors from the community were accustomed to COSI’s old format and design: a smaller building that was jam packed with hands-on exhibits. They responded to the new design viscerally, commenting that they felt uncomfortable and unhappy. All of the museum professionals I interviewed at COSI referenced the negative visitor response to the hallways.

The architect…had an idea…that you'd have this palate-cleanser moment of walking down this pristine hallway, and then you'd walk into the next exhibition area, where we'd have ‘Learning Worlds’…that you would walk into…[and] have this experience around this particular topic. And then you'd walk out, rest your thoughts for a moment, and then move on to the next. Visitors absolutely hated it. They just could not stand it…we were so jam packed at the old museum that everywhere you turned there was something to do. And we lost that when we moved. Part of it was that it's just a larger building, but part of it was that aesthetic of the long white hallways that the architect wanted. And visitors were like, ‘Where's the stuff?’ (Director of Strategic Initiatives, COSI)
COSI’s new interior spaces contrast sharply with the center’s original space, smaller and overflowing with the “stuff” of science with which visitors had accrued memories and associations since the institution opened in 1964. Past experiences with COSI influenced their interpretation of the new built spaces, with the difference between their memories’ representations and those presented in the new hallways sharpening their responses. In his analysis of space and place, Tuan explains how this affective response to space arises: “…the feeling of spaciousness feeds on contrast…culture and experience strongly influence the interpretation of environment” (55). While the architect intended for the hallways to invite a mental “rest” between exhibit experiences, visitors’ previous experiences at COSI had primed them to expect the full duration of a visit to be an immersive and stimulating experience. As a result, visitors found the new hallways not only violated their expectation of the nature of the “science stuff” they would find, they did it in a manner that was “stark and uninviting.”

According to Stenglin’s schema, visitors’ reactions to the blank, pristine hallways may be interpreted as responses to the feeling of being unbound. The severe ambience, “just white, nothing on the walls, nothing hanging from the ceiling,” contributed to an air of “unknowability,” that permeated the space, intimidating and alienating patrons who had visited COSI, perhaps for decades. Additionally, the fact that the immersive “learning worlds” are invisible until visitors proceeds almost to the entrances themselves—nothing protrudes from the outside to hint at contents or invite visitors to explore—speaks to the strength of the classification and framing that these hallways performed on guests.
Stenglin defines classification as the degree to which a space keeps things or people separate, while framing speaks to the “impact such physical boundaries have on the social interaction between participants within a space” (54). The high, imposing white walls of the halls contain the exhibits completely, hiding the science from view and withholding the excitement of anticipation that might build if visitors could see visual cues hinting at their content or themes. Additionally, framing is significantly affected by the strength of classification imposed by the walls: visitors in the halls are prevented from seeing other visitors inside the exhibits. Since most people intend to have a shared social experience during a museum visit, the strong framing of the white walls impairs their ability to make those positive emotional connections and to build anticipation and excitement stemming from watching others enjoying the exhibits.

The museum professionals at COSI all agreed that visitor reaction to the hallways was a problem that had to be addressed immediately. Because visitors had responded positively to the old building’s jam-packed aesthetic, COSI’s staff sought to replicate its effect by filling the hallways with colorful activities and exhibits, murals, and other displays of science art, so that one could “have an experience in the hallway as well as in the exhibit” (Director of Sustainability Initiatives, COSI). This aesthetic of expansive galleries and hallways filled with visible “stuff” harmonizes with the level of binding that Stenglin describes as “free” or “unbound.” Tuan suggests that, at least in Western culture, this aesthetic of unbounded space is attractive, since it symbolizes freedom: “Space lies open; it suggests the future and invites action” (54). Rather than stark, empty space, the colorful proliferation of mini-exhibits and art aim to stimulate the visitor at every
moment of her museum experience. Isozaki, COSI’s architect, was most pleased with the view from COSI’s mezzanine floor, where one can see the expanse of science “stuff” that is most strongly associated with COSI, including the Foucault’s Pendulum and the Unicycle:

“For myself, the most dramatic area is standing overlooking the atrium from the mezzanine floor…You can feel the space. You can see the long corridors, the foyer to the west, the old high school to the east. You can see the other side of the drum (of the Dome Theater). You can feel the vertical height in that space.” (Isozaki, qtd. in Wright)

While Isozaki clearly enjoyed the feeling of vertical height, and the length of the hallways, I suggest this view is appealing to a non-architect primarily because of the expanse of people and things that can be viewed. The Director of Exhibit Experience at Carnegie Science Center suggested that some of the most positive affective experiences visitors had at the center were in spaces where one could view, from a height, expansive “vistas” of science (Director of Exhibit Experience, Carnegie Science Center). This positive response to the “vistas” suggests that part of the excitement about science generated in the space of the science center is from observing others engage, as well as engaging oneself, with the diverse and prolific “stuff” of science. All three science centers now have such science “vistas” from where visitors can observe the activity of the science center and its exhibits (Figure 19, Figure 20; and Figure 21).
Figure 19: Vista from COSI’s Mezzanine Floor

Figure 20: Vista from Entrance to Museum of Natural History and Science at Cincinnati Museum Center
In addition to filling the stark white hallways with colorful art and mini-exhibits, COSI has also dismantled one of the walls, opening up a space on COSI’s first floor to accommodate WOSU, a local public radio station. They also have plans to tear down some of the other walls that impose such strong physical barriers between exhibit galleries and throughways, hoping to further mitigate the negative response to the space of the hallways.

Children, especially, enjoy the exhilaration of exploring and observing others interact in the visible buzz of activity in these open spaces. Tuan suggests that children respond well to a place’s “sense of spatial expansiveness,” as well the sensation that such
a place “conform[s] to their own size” (31). These expansive vistas, with their colorful exhibits inviting hands-on exploration and social interaction, illustrate Tuan’s description of how spaces invite action and exploration on a scale that, children sense, has been made “just for kids.” Inviting feelings of anticipation and excitement, the views in these spaces appeal to children’s sense of adventure, but they also appeal to parents for different reasons, as the Vice President of Experience at COSI explains:

[When the space is] a little more open parents seem to like that a lot, because they can see what's going on and where their kids are…so that's another part of being comfortable…it's a raw energy, but also a little bit of a safety factor in there…this is a place that people come and expect to let their kids to run wild and yet still be able to monitor them from a place and a lot of the architecture doesn't allow that.

This passage speaks to the emotional appeals of open science center spaces and the ways that these invite visitors to connect positive associations with a conception of science as an exploratory endeavor that they can both observe from afar or engage in directly.

The Vice President’s comment also speaks to the importance of spatial flexibility in changing its “bonding” function in the visitors’ experience; knocking down a wall requires resources, both financial and human, but changing the spaces can change the associations that people make with the institution as well as the science it represents. Other changes can be made through less dramatic alterations of the space: the Carnegie Science Center discovered that painting a gallery’s ceiling with light-colored paint, rather than black, changed its whole ambience, making it a more inviting and enjoyable place.
Although architects tend to believe it distracts visitors, the same study also found that increasing natural light by adding more windows boosts visitors’ positive associations with the spaces (Director of Exhibit Experience, Carnegie Science Center).

Spatial flexibility (or lack thereof) also came up as a key issue for staff working to build the L.I.T.E. exhibit in the Museum of Natural History and Science at Cincinnati Museum Center (hereafter, MNHS). The exhibits staff at MNHS builds traveling exhibits as well as those for the Cincinnati Museum of History, but they have not recently built an exhibit for MNHS. The staff suggests this inactivity is a consequence of both the nature of the institution—a research museum staffing scientists more engaged with research than exhibit development—but also because its building, Cincinnati Union Terminal, is protected as a historical landmark (Museum Architect et al., MNHS). Often the building itself determines what may or may not be represented in a space. As the exhibits staff strove to build a laboratory that could facilitate scientific demonstrations and hands-on application of science concepts, they encountered, repeatedly, ways in which the building itself constrained their design practices and the final result:

…We didn't have a sink in the area; we didn't even have access to water. Someone said, “I know there's an area in Natural History and Science where…we have water”…But…there was some distance between that water and that sink…in L.I.T.E. Lab. And someone said, “Well, the pipes run under the floor. We can jack-hammer...” and [the Vice President of Museums] said, “Oh, we will not be jack-hammering this floor.” So then we had to call in Facilities…to say, “…where is the closest water source?”
We then found out that the wall we were standing right by, which ended up being the back wall of L.I.T.E. Lab, there’s where all the water pipes were. And we knew that it connected to the ice cream shop above…and the restroom that was right behind … And we were able to go into that wall with a very small hole, find a pipe, connected it. And we had a donor…[and] the construction company that we were working with…was very accommodating and very supportive and said “I can do that for you for this price.” So we got the sink. (Director of Museum of Natural History and Science at Cincinnati Museum Center)

In this anecdote, the built space itself determines, in part, what the laboratory can represent: the wall with the water ends up being the back of the laboratory, and the exhibit is located in proximity to “the ice cream shop above” and the “restroom right behind,” because of the constraints imposed by the space, rather than through any design logic accommodating flow of visitor movement or meaningful connection between exhibits within the space. The lack of flexibility in MNHS influences significantly the representational and binding functions of its spaces. While it might have been easier to simply jackhammer the floor and connect another water source, all the resources involved—financial, engineering, and creative—had to accommodate and respect the limitations of working in a historical space.

Built spaces, whether historic or brand new, realize bonding functions that influence affective responses from visitors. In COSI, museum staff viewed the immediate responses to the new design’s interior spaces as detrimental to the institution’s mission.
Their manipulation of the space to incorporate “vistas” of bustling science activity suggests the powerful role of pathos in the museum experience as well as the specific manner in which manipulating built spaces can adopt those appeals to realize epideictic functions. In the example of the L.I.T.E. Lab, we can see the importance of flexibility in realizing the space’s representational function. The historical nature of the building has a profound affect on the staff’s ability to manipulate and change the space in MNHS, with consequences for its bonding function as well.

Identifying with Achievements in Science and Technology: Space’s “Bonding” Functions in Hybrid Institutions

Union Terminal’s historic architecture affects how exhibit designers operate in the MNHS, limiting their ability to change the exhibits and the other emotional associations made within the space. Much of the museum is built underground, in a space formerly housing the terminal’s parking garage and some of the train platforms. As a result, they cannot easily add windows to increase natural light or knock out support pillars to increase the openness of a space. However, Union Terminal does have spatial elements that perform a bonding function, making available positive associations with the institutions contained within it from the moment a visitor enters the building. Recall that the social function of “bonding” involves “…the attitudinal disposition of visitors in relation to spaces…its basic function is to align people into groups with shared dispositions” (Stenglin 50). Union Terminal’s Rotunda, reported by Cincinnati Museum Center to be the second largest freestanding dome next to the Sydney Opera House, is certainly an awesome and imposing space. Entering the terminal through the main doors,
one enters the open space of the 106-foot tall dome, where one’s attention is arrested immediately by the visual prominence of the enormous murals that wrap around the rotunda’s walls (Figure 22). Designed and installed by Reinhold Weiss, the murals depict the expansion of the American West, and America’s history of transportation and industry in relation to that expansion. Originally, there were fourteen murals, most of which were moved to the Greater Cincinnati Airport in the 1970s (Weible, “Cincinnati’s Gorgeous Attempt…”). The murals feature men and women dressed in the garb contemporary during American westward expansion; in the background, one can see ghostly silver renderings of various modes of transportation involved in that expansion, including steamboats (to which Cincinnati’s development and expansion are indebted), covered wagons, and steam engines.

13 The murals that were moved to the airport depicted specific Cincinnati industries, including Baldwin Pianos, WLW Radio Station, American Oak Leather Company, Kahn’s meat plant, and Ivory Soap production at Proctor & Gamble. They were moved after the city realized that the passenger traffic at Union Terminal would never again be sufficient to justify the costs of continued operation of the facility. In a fascinating contemporary twist, as of this writing the Greater Cincinnati Airport is currently making cutbacks similar to those that Union Terminal wrestled with in the 1970s; forced by budget cuts to close several gates, the murals must be moved again, but to where no one has yet decided (Weible, “Cincinnati’s Gorgeous Attempt…”).
These murals—enormous, unavoidable, and beautiful—serve as both rallying icons and privileging icons, gathering visitors around “shared communal ideals” as they “intertextually reference other people, places, values, and ideals” (Stenglin 50). The images invite viewers to place themselves within the awe-inspiring, and physically encompassing—the murals encircle the rotunda as the rotunda encircles the guests—narrative of America’s development. The entire museum visit is then framed by the attitudes elicited by the images’ invitation. The murals depict the struggle and labor involved in westward expansion, and invite both respect for that struggle and identification with the individuals who labored for progress. They are invited to associate that pride with the transportation and industry powering westward expansion, and to
connect that pride with the reverence imbued by the sheer volume of space within the rotunda. These emotions are also connected further to the values of nationalism and patriotism through the display of an enormous American flag displayed over the windows comprising the rotunda’s flat face, which looks out over the museum’s parking lot and, in the distance, the city of Cincinnati (Figure 23).

Figure 23: American Flag Displayed in Union Terminal Window Facing the City of Cincinnati
Visitors to the Union Terminal are invited to experience these emotional associations with the Cincinnati Museum Center before they even set foot within the Museum of Natural History and Science. In addition to being the space where visitors “orient” themselves to their visit, the Rotunda houses the admissions booth, cafeteria, restrooms and gift shops, which guarantees visitors will spend some portion of their visit time there. This guaranteed exposure increases the likelihood that the rotunda’s affective resonance will still be carried through to frame encounters of the vistas of science “stuff” once the visitor enters the MNHS, proper.

Carnegie Science Center and COSI also have similar privileging and rallying icons in their spaces, which function to attach the affective experience in the science center to characteristics of the local community. Science centers are generally characterized as presenting disembodied and abstracted scientific principles (MacDonald 14). But memory and nostalgia play a significant role in the social meanings embedded in these science centers’ built spaces. The Carnegie Science Center is home to the USS Requin, a World War II era submarine that “holds the distinction of being the Navy's first Radar Picket submarine” (‘USS Requin Submarine…’). Docked in the Ohio River, the vessel acts as a privileging icon, indexing the people who used it for combat and inviting visitors to, however momentarily, adopt the pride, values, and ideals that led to U.S. involvement in the Second World War. While the constricted space of the sub’s interior might invoke feelings of claustrophobia—of being too bound, too constricted—the Director of Exhibit Experience indicated that people generally enjoy this feeling, perhaps
because they can experience the exhilaration of confinement without the dangers threatening those who actually lived and worked in the submarine.

In COSI, the primary rallying icons are those that invite visitors to rally around tokens of science, but also tokens that function to “place” the science center in peoples’ memories. The Director of Sustainability Initiatives indicated that the most memorable exhibits at COSI are the electrostatic generator demonstration (also known as the “static electricity” demonstration), the Foucault pendulum, and the high-wire unicycle. Each of these is highly visible from many points in the center, and draws the visitor’s visual attention immediately upon their entrance into COSI’s lobby. Not only are these exhibits popular in other science centers, meaning that they index these other institutions and experiences of science there, they create a continuity between the institution as it existed in its earlier material instantiation, indexing past experiences at COSI, and inviting people not only to learn about static electricity, but also to reminisce about their visits to COSI with their young child, or even as a child themselves. The popularity of these science center fixtures suggests the importance of nostalgia as part of the science center experience and as a possible warrant for negative reactions to COSI’s new spaces: visitors also disliked the absence of exhibits that they had enjoyed during visits as children. The stable tokens of science may act as anchors linking generations of science experience in the institution, facilitating a sense of communal ownership of that science, an ownership violated if old exhibits are found to be missing. Director of Strategic Initiatives at COSI explains these feelings of ownership and loss in relation to those tokens that were eliminated in the move to the new building:
Every single person out there in central Ohio, or wherever they come from, they own...[COSI] as much as we ever will. And those reactions, the fact that there's such intensity to those reactions was a real lesson to me in just how true that was. The people felt so strongly about the things we did have, the things we didn't have, the things we'd lost, the things we'd gained. And you just realize, wow, this is their museum. They want it to be the way they want it to be. And you may or may not be able to always meet those needs, but you have to always keep that in mind.

(Director of Strategic Initiatives, COSI)

Visitors were disappointed that the model coal mine, a fixture of the COSI institution as it existed in its original building, was not carried over to the new design. They felt strong emotional connection to the coal mine and identified it strongly with what made COSI COSI. But this kind of threading of enthusiasm for industry and science across generations is also difficult to maintain, in large part because science, by its nature, changes. The social meanings embedded in the space of these science centers indicate just how intimately connected to the communities the institutions housed within their walls truly are. Built spaces influence how exhibits can be composed, which in turn evokes intense affective responses in visitors who are influenced by the functions of existing spaces as well as to their memories, both the constructed, collective memories of pasts, as in the Westward expansion murals, as well individual memories of particular exhibits and particular spaces. Each kind of memory involves intense nostalgia and plays into other meanings available in contemporary spaces.
From this analysis, we can see that an important social function of rallying and privileging icons in these science centers spaces is to unite the community around the value of the museum’s subject: science, industry, and technology. But as COSI’s Director of Sustainability Initiatives suggests, these icons also instill a sense of *ownership* of the subject and how it is represented. This ownership is connected to those affective responses including nostalgia; when the science changes, or an exhibit needs to be updated because of technological innovations, the emotional feeling of ownership associated with science may be displaced. The Vice President of Experience at COSI suggests that this feeling of ownership may be attributed both the museum’s history as well as how it functions within a particular community.

…Columbus is a unique place. If COSI was in any other city, we'd be just the science center and our audience would probably be [a] more well-defined group. But COSI, we're expected to be the children's museum, we're expected to be the science center; we've now become this interesting little hub for all the tech and innovation things that are happening in town. Another part of our business line is all of these events that we do for the technology companies and things in town and we've become a unique venue for those things happening…we're not necessarily a small city anymore but we often still operate like one…all those things kind of merge here.

Perhaps the main social function of science centers like COSI and the Carnegie Science Center and the Museum of Natural History and Science is to serve emerging needs of the
community, whether those needs are the education of young children, the representation of science and technology innovation, or the nurturing of local science and technology advancement. What is owned then, what scientific meanings are made available through those rallying and privileging icons, is always in flux because of the hybrid nature of these centers.

COSI’s Vice President of Experience calls attention to how a city’s size influences an institution’s role and function in its community. The mid-sized cities in this study do not have the number or diversity of museums in a New York or a San Francisco and so their centers serve a variety of community needs, and not just educational ones. This “hybrid” institutional function also affects how the space functions semiotically. Stenglin uses the term “Hybridization” to refer to the layering of meaning that accrues when one space serves multiple functions. According to Stenglin, “Hybridization is very important to Bonding as it not only impacts on the ways people interact with the space but it serves to ‘recontextualize’ the values of one field to another and, in doing so, aligns people into a complex communality” (51). Each of the science centers’ spaces are used for multiple roles, changing the overall scientific meanings made available. For instance, the MNHS occupies the space that was previously used as the taxi and bus entrance to Union Terminal when it functioned as a train station. As a result of its role in the history of transportation, the space’s prior function affects how it is used now: the physical space cannot “be changed in any way, shape, or form.” Consequently, the space is organized “randomly…There was no plan” (Architect et al., MNHS). The effect is, indeed, somewhat haphazard: a visitor walking in through the museum’s main doors encounters a
mastodon skeleton and a stuffed polar bear; walking past these specimens down a ramp they approach a totem pole marking the entrance to “Nature’s Trading Post” where children can bring in natural history items they have collected to trade for knowledge and natural history ‘prizes’ (shells, polished rocks, feathers, etc.); directly in front of this are cases with bird, mammal, and insect specimens that are rotated out regularly, but which are not connected directly to the trading post activities. Nor are they connected to the L.I.T.E. Lab exhibit, the STEM hands-on laboratory exhibit oriented perpendicularly to these cases (Figure 24).
As a result of its random organization of its space, a function of its history, the built spaces housing the MNHS recontextualize the contemporary social functions of the museum—educating the public; preserving natural history collections; representing Cincinnati’s science and technology values—and subordinates those functions to the space’s role in celebrating Union Terminal’s early 20th century promise of progress. In the case of Union Terminal and the Museum Center, these layered functions are a natural outcome of the compromises that entered into the development of Union Terminal and the institutional histories of the Cincinnati history and natural history museums. In the late 1980s, the preservation of the building became the primary rationale for relocating the history and science museums to Union Terminal in the first place; as a result, the museum’s exhibits, collections, and research take on resonances of that original purpose, and prioritize this historical meaning over manipulating the space to represent science with a cohesive structure.

This same phenomenon of hybridization operates at COSI as well, and, to some degree, at the Carnegie Science Center. COSI’s new building was constructed, in part, to symbolize Columbus’s technological future and to strengthen the local economy through cultural development of the downtown riverside area. The new building is much larger than its old home, though, and the costs of operation led almost immediately to financial problems for the institution. Staffing the widely spaced exhibits proved problematic, but even paying to heat and cool the vast space posed a significant burden. To help defray costs, COSI invited institutions with similar educational purposes to operate inside the building:
The building was probably oversized for us, just to be quite frank. Not probably; it was. That’s the whole reason we’ve got people in here like WOSU, like the OSU labs, all these folks that are in here are in here because the building was built too big for what we needed…for a science center. It could've been…at least twenty-five percent smaller, to actually do what we need it to do. (Vice President of Experience, COSI)

While the original building was constructed to house only COSI, the museum professionals discovered quickly that the space was too large for the institution’s purposes. Now COSI is home to WOSU, the local public radio station; Columbus Historical Society; Labs in Life, run by Ohio State University researchers in a space shared with the Life: the Story of You exhibit; and the Center for Research and Evaluation, a branch of COSI that does research on museum guest experiences. The building is also used to host community forums on topics including science and religion, and race (Senior Director of Experience Design and Production, COSI). Each of these functions layers and accumulates to shape the meaning of the overall space.

If COSI’s main purpose, as denoted in its mission, is to excite, inspire and educate people about science, then these other institutions, with their other purposes—communication; preservation; research; community-building and discussion—complicate that overarching goal as well as the messages they offer to achieve that goal. Is there something “scientific” about news-reporting? Does the Columbus History Society focus on the city’s scientific and industrial past? Visitors may wonder about the relationship between COSI’s scientific themes and the functions of the institutions that share its space.
Reciprocally, these other institutions are imbued with the amorphous notion of “science,” “education,” and “fun” that COSI projects as the building’s primary institution. For example, the exhibition *Life: the Story of You* occupies a shared space with Labs in Life, the laboratories run by researchers from OSU who recruit participants from the body of visitors to COSI. These labs perform research on a variety of rotating subjects; as of this writing, those include pharmacology, vision and language, and cognition (“COSI: Life”). In the past, they have also done research on physical fitness and sports science. The labs are demarcated from the rest of the exhibition by their bright overhead lighting (most of the exhibit is dimly lit) and curving glass walls that allow visitors to peer inside at the researchers (Figure 25).
The exhibition space is used for two different purposes, and the space then performs two distinct, but mutually influencing, social functions: the glass walled labs function as space defined by the activity of scientific research, how researchers perform the making or doing of science; conversely, outside the glass walls, the function of the wider exhibition space is defined by the activities of learning and leisure, learning science and/or enjoying a shared social experience. The space’s representational function is realized through multiple activities: scientific practice, scientific learning, and leisure. As a hybrid space, the Life: the Story of You exhibition space “not only impacts on the ways people interact with the space but it serves to ‘recontextualize’ the values of one
field to another” (Stenglin 51). Because it occupies the same space as the exhibition, the function of the research labs, scientific research, takes on the values and meanings made available: research is “fun,” social, a collection of facts to be consumed, and most importantly, research is framed as being self-evident in the way that hands-on exhibits make scientific concepts self-evident. Similarly, the juxtaposition inflects the exhibition’s portrayal of science with the same level of significance as the research done by the OSU scientists. Indeed, a visitor can even do science by participating in a study as a subject in the labs, or, immediately proximate to these labs, they can engage with an exhibit called “Your Performance,” where they input data on their own heart rate, strength, and flexibility. While these two activities are vastly different: one incorporates the subject into a research study, while the other invites the visitor to perform an analogous, but not equivalent, activity. The juxtaposition implies strongly, encourages visitors to take on the view, that research is simply procedure of making measurements that anyone can do. The written text accompanying the exhibit reinforces this implication by paralleling the act of comparing one’s own measurements with others to the work done by researchers in the labs:

Researchers inside the COSI Labs use a variety of tools and machines on their subjects. When they view all of this different information together, it gives them a more complete picture of a person’s fitness level. You can get a better idea of your fitness level by using this station to compare your scores to other people like you. (“Your Performance,” Life: the Story of You, COSI).
The visitor is invited to input her own data into the “machine” that gives her a “more complete picture” of how her scores compare to “other people like you,” analogizing the exhibit’s digital display with the “tools and machines” scientists use to get a “complete picture of a person’s fitness level.” The effect is to conflate the visitor’s activity in the exhibition with the researcher’s activity in the lab space nearby. This layering of meanings made available through this hybridization of space should not be thought of as “bad”; it certainly does work to connect the content of science center exhibits with that done in research laboratories. But hybridization of these spaces lends complexity to representations of science that might be difficult for a visitor, particularly a young one, to navigate.

We can see that the possibilities for such complexities are magnified and layered in these science centers hosting multiple institutions and performing multiple functions in the same spaces. In these ways, the hybridization of the science centers, used for so many different purposes: educational, social, leisure, research, historical preservation, communication, etc. shapes the associations with science that visitors may make. The ways that they may intersect and influence one another are myriad and further shaped by the values, ideas, and beliefs that visitors bring, as well as their personal interests and to what they are willing to attend during their visit. The hybrid nature of the science center building, it seems, is a necessity for institutions in the current cultural and social moment. But that hybrid nature also complicates the different meanings made available to visitors inside.
The social function of museum spaces then primarily functions in two parts: through its production of its three-dimensional built spaces the science centers produce degrees of binding eliciting emotional responses that are then connected to the rest of the museum experience; simultaneously, the space produces social meanings through its rallying and privileging icons, which may be a function of the space’s hybrid nature. The binding functions I have discussed frame the generic function of the science center as primarily epideictic; the nostalgic and nationalist functions that rallying and privileging icons realize to encourage community ownership of these institutions also seems to privilege the buildings’ epideictic functions. These rhetorical functions suggest that a visitor to the Cincinnati Museum Center might experience emotions of wonder and reverence in the openness of the immense rotunda, where they attach these feelings to the pride and respect invited by the rallying icons in the nationalistic murals of Westward expansion. The sensation of unbounded freedom elicited in the rotunda might then be connected to those narratives of national pride and development, even before a foot is set into the museum. Once inside, principles of science on display are framed by these emotional associations: the endeavors of astronauts depicted in a NASA exhibit, the findings of researchers using MRI to study mummies, or a life-size model cave environment, are each potentially connected to those meanings embedded in the museums built spaces. However, the rhetorical functions of these spaces may be altered if the museum staff has the resources to manipulate the space—changing the lighting, tearing down a wall, or adding some colorful art. But we have also seen that pressures including feelings of community ownership of the space and its contents, as well as
financial pressures, influence and shape the ways that buildings’ spaces function to elicit feelings of nostalgia, pride, nationalism, and community ownership, as well as how spatial hybridity may affect more explicit messages about science within the exhibitions themselves.

Realizing the Theme of Celebration: Textual Functions in COSI

In addition to the important social functions built spaces effect, they also realize textual functions, which work to organize a building into a meaningful whole. Stenglin describes this function as the way in which “…information is patterned so that a text ‘hangs together’” (54-55). In the same manner as spoken language or written texts, “buildings…unfold in time. They also unfold in space” (55). While this study does not track guests as the building unfurls before them in time, it is still useful to examine how these science centers organize the manner in which they themselves unfold in static space. Stenglin identifies several resources for analyzing a built space’s textual function; I focus on the principle of theme and rheme to examine these sites.(58). Generally, the principle of theme and rheme is useful for analyzing the “flow of information in space or series of interconnected spaces” in terms of how a theme “sets the scene” and “functions to orient us to that space and/or the other spaces inside the building” (Stenglin 56-57).

Signs, arrows, and maps have clear textual functions in terms of directing visitors along the accepted pathways through which they can navigate the museum. However, upon entering a museum, its “theme” can also be realized in written texts, visual and hands-on activities that prepare visitors for what kinds of “rhemes” to expect as they navigate those pathways. Theme and rheme are resources for understanding how specific built spaces
communicate something about the museum’s content, but also how to move through the spaces of the museum to encounter that content, content offering itself for the visitor’s mastery, inspiration, and enjoyment.

The concept of theme and rheme in Stenglin’s schema positions the theme as the element of the built space which does the scene-setting: “in a static snapshot of a space, the Theme or point of departure comes first and functions to orient us to that space and/or the other spaces inside the building” (57). Both COSI and the Museum of Natural History and Science have strong themes that greet visitors entering their facilities; at COSI, the visitor enters a spacious lobby; to their right as they enter is a sign for the Columbus Historical Society; to their left are guest services and the ticketing area; above their heads are strips of neon light in pink, green, and blue. But the most prominent aspect of COSI’s primary theme is the iconic Foucault Pendulum, swinging in interminable, slow arcs in front of the large orange and yellow sunburst framing COSI’s name (Figure 26).
The pendulum’s location across the lobby from the visitor creates a vector between them, what Kress and van Leeuwen have defined as a “real or virtual” line between elements in a scene that function as the “pictorial equivalent of the action verb” (166). Through its visual prominence in the direct line of sight, the pendulum draws the visitor further into the space and situates the visitor as an actor who observes, by observing the pendulum and its motion, the “goal” of the science center experience:
science. The pendulum itself signifies humans’ ability to harness and make evident a phenomenon of a grandiose scale: the (usually) imperceptible motion of the earth’s rotation. As COSI’s science “theme,” then, the pendulum positions science as being “offered” for the active visitor: science as an awe-inspiring, but stable, set of phenomena that they may consume and master. Once drawn further into the lobby by the pendulum’s mass, a second vector connects the visitor to the motion of the high-wire unicycle, 17 feet overhead, where other visitors demonstrate their mastery over gravity by confidently pedaling across the lobby’s length on a wire. A third vector connects the visitor to the “Founder’s Atrium” behind the pendulum, where the electrostatic generator demonstration show is performed. There, the dangerous, and awesome power of electricity is harnessed by visitors who act as conduits of electrical charge, as evidenced by its affects on their hair. These visual experiences comprise COSI’s primary theme, on which the rest of the center elaborates in its exhibits, programs, and spaces. Significantly, these thematic elements are the ones that COSI’s Director of Sustainability Initiatives indicates are the most vividly experienced by guests: “…they’re memorable, they want to see them when they come back.” As the “theme” for COSI, these exhibits position the other exhibitions and spaces as elaborations of these affectively compelling and highly physical experiences. These thematic elements share in common their ability to be appreciated on multiple levels: visitors may admire and enjoy them for their novelty (an enormous pendulum!), their apparent defiance of common sense (a unicycle? on a high wire?!), or their vague sense of danger or the uncanny (the boy’s hair stands up all over when he touches the static electricity generator!). But they are united in how they frame
the scientist (and by extension, the visitor) who “discovered” and explains these phenomena as able to harness and master the phenomena. These prepare guests to expect interactive, physical exhibits that have can evoke a visceral, affective response and which position the visitor as the “actor” who can acquire mastery over the “offerings” of stable scientific phenomena, all of which is further inflected with positive associations through the social functions of the spaces described above.

These aesthetic and affective responses are effects of the theme’s epideictic rhetoric: COSI’s theme functions to celebrate these tokens of science for their demonstration of human mastery over nature and their inspiration of awe; they also invite them to envision a future where they themselves might “discover” such phenomena. At the same time, a close reading of exhibit labels accompanying the Foucault Pendulum, or a brief discussion with the unicycle docent/staff reveal intellectual explanations for these phenomena. The pendulum demonstrates evidence of the earth’s rotation, and doing some light math allows you to calculate the pendulum’s period and the rate of rotation, elaborating concepts from physics and math that may be applied in other contexts beyond the single museum visit. Similarly, the unicycle docent can explain how the 250lb counterbalance drops a rider’s center of gravity down below the wire, keeping him firmly attached as he pedals; and the electrostatic generator show certainly explains the principles of physics responsible for the creation, storage, and manipulation of static electricity. These explanations of phenomena can be understood as elaborating a forensic rhetoric: by understanding these explanations, we can make predictions and inferences about future phenomena that have not yet occurred. Yet without any prompting to make
inferences or calculations, the overall effect of the text is still, primarily, celebratory in these cases: the visitor is invited to marvel at the ability of science to explain future phenomena, to even understand how such explanation might be accomplished, without pressuring the visitor to actually perform such a deliberative function.

Additionally, if we consider the audience for COSI and other science centers, we can see that epideictic functions are more readily accessible to a wider swath of the audience entering the science center. Children are certainly capable of understanding scientific concepts and are asked to do so in science classes at school. Yet because of the social experience of science centers—they have come to enjoy the day with their families—unless the family actively connects those epideictic and deliberative meanings to one another, it is likely that children, particularly young children, will only appreciate the visceral epideictic meanings. These memorable exhibits elicit visceral responses and encourage visitors to admire and thrill at the novelty of science; they also act as the building’s theme, preparing visitors to experience similar responses as they navigate the rhemes elaborated in the building’s galleries and spaces.

COSI’s exhibition galleries can be accessed via hallways that are bisected by the lobby and which extend out to the left and to the right of the primary themes. Described with terse, one-word titles, COSI’s gallery spaces are rhemes that (now) use image-rich signs and wall-art to encourage visitors to travel down the hallway and explore their subjects: Space, Adventure, Ocean, Life, Progress, Gadgets, KidSpace (Figure 27).
Significantly, most of these exhibitions, are intended to be permanent and the gallery spaces that contain them are highly-stylized and designed; consequently, they are also extremely static in terms of the scientific content that they may display. For example, \textit{Ocean} is a themed exhibition that invites visitors to “explore the physical nature of water through laminar streams, eroding sand, and energetic waves” (COSI, “Ocean”). Constructed to look like a cave or grotto, the walls of this exhibition space are styled to
look like stone; a “stone” replica of “mighty Poseidon” dominates the visual field of the main exhibition area, where water-themed, hands-on exhibits offer visitors a “mythical playground symbolizing the ancient stories of the sea” (Figure 28). (COSI, “Ocean”). A separate section of the exhibit, geared toward an older audience, contains “real ocean exploration technology…a research habitat [where one can]…use real technology such as submersibles, sonar, and remote operated vehicles” (COSI, “Ocean”). The juxtaposition of play and myth, research and technology in the exhibit is jarring, but perhaps more troublingly, it is also fairly permanent. The Foucault Pendulum, the high-wire unicycle, and the electrostatic generator could conceivably be used anywhere to produce both the visceral excitement and explanation of the scientific concept to be applied elsewhere. While Ocean might elicit excitement and visceral enjoyment, particularly in a younger visitor, it is highly dependent on the stylized aesthetics of the “grotto”; “playing” with the water cannon is likely much more compelling than reading the labels describing laminar flow, concepts that might actually be applied elsewhere.
Ad

ventur

e, a similarly static exhibition, is self-described as “dark, foreboding, and elusive…an entirely self-contained, mysterious world inside COSI.” (COSI, “Adventure”) It aims to facilitate “critical thinking and reasoning skills to find and enter a four-part code”; as visitors navigate the dimly lit space, they seek animal symbols built into areas of the exhibit and enter them into keypads in front of animatronic statues where they receive pieces of code to “obtain the Treasure of Knowledge” (Ad

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ley of the Unknown). The darkened exhibit space, made to look like weathered-stone, with its talking “great statues” is more reminiscent of a re-enactment of an Indiana Jones film than of an endeavor in “critical thinking and reasoning skills.” (Figure 29). As a constructed exhibition, a visitor may only enter the experience and crack the code one time before she is simply traveling the same paths over again. Ocean and Adventure are
beautiful and compelling, but, once explored, they are incapable of offering new experiences or information.

Additionally, if COSI wished to transform either space into a gallery displaying an exhibit on medical technologies or 3D printing, the costs of changing the shape to accommodate these new subjects would be cost-prohibitive. These “rheme” exhibitions seem to violate or complicate the “theme” exhibits that greet visitors in COSI, which may
have also contributed to visitors’ initial responses to COSI’s new building design. The Foucault pendulum, the high-wire unicycle, and the electrostatic generator are all themes that were also fixtures in COSI’s former building; their inclusion provided continuity between the old building and the new and reassured visitors as they entered that their experience would be similar. But the “rhemes” in COSI’s building provide static experiences that are awe-inspiring and exciting in their first iteration, due mainly to their aesthetic, sensory qualities and their novelty; once familiarized, there is little intellectual or deliberative function to these exhibits, and there is little possibility for them to be altered easily.

Like COSI, the Museum of Natural History and Science presents a theme on which the remainder of the museum elaborates in its rhemes; upon entering the museum doors, a vector connects the visitor and the skeleton of a mastodon (Figure 30). In front of the mastodon is a case displaying a mastodon’s jaw. Immediately to the right sits a docent ready to provide information and directions. An icon of the natural history museum and collection, the mastodon is imposingly large and very old; its visual prominence commands guests’ attention and offers itself as the epitome of the type of specimens, awe-inspiring and old, that represent the natural history knowledge museum professionals and researchers have collected. As the center’s theme, such a specimen functions similarly to what Richard Toon has described as the “technological sublime,” in which “experiences linked to technology have transcendent significance” (30). In this scenario the mastodon has similar significance, a sort of “scientific sublime” inviting the visitor to marvel at the scientists’ mastery required to identify the specimen, describe its ways of
living, analyze its age and position it in a larger narrative about the evolution of species. Significantly, the mastodon is also perhaps one of the more controversial items in the museum; the local population has a high density of evangelical Christians who occasionally visit the museum specifically to engage staff and other visitors in debates about the age of the earth (Exhibit Programs Specialist et al., Museum of Natural History and Science). For the museum, the mastodon then also represents a strong stance towards a scientific view of the earth and its age, and one that is as fixed and well-understood as the specimen itself. The rest of the exhibits in the MNHS, including *Pathways to Change*, *L.I.T.E. Lab*, *Nature’s Trading Post*, *the Cave*, *the Ice Age*, and the *Dinosaur Hall* all function as extensions and development of that certain knowledge, at which visitors are also invited to marvel.

![Mastodon at Entrance to Museum of Natural History and Science](image)

*Figure 30: Mastodon at Entrance to Museum of Natural History and Science*
These examples of science center themes and rhemes elaborate how the built
spaces inside function to perform, primarily, epideictic functions inside the museum. My
analysis has demonstrated the very specific ways that these centers’ spaces function to
shape visitors’ experiences of science: before they read a single label or watch a single
demonstration, they are inundated with semiotic texts that invoke feelings of exploration
and excitement, nostalgia and nationalism, community and cognitive mastery. It vital at
this point to note two things about these functions: 1. They are highly visual, suggesting
that for space to function as a meaning-making resource, it must primarily be experienced
visually. For visitors who are sighted, museums are inescapably visual places, and the
spatial organization and aesthetic characteristics are intimately connected to the way the
experience is conceived of as a whole. 2. Many features are already determined before
exhibit designers or curators begin working within the spaces; however, as accidents of
the architect, artists, or other stakeholders’ decisions, these social functions are powerful,
and perform aesthetic and affective functions that frame science and science education as
epideictic subjects, prior to any experiences with exhibit content or conversations with
docents or explainers.

Collaborative Composing in the Science Center: Exhibitions and Programs

Teams of museum professionals who work to design exhibitions for these science
centers are aware that built spaces affect the guests’ visit experiences. The space
influences the process of exhibit conceptualization as well as the execution of that plan.
As in the limitations imposed by word processing software, or pen and paper, the space
onto which exhibits are “written” influences how exhibitions are produced, what visitors
perceive, and the attitudes they take on about those perceptions. In the last section, I discussed the example of L.I.T.E. lab to demonstrate how Union Terminal’s status as a historic landmark constricted its spatial flexibility and required creative problem-solving to execute the plan for that exhibition. In what follows, I outline the composing processes used to generate science center exhibitions in these institutions and gesture to how the social and textual functions of spaces influence individuals inventing and constructing the designs. Social and textual functions of built spaces are a function of how those were designed for a specific time and place in the institution’s history. Their epideictic quality reflects stakeholders’ ambitions to draw tourists and generate revenue for their communities. Exhibits were also often designed by the principle of “fun” or “exciting” exploration. Here I examine how built spaces might influence exhibition composing as these science centers and their missions develop and adapt to new external influences and pressures. First, a bit of background about how exhibition composing in general is done at these institutions.

To better understand exhibition and program composing processes, I interviewed museum staff at COSI, the Carnegie Science Center and the MNHS. “Programs” are the ongoing scripted and unscripted educational presentations made regularly at science centers. Examples range from the elaborately planned and staged electrostatic generator demonstration, to multi-day camps and school programs, to extemporaneous conversations between guests and volunteers who staff traveling science carts. These programs are not categorized as “exhibitions” because they vary by audience, content, and time allotment, and often require different resources and materials than exhibits.
Exhibitions require planning, design, and construction of interpretive materials installed in galleries and maintained, often with little alteration, for years. They are usually more costly than programs, and more likely to be funded by an external source, rather than general operating funds. While programs always involve some form of social interaction between the program lead, demonstrator, or volunteer, staffing exhibits full time with trained docents is often prohibitively expensive, and so interactions between visitors and “explainers” in the exhibition spaces is not always possible. Despite the differences between programs and exhibitions, the same teams of people use similar processes to conceptualize and plan them.

Exhibitions at the centers in this study are always collaborative compositions. Individuals may act as “project sponsors,” providing much of the creative direction and oversight for developing an exhibition or program, but a team of individuals is required to complete all of the tasks involved: propose a theme or topic; research relevant information; winnow and hone topical content; brainstorm which communicative modes to incorporate and for which purposes; and to design and fabricate the physical elements of the exhibitions themselves, including labels, graphics, interactive exhibits, and others. Team members come from a variety of backgrounds and work under a variety of titles at different institutions, but their functions seem to be similar: project sponsors, project managers, floor staff, exhibit designers, graphic designers, fabricators, technicians, architects, educators, content specialists, and expert consultants. Professionals come to museum work via a variety of educational paths, and more often than not, hold degrees that are not directly connected to museum collections or display. Participants in my study
held bachelors and masters degrees in history, archeology, anthropology, physics, entomology, education, communication, theatre and film, fine arts, architecture, and other fields.

This variety also extends to those doing the research legwork on the scientific topics to be represented; a degree in science is not required, but all three science centers involve in their research processes expert consultants from local universities and research institutions. Content specialists and researchers on exhibit teams act as hubs in a network, funneling and consolidating information on the exhibition’s topic from their sources, including expert consultants, experts who might be tenured faculty at universities or experts from private corporations such as American Electric Power, scientific journals, and internet sources such as the Association for Science and Technology Center’s Exhibit Files and databases of interactive activities, such as howtosmile.org.

The methods for inventing exhibit content and form used by the Carnegie Science Center and the Museum of Natural History and Science are less delineated than COSI’s, but all three institutions currently consider state standards when designing their exhibits and programs. The Carnegie Science Center employs educators and content experts, in addition to their designers and floor staff who regularly interact with visitors. They involve all members of staff who work with or around exhibits in the invention process; topics are often selected because they align with state standards or touch on local science and technology innovations. Once a topic is selected, individuals in the group brainstorm ways of conveying the topic through a dialectic process of debate and compromise:
Everybody gets a voice at the table, but then I do try to have some sort of neutral mechanism to narrow down the topic, so we're not just picking all the stuff we like and missing things... because we don't like them... Like with Human Body, we just sort of sit down... but there are a hundred things that we can cover in the human body that match the standards, and then we just put cards around the wall and try to lump things together to figure out how we want to do it... I try to get people to rank things based on their area of expertise... And so that narrows it down, and I mean 80% of it is “Everybody's OK with this set of exhibit ideas, but for some reason somebody really liked this idea and somebody else really hated it. Let's talk about what the problem with it is.” Or, “Nobody was interested in this at all, why wasn't anyone interested in this one?” Because it can't come down to a popularity contest... Everybody has to be willing to accept that 20% of the exhibit isn't going to interest them. (Director of Exhibit Experience, Carnegie Science Center)

Exhibits staff at the Carnegie Science Center, then, dialectically decide on how to represent a topic, speaking from their areas of expertise. For example, a fabricator might object to a particular interactive exhibit because it is too costly to produce or too difficult to maintain; a whole exhibit station and its components in the RoboWorld exhibition had to be redesigned and rebuilt when it was found that the original exhibit put small children into (minor) physical danger (Director of Exhibit Experience, Carnegie Science Center). In the initial invention process, though, content specialists, educators, designers, and floor
interpreters each speak from their areas of interest and expertise to brainstorm and assess the best ways of speaking to their audience.

Inventing the Exhibition: Conceptualizing Content and Design Under Financial, Social, and Material Constraints

Studying the process of invention for designing exhibitions illustrates the constraints that influence choices about what scientific content to display and how to best convey it. Additionally, reading these exhibition design processes in the context of the built spaces that contain them demonstrates another dimension to how built spaces themselves function as meaning-making resources. Here, I analyze how designers generate exhibit content and themes and the communicative modes to convey them. I observed in my interviews an emerging focus on designing exhibits and exhibitions with more explicit cognitive outcomes, which I suggest represents a shift in the wider culture’s beliefs and values regarding science and science education. Desire to realize more cognitive outcomes through their displays has also spurred designers to embrace more structured models for inventing plans for exhibitions, especially at Carnegie Science Center and COSI. But despite the best efforts of these design teams, this emphasis on cognitive outcomes may ignore the ways that built spaces’ affective functions may prime guests to experience exhibitions aesthetically, positioning celebration or aesthetic creation as equally, or more valuable, than educational or cognitive outcomes.

Invention in exhibition design is collaborative and highly intertextual; choices about content and the modes used to communicate science have generally been developed according to non-linear and simultaneous processes, informing one another reciprocally. Interview data suggest that this simultaneity may be giving way, in some centers, to a
more standardized logical procedure. I contend that this transition in practices of invention and design may be due to external pressures all educational institutions that receive public funding are facing: to realize specific behavioral and cognitive outcomes in alignment with state and federal science standards for schools. Since the early 2000s, trends in education include increased student and teacher assessment, much of which has been developed to align with initiatives such as the Common Core State Standards (related to math and English) and the Next Generation Science Standards. To maintain their visitor base of school field trip groups, science centers have felt an increasing pressure to realign their exhibitions and programs to address those state standards as well.

Team members brainstorming specific ideas for new exhibition topics, displays, and themes draw from other museum resources and experiences to generate ideas, revealing how the *intertextual* nature of the exhibition invention process. Each of the museum professionals from the centers in this study suggested that their own frequent visits to other museums were vital for understanding how they approached exhibition design. For example, the Director of the Museum of Natural History and Science described a trip she made to Science North, a science center in Ontario, Canada, to research their trading post exhibition. During her visit, she met with colleagues and discussed the creative and budgetary issues they faced as they designed the exhibition. When she returned to Cincinnati, she used many of the ideas gleaned from consulting colleagues and visiting Science North to establish a new Nature’s Trading Post in the MNHS. But the director’s point of pride in describing this story was not just that she had been able to recreate the spirit of the Science North Trading Post exhibition, but that she
had done it at a fraction of the original’s cost. Referencing another science center’s exhibitions for ideas seems to be a common and accepted practice.\(^\text{14}\)

Visiting other exhibitions certainly influences the creative processes of exhibition designers, but they need not inspire exact replicas; instead, they may fuel more general ideas about the rhetorical efficacy of particular communicative modes. The Director of Exhibit Experience at Carnegie Science Center illustrates the generative and recursive nature of this aspect of invention as he describes how museum professionals draw from existing examples and resources. New ideas may spin off from existing examples or bodies of content, and suggest modifications for existing exhibitions designs or themes:

[Developing the content and the form is] real chicken-and-egg. Some of it-

- like with RoboWorld--it’s, “Okay, let’s go visit all the Robot Labs around and see what’s they’re working on.” And [we] see what sort of commonalities there are and what we don’t know about. Some of it is just everybody keeps up on [the scientific literature] all the time…like a human body exhibit comes up and some of our science guys say, “Oh, I’ve got a whole file of things just waiting for a Body Exhibit to pop up.” And then again, someone…will Google “Giant Heart Exhibit” and see what pops up, and it's “Hey, there’s something!” And that will spark something,

\(^\text{14}\) Significantly, interview data suggest that copyright infringement and intellectual property in the field of exhibit composition is a gray area where there are few set rules. Some exhibits are seen as “sacred” or off-limits, but poaching ideas for exhibits seems, generally to be both acceptable and standard practice, with designers suffering little compunction about lifting an idea or activity from various contexts. Perhaps this laissez faire attitude is connected to the fact that individual exhibit designers are rarely credited as “authors” of the exhibits; if anyone, exhibit signage generally credits donors or consulting experts, such as the scientists from Carnegie Mellon University who advised on RoboWorld or the scientists who generated the body of content used to write exhibit texts for The Science of Mummies.
which will spark something else, and what we come up with is generations away. (Director of Exhibit Experience, Carnegie Science Center)

This example points to the variety of processes available to generate exhibition content and form: designers visit other museums with similar exhibition themes to generate ideas for compelling content or extraordinary activities, which can then be modified for the purposes and goals of the new theme. Often staff already have a body of existing literature on a subject that they can quickly reference when the opportunity or funding surfaces. Even serendipitous Googling can be used to research existing examples or generate new ideas. A donor may approach the museum with an idea for an exhibition’s content, or even wish to donate a specific hands-on activity for an existing exhibition.

Whether a theme—such as “the human body”—or content on that theme—such as a description of circulation—or activities to convey a particular aspect of that theme—such as a 15-foot functioning model heart, arises first, any of these exhibition elements may be used to generate and refine ideas about any other aspect of an exhibition. The Director of Exhibit Experience’s description further suggests that the creative process of inventing exhibition themes, researching content, and brainstorming the best communicative modes to convey the material, is not a set of separate processes moving in a single, inexorable direction. Rather, like composing in more traditional modes, inventing exhibition themes, content, and modes is a simultaneous, generative, and recursive process.

At the Museum of Natural History and Science, the invention process is similarly simultaneous, and somewhat diffuse in structure. Interviews with the exhibitions staff suggest how external influence from donors may influence the process of invention. In
particular, when an external institution has commissioned a design, the staff may be constrained from the beginning by specific content they must display, or modes of communication they must use:

…They came to us and said, “We want an exhibit on 20 women who helped form the Civil Rights movement.” And they practically handed us a booklet that they had created. So we just took some of the women in our proposal and Ruth actually had some ideas for interactives that we threw into it… (Architect et al., MNHS)

Depending on where the theme of the exhibition originates, different paths may be followed to generate text, images, and hands-on activities. In this scenario, the exhibits staff was highly constrained by the external organization’s content; they were commissioned primarily to design labels to display the text and hands-on activities to make the material “pop.” It is interesting that the technician who made this statement suggested that they “threw into” the exhibition its interactive activities, suggesting that sometimes the relationship between content and its mode of delivery is less, rather than more, explicit in the minds of their designers. Rather than because it illustrates perfectly a process or perfectly realizes a phenomenon, images and hands-on activities are often chosen according to constraints of cost, functionality (whether an activity works), durability (whether kids will break it) and fun (whether it is appealing or engaging).

Sometimes, though, the materials are chosen to embody or realize an essential aspect of the exhibition’s message. For example, the exhibits staff at the Museum of Natural History and science completed L.I.T.E. Lab in 2011; this hands-on interactive
exhibition and demonstration space was funded in part with a grant from the Department of Energy. Accordingly, they were mandated to use particular materials to realize part of the exhibition’s message, which was primarily about scientific inquiry, but also emphasized the importance of sustainability:

…we were required to find reusable, renewable things that were…recycled, low-energy, low VOC\textsuperscript{15} and we did a pretty good job...and we saved a lot of money doing that. Plus we used Building Value\textsuperscript{16}, to rip out the old exhibit, which was an effective way to recycle all of the old stuff. So that was...depending on who gives us the money, sometimes it dictates what we're going to use, too. (Traveling Exhibits Coordinator, Exhibits Staff, Museum of Natural History and Science)

The materials were determined by the exhibition’s funding organ; the content of the exhibition was not explicitly related to the rationale for choosing DoE-approved building materials, but rather was “designed to engage creative thinking and problem-solving skills—the real tools of scientists and innovators!” (Cincinnati Museum Center, “Make New Discoveries”). The Director of the MNHS suggested that the exhibition was focused on using hands-on activities to focus on exciting children about STEM fields and that its design was influenced by visiting other exhibitions like it in other museums. The implicit message about sustainability and its significance was then embedded into the materials used to construct the exhibition itself.

\textsuperscript{15} VOC here refers to “volatile organic compounds,” which are chemicals with high vapor pressure at room temperature, and which can have negative environmental and health effects. \textsuperscript{16} Building Value is based in Cincinnati, and is a “nonprofit social enterprise that salvages reusable materials for sale to the public. Our efforts help the environment, reduce the cost of disposal, and give architectural gems a second life” (Building Value).
Other interviewees at MNHS or CSC referenced constructing hands-on activities or images primarily for their ability to effectively convey a concept, but this seemed to be an emerging principle for invention, rather than a long-term practice. Rather, engagement, and novelty—that you can’t see this at home or school—seem to be the guiding principles for designing hands-on activities. While exhibition invention is intertextual and content is generated simultaneously in brainstorming sessions where text, images, and hands-on activities are generated, content is further refined through vetting from expert resources. This indirect connection between generating content and the modes to convey it may be changing, though, and in my interviews at COSI and the Carnegie Science Center, especially, museum professionals were moving toward a more standardized system of exhibition development.

Citing the excitement he felt in an interactive electric car exhibition, the Senior Director of Experience Design and Production at COSI questioned whether excitement was an adequate response for an exhibition to elicit. While in the past, hands-on exhibitions might have been selected for just such a response, increasingly excitement is perceived as an inadequate, or partial response. The Senior Director wondered whether it might be possible to use the same medium—an interactive electric car—to convey more concrete messages about energy:

…I'm not going to go out and say, “At the Baltimore Science Museum, I saw this really cool interactive where they walk up and the car is cut in half and they push these buttons and it lights up the car and the parts of the car. I want that in my exhibit because that was fun.” That's not the case.
What I should have been saying, and this is true about that exhibit, is,

“When you walk up to the exhibit and you push these buttons, it's pretty entertaining, but at the same time, I remember that it included a fuel cell in it and this is what it taught me about the fuel cell. And it included this and this is what it taught me. And, you know, next time I buy a car, I'm going to think about that.” (Senior Director of Experience Design and Production, COSI)

The Senior Director’s example points to a recent turn in exhibition invention that puts their cognitive and behavioral outcomes or rhetorical effects at a new premium. While a compelling interactive activity may, indeed, be memorable or exhilarating, he suggests that this ought not be an exhibition’s only, or even its primary, rhetorical effect.

In the past, it was often acceptable for an exhibition to include “fun” activities with little or no interpretive text, but changes in educational curricula and funding have begun to impose pressures on exhibition designers who must now design exhibitions and programs that produce, or at least perform, more explicit educational functions. Since the 2000s, state and local school funding in the mid-west has been diminishing, pressuring districts to do away with field trips, particularly ones that can’t be shown to offer programs or experiences aligning with science education standards. Since school trips comprise a significant portion of their visitors and income—85,000 schoolchildren visit the Carnegie Science Center each year—some science centers have had to adjust accordingly. The centers in this study have reframed their programs and exhibitions, holding on to the institutional mission to inspire, but with a new emphasis on how that
inspiration can be elicited through standards-based experiences: “…we can talk about [exhibits and programs] at the fun accessible level, but if you're a teacher I can also turn around and say, ‘Here are the ten standards that you're going to hit on if you take a look at this exhibit or if you go to that theater show’” (Director of Science Education, Carnegie Science Center). Public educational institutions, even informal ones, that adhere to state and federal standards are also much more likely to continue receiving state funding.

The Vice President of Experience explains how exhibition design, in the past, could be guided by the principle of fun or excitement: “in the past we went after the coolest stuff and coolest phenomenon and coolest real things and you would put them in a collection” (COSI). Engagement is certainly still a primary outcome COSI is tasked with accomplishing in their exhibitions, but the Vice President of Experience goes on to explain how funding constraints have shifted significantly how COSI conceptualizes program and exhibition design:

…it has changed…for everyone but it has definitely changed in our community…The way people fund is completely different now, and it's really based on serving needs, having outcomes, impacting behavior, moving the needle. All that sort of jargon. STEM, making a difference in test scores…So we're moving more to [ask], “What are the outcomes of this exhibit going to be?” We know the community has this need, we know we can deliver, [and] can serve that need in a really cool way that gets people engaged.
In the past, funders could be persuaded to support exhibitions that were simply engaging, but now the expectation is that emotional engagement—fun, excitement—will be a vehicle to achieve behavioral and knowledge outcomes. Ticket sales and school trips and programs comprise 70-80% of the funds COSI requires to operate, so maintaining their base audience of school children is vital to their sustainability (Vice President of Experience, COSI).

To accommodate these pressures, and ensure that behavioral and educational outcomes are achieved, COSI has streamlined how it develops its exhibitions, delineating in a document the step-by-step process and roles individuals play in the process of developing a new exhibition or program, (“Process for Identifying a New Project for Design”). Generally, the exhibition design team begins by identifying either an audience or a topic. Sometimes topics arise organically from designers’ interests, but alternatively, a topic may be a condition accompanying the promise of a donor’s supporting funds, or it may align with an initiative the institution itself has adopted. Sometimes, donor and institutional interests may align fortuitously; for example, at the time of the interview, COSI’s team was developing an energy exhibition with funds donated by American Electric Power (AEP), the primary electricity provider for central Ohio (Senior Director of Experience Design and Production, COSI). In this scenario, AEP’s vested interest in energy matched the local community’s concerns: in 2008, COSI surveyed Columbus residents to determine the science and technology issues they prioritized, one of which was energy. From the survey results, COSI developed their Strategic Areas of Focus—Health and Medicine; Technology and Innovation; Energy and Sustainability; and Early
Childhood Education—which are frameworks from which themes and content are drawn
for programs and exhibitions (Senior Director of Experience Design and Production,
COSI). Since the community identified energy and sustainability as a key concern, it was
fortuitous that AEP was also interested in funding an exhibition on the subject.

Once the exhibit team has settled on a topic or an intended audience, they proceed
from there to conceptualize what kind of intellectual, and financial resources will be
required to create an exhibit experience that successfully realizes desired effects or
outcomes. Individuals on the design team serve specific roles in the invention, design,
and construction process. After an industry review or literature review is conducted for
preliminary research, the project sponsor creates a “logic model” that connects the
exhibit’s subject or theme with a “COSI Behavior,” which, they contend, is “…vital for
the continued life of COSI, our community and our world” (“COSI Behaviors”). COSI
Behaviors aim to elicit knowledge, skills, or attitude-based outcomes associated with six
explicit behaviors. COSI Behaviors range from those very specific to the institution of
COSI—“Invest in COSI to ensure COSI’s social, economic and environmental
sustainability” and “Share excitement for COSI science and learning with others”—to
those primarily focusing on general science, education, and community behaviors:
“Embrace science as a natural part of everyday life” and “Use science to think critically
about issues, make informed decisions and solve challenges” (“COSI Behaviors”). The
question of which behavioral outcomes to address and which communicative modes will
be used to convey the messages, is central to COSI’s invention process from the very
beginning (“Process for Identifying…”). Each exhibit need not accomplish all three
outcomes, but it must do at least one; the visitor’s museum experience—a combination of exhibits and programs—should aim to achieve these outcomes (Senior Director of Experience Design and Production, COSI).

Once an exhibition component’s outcome is determined, COSI has also built into its exhibition design procedure a process for assessing the efficacy with which an exhibition realizes that outcome. Once the “experience themes” of the project have been created, the Associate Producer generates a “component brief” wherein a “specified mode of delivery,” such as a written label, a graphic image, or a hands-on activity, is described in terms of the scientific content it will convey and the vehicle of that transmission: “what will this component convey to the specified audience?” and “what is the ‘thing’ that we will produce to convey the educational message?” Once the component has been created, a “project evaluation” is developed to conduct a “Formative Evaluation with COSI Guests, [and] Team Members…to determine if the ‘thing will convey the educational messages” (“Process for Identifying…”). This sort of internal assessment, as well as ones conducted by external organizations, such as the Institute for Learning Innovation17, were cited as valuable new tools for reimagining built spaces and exhibitions at both COSI and the Carnegie Science Center.

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17 In spring of 2012, I conducted the interview wherein the Director of Strategic Initiatives cited using the results of summative evaluations performed by the ILI to evaluate the outcomes of Innovation Showcase, exhibition they had recently opened. Soon to re-open after a hiatus period, the ILI’s new mission is to embrace “the role that lifelong, life-wide and life-deep learning, in particular free-choice learning, can play in helping to address critical issues facing the world.” (“Institute for Learning Innovation”)
Like COSI, the Carnegie Science Center exhibit designers create exhibitions and programs to achieve particular outcomes; they differ from COSI’s in name, but are similar in spirit:

…each exhibit will have three different kinds of goals: cognitive or learning from the exhibit, active—what we want to do with the exhibit. And the affective--having someone feel whatever it was- is it awe, humor, is it excitement, is it inspiration?...(emphases added; Director of Exhibit Experience, Carnegie Science Center).

These outcomes are used to concretize the exhibit’s purpose and to help the content experts winnow down the topics and information to be included. Both COSI and CSC work hard to convey relevant and accessible scientific concepts that are associated with a variety of positive emotional outcomes, including awe, humor, excitement, and inspiration. COSI calls these affective outcomes “attitudinal” behaviors, while the Carnegie Science Center’s term, “affective” speaks more to an explicitly emotional response. Such affective responses, as I discussed previously, have begun to be seen, increasingly as inadequate effects for a science center experience. Yet affective responses were, in my interviews, most often associated with hands-on activities, which are also the science center’s “bread and butter.” Perhaps, though, COSI’s streamlined model will allow for exhibit design of effective hands-on activities that convey both intellectual and affective outcomes in equal measure. Indeed, the Director of Sustainability Initiatives at COSI contended that hands-on activities may not only capture visitor’s imaginations

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more effectively than written text, they may even more compellingly and clearly convey an intellectual concept:

The “Fuels” interactive in the Innovation Showcase has four fuel pumps and each one is a different type of fuel…These are mock-ups, but they use the real hose and nozzle—we purchased the real thing. So…you're invited to plug into the vehicle mock-up, the hose, and then a little screen lights up and tells you how long it’s going to take to fuel the car with that particular fuel…People are familiar with gasoline, so the bio-fuel, the ethanol, [requires] about the same [amount of time to fill] as gasoline, but the electric car takes longer to fuel than the gasoline…We never say, “Electric cars take longer to fuel than gasoline-powered engines.” We don't say that, but [visitors] figure it out by doing the thing. So that is the knowledge outcome but we don't use a text panel to impart that. We use an experience.

This example suggests that the new and more standardized method of inventing exhibit content and design may, in fact, result in hands-on activities that realize positive emotional outcomes, but also make intellectual meanings more readily available than would written interpretations. COSI’s and the Carnegie Science Center’s models for inventing content and developing designs for their exhibitions and programs demonstrate the explicitly rhetorical nature of exhibit design invention and composition. All three science centers consider the process of inventing content as inextricably linked to an exhibition’s audience, message, and modes of delivering the message to that audience.
Examining the social, financial, and material constraints shaping exhibition invention and composition processes suggests that, without these barriers, designers could create more cognitively and affectively meaningful science exhibitions. We can imagine a team with infinite financial, intellectual, and material resources, freed to present “pure” science without the encumbrances of a donor to please or an audience to satisfy. Yet without these encumbrances, exhibitions would be addressing a vacuum; these complexities are part and parcel to the creative process behind an institution’s endeavors to represent science for the public. What the increasing attention to audience and external pressures such as educational standards do suggest, though, is that, as in the late 1990s when cultural institutions were pressured to realize economic and revenue-generating roles in their communities, science centers are now being pressured, by financial and social exigences, to realize more educational, deliberative functions yet again. Professionals working in museums ought to be aware that the outcomes they hope to realize in their exhibitions do not happen in a vacuum either. This study has aimed to demonstrate the manner in which the built spaces of these science centers realize social and textual functions conveying implicit messages about science that may prepare visitors to experience science as an affectively-inflected body of content that has been—and can be—mastered to realized technological and industrial progress. Professionals who puzzle over why their more nuanced intellectual treatment of a topic in an exhibition is overlooked may need to comes to terms with the specific ways that the semiotic spaces of their science centers not just influence their visitors emotionally, but may prime them
to understand through the screens of those experiences what they are seeing, hearing, reading, and feeling in the exhibitions in particular ways.

**Conclusions**

Built spaces realize semiotic functions beyond establishing the subject as worthy of attention. Using social semiotic theory as an analytical lens helps us read, on a fine-grained level, how these built spaces function rhetorically beyond acting as context for the rhetorical exchanges that constitute the “real” museum experience. This enriched view of material spaces suggests we attend to the ways in which these science centers’ built spaces both contain and, themselves, function as what Kenneth Burke has called *terministic screens*, both “selecting and deflecting reality” for visitors. Such spaces are overtly rhetorical in that they exhort symbolic inducement to action, even if that action is simply allowing the atmosphere of excitement and exploration to percolate into one’s conception of “science.” These particular terministic screens function, to draw from Kenneth Burke’s terminology again, as *agents* that *act* in the rhetorical situation of the visitor’s museum experience to realize the centers’ motives, their missions to excite and inspire visitors about science. As a result of the motives behind stakeholders’ designs for the exterior and interior architecture of these buildings, the social and textual functions of built spaces realize many purposes that establish these science centers’ ethos as epideictic. Dale Sullivan articulates a “constellation of purposes,” including education, celebration, preservation, and aesthetic creation that cohere to an epideictic “consubstantial space which enfolds participants.” (Sullivan 114). Through the relative
permanence of the interior spaces, it becomes difficult for exhibit curators, with new motives, to foreground a different “selection” of reality.

Applying social semiotic theory reveals clearly how the built spaces realize these epideictic purposes, and analysis of these spaces in particular has shown how they function to realize powerful celebratory, aesthetic, and educational themes. Through their social functions, the spaces celebrate and aestheticize science as an inviting, social and visual exploration of science “stuff”; the social and textual functions of these spaces also celebrate and educate about a particular version of past experiences with science and industry: both the individual (as the visitor whose memorable past experiences with the Foucault Pendulum influence present experiences) and communal (as in the didactic murals or submarine, which celebrate and represent past nationalistic achievements industrial achievement, wartime technologies, etc.). They may confer values about particular kinds of science or applications of science: for example, we see that rallying and privileging icons in the murals at the Union Terminal invite visitors to appreciate not just “technology” or “industry,” but specifically the ways in which they were applied to advance westward expansion. This visual message, composed in the 1930s, is one that we may wish to complicate with our current, revised ideas about the brutal human and environmental consequences of “progress” made during U.S. expansion. And the textual functions of exhibits acting as “themes” in these centers’ lobby spaces construct science as a set of concepts offering themselves up to the visitor as both aesthetic—scientifically sublime—as well as educational and celebratory—imminently controllable and applicable through mastery. In this fashion, museum’s built space’s functions as a primer
in the appropriate affective stances with which to understand science: science is exciting; science is important; science is beautiful; science is progress; science is fun—*you can master science*; these messages available in these spaces position the individual in relation to science, and further, tell her about how science is positioned within the broader culture.

In the last chapter, I suggested that building architecture and geographical siting of science centers, imagined and executed by stakeholders in the late 1980s and early 2000s, evidenced a shift in public culture and its attitudes and beliefs about the value and utility of science. Built to attract tourists and generate economic revenue for the city, these science centers’ architectures reflect those motives through the ways that their interior built spaces realize epideictic purposes to a greater extent than they facilitate deliberative ones. The semiotic functions from outside are then echoed inside, through these built spaces, and pose very real constraints on exhibit designers working in the present. Sometimes those constraints work in very specific material ways, such as the problems MNHS staff faced while building a sink during L.I.T.E. Lab’s construction. Beyond this kind of constraint, inflexible built spaces may also affect exhibition composers’ ability to address emerging educational exigences in the wider public sphere. We may read the increasing formalization of exhibition invention and composition procedures at COSI and Carnegie Science Center as evidence of such external exigences and pressures: as federal and state governing bodies embrace educational standards and outcomes assessment, their financial influence on these centers has begun to pressure exhibition designers to create exhibitions realizing cognitive as well as affective
outcomes. And we have likely just begun to see how these changes will influence science center development.

Pressures exerted by outside exigences have necessitated that exhibition designers adapt their processes and the material outcome of their design, a trend that will likely continue. Their ability to adapt, or demonstrate flexibility in their design, brings us back to the flexibility of the built spaces in which they work. The less flexible an exhibition, the more difficult it is for exhibit designers to accommodate changing conceptions of science and changing attitudes and exigences science centers face as they represent it. Spaces that are highly stylized, and therefore relatively static, either by design—such as COSI’s immersive “learning worlds”—or by accident of history—as in the Museum of Natural History and Science’s built spaces and materials—are often impossible or prohibitively expensive to alter, and therefore their content is similarly difficult to revise or update. The greater flexibility a space has, the more ability it has to present and update its representations of science; the less often changes can be imposed because of financial or material constraints, the more the conception of science as a frozen set of concepts is reinforced and the less the science center can adapt to changing exigences.

An additional dimension to the spatial flexibility is the epideictic quality of the science centers’ built spaces. While initiatives such as COSI’s Formative Evaluations, may ensure that exhibition ‘components’ do indeed achieve the outcomes for which they are intended, exhibitions are contained inside spaces whose semiotic functions realize particular epideictic purposes. That epideictic enclosure then inflects the content and ‘educational messages’ of the exhibits with the affective associations I have described
above. The spatial inflexibility, combined with its embedded epideictic functions, privileges one selection of reality. Exhibit curators may address that selection in their exhibitions, but the built spaces will still influence visitors’ experiences of the exhibitions they contain. More sophisticated combinations of communicative modes in exhibits to realize both cognitive and affective responses may address this issue in part. They may be able to nuance the messages about scientific practice or theory and harness those cognitive messages to the affective responses that the museum’s built spaces elicit. Yet as I demonstrated in the first and second chapters, exhibitions displaying science have a history all their own that may constrain designers’ abilities to reprise how these communicative devices represent science.

Used historically in the unique museum’s unique context, exhibitions have established a recurring rhetorical situation, as Lloyd Bitzer defines the term: “…a natural context of persons, events, objects, relations, and an exigence which strongly invites utterance” (5). Throughout (and through) the history of their use, science exhibitions in museum contexts have recapitulated the rhetorical situations in which they emerged (or very close relations to those situations): the “event” of the museum visit; the “objects” of science; and the “relations”—or underlying logic implying how the visitor ought to make sense of those objects in that event remain uniform in many respects. The exigences which exhibitions address do change, but the other factors of this rhetorical situation remain (nearly) the same. As such, as a part of that tradition of display, the new exhibitions will be constrained as Lloyd Bitzer has described: “the [rhetorical] situation recurs and, because we experience situations and the rhetorical responses to them, a form
of discourse is not only established, but comes to have a power of its own—the tradition itself tends to function as a constraint upon any new response in the form.” (13). What exhibition designers can communicate in an exhibit is influenced profoundly by how the built spaces influence visitor engagement and sense-making outside the exhibitions, as well as how the exhibitions, themselves, engage with those meanings and make ones of their own. The ways exhibitions function to communicate is, in part, due to their participation in a rhetorical tradition. In the next chapter, I analyze exhibitions to bring light to the relationship between their communicative functions and the implicit theories about science and scientific practice they imply through those functions.
Chapter 5: Concretizing Noble Science: Exploring and Problematizing how Multimodal Exhibits Accommodate Science

In the previous chapter, I demonstrated how the traits of science centers’ built spaces function to make available particular affective associations with science; the building’s material traits may celebrate technological and industrial progress, index national or local pride, or present vistas of science ripe for exploration and discovery. These associations are invoked before the visitor sets foot into a science exhibition, and may contribute to or complicate the meanings available in an exhibition. For example, expansive white walls enclosing exhibitions also close off people from one another, a visual confinement that may intimidate visitors; this affective response may then influence the visitor’s response to the presentation of science within an exhibition, “priming” the visitor to be intimidated by the exhibition’s content or quelling a spirit of adventure that might make a visitor more likely to fully explore the exhibition’s components.

The relationship between the science centers’ spatial semiotic meaning and its exhibitions’ presentation of science cannot be understood without an analysis of the exhibitions themselves. And to fully understand meaning making in exhibitions, we must look closely at their component exhibits and displays—the written signs and
explanations, the pictures, illustrations and diagrams, and the hands-on devices and manipulable gadgets, all of which combine to play an integral role, perhaps the museum’s defining role, in shaping the visitors’ attitudes towards and beliefs about what science is and what it produces. Understanding how exhibits’ multiple communicative modes combine to accommodate scientific content and practice is key to understanding the science center experience and how these science centers envision the achievement of their missions. Each of the three sites in this study cite “inspiration,” or “motivation” as a key part of their mission; these desired responses are primarily affective, and each of the sites aims to connect these responses with some aspect of science, technology, or industry. For example, COSI aims to “motivate a desire toward a better understanding of science, industry, health, and history,” while the Cincinnati Museum Center “inspires people of all ages to learn more about the world” and the Carnegie Science Center’s mission proudly proclaims that the center “delights, educates, and inspires” (CSC). Each of these missions connects those affective responses to an explicit educational goal as well—the CMC wants to inspire us to learn about the world; CSC places its educational mission between its twinned affective goals of delight and inspiration; and COSI keeps their educational claims broad, motivating a desire for better understanding, rather than guaranteeing a visit will result in such enlightenment.

Significantly, each of these sites harnesses together the educational and affective aspects of the science center mission into the form of the experience. John Falk and Lynn Dierking define the museum experience as a “gestalt” that “…includes feelings of adventure, of awe, of affiliation with loved ones or friends, and of seeing, perhaps
touching, and learning about new things” (Falk and Dierking 83-84). The Senior Director of Experience Design and Production at COSI asserts that experiences are the means by which educational and emotional aims are achieved. COSI motivates desire for scientific understanding “…through involvement in exhibits, demonstrations, and a variety of educational activities and experiences.” The Carnegie Science Center generates delight, education, and inspiration “…through interactive experiences in science and technology.” And the Cincinnati Museum Center inspires learning “… through science; regional history; and educational, engaging and meaningful experiences” (emphases added). The visitor’s “experience” of the exhibit may then be framed as fundamentally rhetorical in nature; these experiences are realized through symbolic inducement motivated by the museums’ epideictic goals of inspiration, excitement, and education. Kenneth Burke’s concept of identification suggests that visitors will be persuaded by symbolic inducement that invites them to identify some aspect of their being with an exhibit’s theme, content, or message. Experiences are characterized in these mission statements as being engaging, interactive, meaningful, educational, exciting, and delightful. As the defining element of the science center, exhibits are conceptualized and planned with these aims in mind.

An experience in an exhibit as designed by a curator might be intended then, to convey a concept or idea, inspire delight or wonder, elicit an analytical inference, or to perform of these purposes at once. In fact, I would argue that this simultaneity is the central feature of how exhibits invite visitors to identify with science: exhibits effect science—they bring into being a particular version of “science”—that, as a result of the unique museum context and special traits of the multimodal exhibit, are also intended to
be identified with *affectively*. I use “affective” here in its most commonly understood usage: relating to feelings or attitudes. Together, the realization of intellectual concepts and affective identifications comprise the museum experience, influencing (but not determining) the attitudes, beliefs, and ideas about science that are available to visitors. I view exhibits as a unique instantiation of what Burke refers to as a “terministic screen,” designed to induce visitors to associate scientific inquiry and content—explanation and demonstration of concepts, phenomena, or ideas—with affective experiences—how we should feel *about* these concepts, phenomena or ideas as well as how we should feel *around* them.

In this chapter, I concentrate on the affective responses and cognitive meanings made available through the textual, visual, and interactive modes of communication used to compose science center exhibits, as they function individually and in combination as constituents of the larger exhibition. I use social semiotic theory to produce a fine-grained analysis of exhibits from each of my three research sites to explore the semiotic function of the textual, visual, and haptic modes in a science exhibit. I define the “haptic” mode in my study as the material devices or objects that, through a guest’s physical manipulation, facilitate the construction or transfer of concepts or ideas. Based on my analysis of multimodal displays, I contend that, while textual and visual content in exhibits may work to induct visitors into a scientific worldview, haptic devices in exhibits may complicate or contradict their rhetorical function. Specifically, the haptic exhibits in this study invite visitors to perform an embodied “shorthand” of scientific inquiry; that performance then invites them to view science as a practice of careful observation.
whereby “enthymemic revelation” uncovers irrefutable fact. In this manner, these science center exhibits implicitly instruct visitors to valorize and emulate a representation of scientific practice as a combination of facile, pleasurable observation and manipulation of objects.

According to Eileen Hooper-Greenhill, the museum itself is defined for most visitors by the “experience of the displays”; through the written texts and labels, illustrations, diagrams and charts, objects and embodied audio, visual and haptic features “museums produce and communicate knowledge” (4). I define a museum exhibition as a thematically unified collection of exhibit stations, which incorporate displays of visual images, written texts, and haptic devices, which are meant to be engaged with through touch as well as sight (hearing and, less often, smell are also senses engaged in exhibits). Each exhibit station illuminates or explains some key scientific concept relating to the exhibition’s larger theme. Exhibitions are primarily experienced visually, since visitors navigate around exhibits and select which ones to engage via visual perception. All science center exhibitions in this study include textual, visual, and haptic or “hands on” communicative modes, although the proportion of each varies by museum, exhibition, and from exhibit to exhibit in a given exhibition.

Other rhetoricians have examined the relationship between the visual and the verbal in integrated text (Birdsell and Groarke; Rudwick; Finnegan), as well as how material objects function to realize scientific meanings (Daston). In particular, these scholars show how harnessing together visual and verbal components can direct the audience to understand the object of investigation through a particular disciplinary lens.
For example, Jordynn Jack’s analysis of Robert Hooke’s *Micrographia* theorizes a “pedagogy of sight” conducted through detailed illustrations and written descriptions of both the process of looking through a microscope as and the subject of observation visible through the view-finder. Hooke attempts to persuade readers not only that they are seeing scientific specimens, but also that the specimens should make them feel a specific way:

[Hooke] persuaded his readers not just to recognize microscopic specimens, but to see them in specific ways: as evidence of the mechanical philosophy Hooke espoused, as proof of God's divine creation, and as aesthetic objects viewed for pleasure as well as moral and intellectual edification. In this way, Hooke's pedagogy of sight did not just teach readers to see his microscopic specimens, but taught a specific way of seeing his microscopic objects, one imbued with ideological purpose.

(193)

Hooke wanted his readers to view the specimens in the microscope as he did, as microscopic mechanical bodies, designed by God and offering pleasure to those with the patience to examine them closely (205). The “pedagogy of sight” explained the manner in which Hooke’s verbal and visual instruction brought new objects of study into being, and advanced a particular set of attitudes to be associated with seeing those objects. His “explicit, didactic attempt to teach a new way of seeing to an audience,” proceeded from the hope that the audience would learn to see microscopic bodies according to “some motivated program,” according to the values and beliefs Hooke espoused (193).
Understanding Hooke’s combination of ideology and pedagogy is useful for understanding how science centers use exhibits to instruct visitors in seeing science as both educational—conveying scientific content—and affective—inspiring, fun, and socially valuable. With this touchstone, we can more easily see the ideological commitments that motivate exhibit design: science museums do not just present scientific concepts; they do it with the explicit (and perhaps more primary) goal of motivating future interest in science (and its potential as a career), and encouraging visitors to perceive their commonsense, everyday world through a scientific lens. For instance, the sign welcoming visitors into COSI’s *Life* exhibition instructs the visitor to relate the content in the exhibits to their own lived experiences, stating that the exhibition’s subject matter “is about the story of you – *your* Body, Mind, and Spirit.” This claim is paired with a quote attributed to Hippocrates, that directs the visitor to see direct, empirical observation as the key to truth-making in science: “We must turn to nature itself, to the observations of the body in health and in disease to learn the truth.” Before setting foot inside the exhibition, then, the visitor is directed to understand the general scientific concepts it presents as specifically applicable to herself; equally important, she is asked to view observations cataloged through her embodied perceptions as the *key to unlocking scientific truth*. Before the visitor even walks in to the exhibition, then, this pedagogy of sight tells her what she will see, but also how she should position herself in relation that seeing. More importantly, this pedagogy of sight also instructs her in specific (and problematic) ideas about scientific epistemology and method that are reinforced throughout the exhibit.
The multimodal exhibits in COSI’s *Life* exhibition are then framed through the message on the signs flanking the gallery entrance. The relationship between the textual and the visual in shaping what is seen is further developed in John Dinolfo, Barbara Heiffron, and Lesly A. Temesvari’s study of cell biology courses. Following students learning how to use microscopes to identify cell structures in various preparations, Dinolfo et al. argue that written and verbal description are vital for shaping a learner’s framework for interpreting “bio-images” through a particular disciplinary lens. They assert the priority of verbal familiarity over visual familiarity in structuring a professional cell biologist’s interpretive lens: “…our preliminary data suggests that students at this level don’t use seeing first as a way of knowing (interpreting) bio-images. They are instead dependent upon detailed, descriptive, and explanatory directions about how to “see” or “read” cells” (412). Dinolfo et al.’s study extends Jack’s “pedagogy of sight,” by emphasizing the role of verbal description for inducting novices. Oral or written description of what will be seen is required for novices to successfully interpret scientific visuals according to professional conventions. We can assume that science center exhibits are not asking visitors to approach their content according to “professional conventions,” since most visitors are young children or family members of young children. But since most visitors are young or helping to teach the young, we may assume that engagement with verbal and oral exhibit texts is vital for understanding the way of seeing science that museums hope to introduce to visitors. Taken together, Jack and Dinolfo et al. suggest that science center exhibits employ a particular pedagogy of sight, but according to their
models, consumption of written and verbal museum texts is essential for seeing science according to the center’s ideological commitments.

Studying the relationship between written texts and other communicative modes in science center exhibits allows us to infer important information about a science center’s mission and its implicit ideological values. But “hands-on,” or “haptic” exhibits are the defining feature of science centers. Partly for these reasons, and partly for others I will discuss later, haptic exhibit elements are also science centers’ most resonant or compelling modes of communication. Yet, while rhetorical studies have examined the role of visual arrangement in museum education, as of this writing, none have examined the hands-on exhibit. Jeremiah Dyehouse has documented how one display of horse evolution at the American Museum of National History functioned to demonstrate and popularize the epistemic processes of science (339). While Dyehouse suggests that the example he studies is unique in its emphasis on epistemic processes, I argue that haptic exhibits in science centers, by their nature, instruct visitors to view science as a particular kind of epistemic process. Dyehouse fears that natural history displays may be misunderstood, or harm scientific arguments or reputations (342). I suggest, similarly, that without the direction of explanatory written or verbal texts, hands-on exhibits do convey a misleading sense of how scientific knowledge is developed and how concepts are studied today. In what follows, I review the social semiotic theory I use to scaffold this chapter’s analysis.
Method: Using Social Semiotic Theory to Read Science Center Exhibits

In *Writing Science*, M.A.K. Halliday and J.R. Martin analyze scientific discourse to explore the means by which a language’s style and content function together to “construe” or create meaning. A social semiotic approach, they contend, suggests we view the unique features of scientific discourse as products of its functional history: how it developed over time, through use, to serve the needs of scientists seeking to observe, explain and report their findings to others. Scientific language, they assert, is “a linguistic/semiotic practice which has evolved functionally to do specialized kinds of theoretical and practical work in social institutions” (x). For example, passive voice constructions were developed by those writing scientific reports in order to corroborate, through written style, the writer’s ethos as a reliable, remote “witness” to the experimental phenomenon in question. A social semiotic view of a written text assumes that the discourse’s word choice and grammar, together, produce meanings. Halliday and Martin’s perspective assumes that this process of meaning-production is both a product and an effect of its uses in particular social institutions. For example, through this lens, I view the development of scientific displays of specimens, outlined in this project’s first chapter, as both a product and an effect of how natural philosophers used display in their processes of making scientific knowledge.

According to the social semiotic model, discourse has three primary functions: representational, interpersonal, and textual. The “representational” function concerns the

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18 Language is understood broadly here to encompass verbal, visual, spatial, and embodied/gestural communication; its use in theorizing meaning making systems beyond the verbal make it extraordinarily high-powered for studying museums, which are integrated texts that ask us to engage with science intellectually, emotionally, and physically.
ways that grammar and word choice are used to realize processes, relationships, circumstances, and participants (Lemke 93). For example, we tell a child that the round thing we roll towards them is a “ball,” and that the furry family pet is a “dog.” The social or “interpersonal” function concerns the way that language is used to orient the audience to the “state of affairs” that the representational functional presents, “often to indicate how true or certain the producer wishes the interpreter to take it as being, or to indicate an evaluation of it as good or bad, ordinary or surprising, necessary or obligatory, in the perspective the producer is creating for the interpreter” (Lemke 93). These functions are performed by descriptions, imperatives, and interrogatives, which respectively, offer the audience information, request the audience’s services, and request information from the audience (Halliday and Martin 27-28). For example, if I “command” the child to “be gentle with the dog,” I communicate the importance of being kind to the family pet, and orient the child to the dog as being “good” or “worthy of care.” Finally, the “textual” function of language is the means by which a sentence, a paragraph, a statement is made to “hang together” as a whole. Jay Lemke clarifies that language has a “system of organizational relations defining wholes and parts of those wholes, both in the semiotic space of the text and in the (ecosocial) interactional space of the meaning-making act itself” (94). This system of relations is recognizable in the ways that we organize statements into the Given-New, or the Theme-Rheme. For example, if I said to the child, “Remember how I said to be gentle with the dog? We softly stroke the dog’s ears; we don’t pull the ears,” my reference to the earlier statement presents what is given
(gentleness), and then my explanation of *how* to be gentle (softly stroking) is the new. Cohesive statements and texts are often the result of the textual function in language.

Like all language, scientific discourse uses each of these semiotic functions—representational, interpersonal, and textual—to realize its meanings. However, M.A.K. Halliday has argued that it also has its own unique traits, recognizable linguistic characteristics that have developed for specific purposes: technical terminology, semantic leaps, syntactic ambiguities, grammatical metaphors (nominalizations), special expressions, and taxonomies, to name just a few here (71). Written and verbal examples of scientific discourse are distinguishable from “everyday” language because of their unique grammatical features: specific terms such as “microclimate” or “gravitation” condense enormous amounts of observations, measurements, and interpretations of data into stable phenomena that are most meaningful to the experts in the social communities of ecology or physics. Nominalization explains the way that these experts, though repeated observation and measurement, come to stabilize processes and individual observation into discrete “things” that we can discuss and see. When we organize those terms into relational hierarchies and classes, we deploy technical taxonomies implying relationships that are not immediately obvious to the layperson—for example, we can discuss *types* of microclimate existing within a given ecosystem (as well as types of ecosystems), or the ways that the planets in our solar system may be categorized by mass and subsequent gravitational pull. Each of these unique traits of scientific discourse demonstrates how it functions as a resource to (re)construe everyday experience into scientific phenomena. But these unique traits can also be problematic for learners seeking
to be initiated into the scientific orientation. In science centers, the challenge for exhibit
designers is significant: everyday experience must become scientific, and scientific
phenomena, because of the varied nature of the science center audience, must be rendered
legible as part of the everyday. By framing the everyday in scientific terms, science
center exhibitions construe the world of science for visitors; following Jeanne
Fahnestock’s terminology, I call this construal the work of science “accommodation” that
museums do.

For accommodation to occur, then, for the scientific to be rendered “legible” as
part of the everyday, the science must be framed according to some culturally-defined set
of ideas that can be conventionally recognized by most members as having value for
describing “reality.” Gunther Kress and Theo van Leeuwen characterize this “fluency” as
a sign of group membership where the initiated share “… sets of abstract principles
which inform the way in which texts are coded by specific social groups, or within
specific institutional contexts.” (165). They refer to these sets of principles as “coding
orientations,” and they include among their examples the “technological,” the
“naturalistic,” the “abstracted,” and the “sensory.” Each coding orientation has its own
set of criteria, agreed upon (sometimes tacitly) by the initiated members of that
orientation’s social group, by which individuals judge whether a claim about the world is
true. Table 3 summarizes each coding orientation with its criteria and conventions for
establishing a claim’s “reality value.” Throughout this chapter, I refer to the “naturalistic”
orientation as the “common sense,” because I equate the conventions for this orientation
with those conventions with which the science center aims to make scientific terms and

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concepts legible as “common sense” or everyday. I believe the designation of the “sensory” orientation is a bit misleading, since all the orientations depend on the individual’s sensory perception and discernment; I refer to it hereafter as the “aesthetic” orientation, because its conventions invite individuals to appreciation and value the subject perceived for the pleasure it conveys through its appearance or sensation.
<table>
<thead>
<tr>
<th>Coding Orientation</th>
<th>Criteria for Establishing “Reality Value”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naturalistic (“Common Sense”)</td>
<td>The dominant orientation in western society. Shared by all members of the culture when “…they are being addressed as ‘members of our culture’, regardless of how much education or scientific-technological training they have received.” (Kress and van Leeuwen 165-6)  “Underpinning this is the belief in the objectivity of photographic vision, a belief in photography as capable of capturing reality as it is, unadulterated by human interpretation.” (Kress and van Leeuwen 163)</td>
</tr>
<tr>
<td>Abstracted</td>
<td>“used by sociocultural elites…modality is higher the more an image reduces the individual to the general, and the concrete to its essential qualities. The ability to produce and/or read texts grounded in this coding orientation is a mark of social distinction, of being an ‘educated person’ or a ‘serious artist’” (Kress and van Leeuwen 165)</td>
</tr>
<tr>
<td>Sensory (“Aesthetic”)</td>
<td>“…used in contexts in which the pleasure principle is allowed to be the dominant: certain kinds of art, advertising, fashion, food photography, interior decoration, and so on. Here colour is a source of pleasure and affective meanings, and consequently it conveys high modality…” (Kress and van Leeuwen 165)</td>
</tr>
</tbody>
</table>

Table 3: Coding Orientations and their Conventions for Establishing "Reality Value"
In science centers, accommodation involves introducing visitors who are “fluent” with conventions of “truth-making” in everyday life to the conventions required for making “true” or “real” descriptions of scientific phenomena. As socially inscribed ways of understanding texts, these orientations can also influence the production of texts, where rhetors influenced by those “sets of criteria” create written texts, images, and visuals which “speak” to an imagined audience fluent in the same criteria of the coding orientation. But Kress and van Leeuwen specify that a coded claim made according to an orientation’s principles

…is ‘interpersonal’ rather than ‘representational’. It does not express absolute truths or falsehoods; it produces shared truths aligning readers or listeners with some statements and distancing them from others. It serves to create an imaginary ‘we’. It says, as it were, these are the things ‘we’ consider true, and these are the things ‘we’ distance ourselves from…

(155)

The ‘realism’ of a particular style of visual representation, or a particular diction, is determined by the social groups who have ‘agreed upon’ criteria by which assessments of the ‘real’ or ‘not real’ are made. The credibility of a statement—textual, visual, or embodied—intended to represent a specific reality, is judged based on criteria that are established between the rhetor and the auditor. Therefore a claim interpreted according to common sense conventions will not necessarily be acceptable when interpreted by an audience evaluating the statement according to the abstracted orientation’s conventions. For example, a visitor to a natural history museum views a diorama displaying three deer:
two large and one small, one of the two larger specimens with horns. A visitor could easily interpret this scene as a “family group,” reading in the “scene” markers of the common sense orientation that privileges (western) human social groupings as the measure for understanding other animal groupings. A scientist reading the scene’s markers of the abstracted orientation might view the diorama according to conventions of animal behavior, perhaps as a representation of a female defending her offspring from a strange male.

In addition to helping us understand science accommodation in science centers, this illustration of coding orientation can help us to nuance our understanding of Burke’s concepts of “identification” and “terministic screens.” Kenneth Burke would argue that the principles that underlie the “abstracted” or “commonsense” orientations are simply distinct sets of *terministic screens*. For Burke, terministic screens are not just “sets of conventions” or “habits of mind” but a sort of filter through which we understand our surroundings. Burke argues that any terminology or use of symbols constitutes “a reflection of reality,” but also “by its very nature as a terminology it must be a selection of reality; and to this extent it must function as a deflection of reality” (1341). That is, the language and symbols we use to communicate in any given situation necessarily must direct attention to or “construct” some elements of reality while screening out our attention to others. In *A Rhetoric of Motives*, Burke argues that we can accept or reject identification with an idea, attitude, or group; in *A Grammar of Motives*, Burke suggests that the texts with which we engage the world—our terministic screens—are both selections and deflections of reality: for each choice of what to look at or engage with, in
that moment we are simultaneously choosing an infinite number of realities with which we will not engage. Conceptually, coding orientations unite the concepts of identification and terministic screens, demonstrating how the terms, ideas, and attitudes within the “realities” are already shaped by context of the social groups and ways of knowing that we have been exposed to through participation in those groups. Exhibits function as multimodal terministic screens; these integrated texts are composed with particular coding orientations, with the goal of making available specific claims about ‘reality,’ by curators and museum professionals, who themselves operate with a particular set of criteria for understanding the world they represent.

The coding orientation concept also highlights the mutually influencing aspects of science’s principles, theories, and methods, and shows how these become legible within the framework of a specific community’s ideas and beliefs. Stella Butler highlights the role of science centers in presenting not only the concepts of science, but also situating them within the scientific community, since “ideas and theories…play a social as well as cognitive function, providing a common bond between a community of practitioners, a means of uniting a group through adherence to its norms” (114). Understanding science center accommodation then involves studying how visitors fluent in the commonsense coding orientation are inducted into science’s abstracted coding orientation and its accompanying set of concepts, theories, procedures and methods. Science accommodation also involves the social aspects of how those concepts, theories, and methods are used within the scientific community to make persuasive claims in particular institutional contexts. In other words, it involves attending to how the (selective)
deployment and (selected) reception of (a determined selection of possible) terministic
screens realizes particular concepts and invites attitudes towards those concepts.

Understanding the representation of scientific content and the affective
associations attached to it in exhibits involves understanding how the claims made in
visual and haptic exhibit elements work with those written words to communicate the
“scientific” and characterize its nature. Halliday and Martin’s schema for understanding
scientific discourse focuses only on written texts, asserting that the verbal is the primary
mode by which scientific meaning is made. But science center exhibits present another
layer of complexity in using social semiotic theory for analysis: although they do possess
written texts, as compositions, exhibits employ a variety of communicative modes with
different affordances that make meaning alone and in combination with one another.
Sparring with an “Air HockeyBot” or navigating around a motion-sensing robot might
receive more of the visitor’s attention than the written explanations of their underlying
robotic processes. Individually, each of an exhibit’s modes realizes semiotic meaning, but
also, taken together as an exhibit, they make available layered meanings as the
“integrated text.”

Jay Lemke has suggested that each mode in such a multimodal composition
interacts with the others, multiplying meanings available to the audience: “meanings
made with each functional resource in each semiotic modality can modulate meanings of
each kind in each other semiotic modality, thus multiplying the set of possible meanings
that can be made” (92). In an exhibit that employs a diagram, a written description and a
haptic element, each feature may convey its own representational, social, or textual
meaning. For example, in COSI, the “Plastination” exhibit consists of a visual-written label that includes a step-by-step description of the process; the explanation also uses arrows and written cues to direct the visitor’s attention to a visual illustration of the changes cells undergo during plastination; and the ultimate result of the process: a “real” plastinated human torso which visitors may manipulate (Figure 31).

The written text performs all three semiotic functions: representational—introducing the concept of plastination as a process of preservation—interpersonal—describing for the
audience the step-by-step process with technical terminology—and textual—directing the visitor’s attention to the visual and haptic elements of the exhibit. Each of the other elements of the label—the arrows, the illustration of the cells, and the plastinated torso also realize their own semiotic functions and may interact either to enrich one another or to reduce the salience of another’s semiotic function. In this exhibit, especially, I would argue that the representational meaning of the written text is primary—reading the explanatory text about plastination is vital for understanding the process, but the explanation’s textual function ultimately directs attention away from the scientific description by directing the visitor’s attention to the torso itself; immediately under the prominent label “plastination” is the text: “The human torso on your left is very real” (emphasis added). After being directed to look left, and to look left specifically to observe a real human torso, dissected into manipulable slices, it is less likely that the visitor’s attention will continue to be captivated by the written label’s message.

Other scholars in visual media studies, communication, and linguistics have further developed and applied social semiotic theory to understand the meaning-making function of visuals, the manipulation of objects, and even three-dimensional spaces (Kress and van Leeuwen; Jewitt and Ott; Kress, Jewitt, Ogborn and Tsatsarelis). In the following sections, I draw on these scholars to demonstrate how these multiple communicative modes combine in exhibits to produce representations requiring visitors to simultaneously view the world in three competing and often contradictory ways: as the commonsense one they inhabit daily; the sensory one they hope to enjoy as a visitor engaging in a leisure activity; and the abstract, scientific one that inducts the learner into
the conventions of “truth-making” in the scientific worldview. I demonstrate how texts, illustrations, diagrams, and haptic devices realize representations of science and its worldview that are sometimes contradictory. Table 4 presents a schematic overview of the communicative modes in exhibits and the ways that they make available representational, social, and textual meanings individually. I will refer back to these functions as I analyze texts, images and diagrams, and haptic exhibits individually and as they function together to realize multiple meanings.
<table>
<thead>
<tr>
<th>Modes</th>
<th>Written/Verbal</th>
<th>Visual</th>
<th>Haptic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Representational Function</strong>&lt;br&gt;What concept, phenomenon, process, relationship, is represented and how is that meaning realized?</td>
<td><em>Word choice</em> and <em>grammar</em> construe the scientific as the everyday and the everyday as the scientific.</td>
<td>Visual components present concepts or narratives using elements we can recognize and which have “comprehensible relations to one another in terms of the typical scripts of that scene.” (Lemke 93)</td>
<td>Displayed objects (that cannot be touched) function metonymically, standing for all objects of the same type or class; through embodied metaphor or analogy, manipulable objects and built environments represent scientific phenomena and concepts</td>
</tr>
</tbody>
</table>

| **Social Function**—How does it encourage the audience to orient towards what is represented?<br>*Whether the representational meaning is accepted as “truth” is dependent on* | Written texts *describe* phenomena, *request* participation, and *demand* that the visitor look, participate, or imagine meanings extended in visuals and hands-on exhibits. | Visually are offered to visitors as empirical evidence of textual construals AND/OR as objects of aesthetic enjoyment | Manipulable objects and built devices *demand* (often in writing) that visitors manipulate objects or complete procedures to embody phenomena *described* in texts. Visitors are *invited* to feel exhilaration or |
| Textual Function—how does it contribute to the meaning of the overall composition/integrated text? | Directs visitor to view visuals and hands-on exhibits as empirical evidence of scientific phenomena described in written text. Provides background and scaffolds most visual and hands-on meaning. | Functions in additive fashion together with written texts to extend and illustrate representational construals; act as evidence by representing or concretizing written statements. “…As material objects, depictions participate in interactions that define parts and unite them into wholes in the ecosystem networks where objects are viewed and used.” (94)s | Functions in additive fashion together with written and visual texts; but, without framing of written texts, may be enjoyed as simple “fun.” A “pedagogy of embodiment”—for how to interpret the embodied experience. Fun factor is most salient because of the bright colors; durable materials, etc. that set these off as ‘kid friendly’ rather than as the hallowed ‘scientific equipment’. |
Reading written museum texts through the lens of social semiotic theory then asks us to consider in what ways the written texts reconstrue the world for museum visitors. What assumptions are made about the “realities” with which museum visitors already have familiarity? In what ways does the language of the museum display induct the visitor from one coding orientation to another? And what is the nature of that experience that is reconstrued through the lens of science? Below I analyze exhibits of three typologies, based on the dominance of the mode in realizing the exhibit’s semiotic function. The three exhibitions in which the exhibit case typologies appear were selected originally because they possess content that appeals to diverse audiences, and should therefore tell us something valuable about how accommodation works to induct the uninitiated into a scientific worldview. I examine an exhibit case from each of the three science centers’ exhibitions to characterize the way that they represent or construe science for the viewer. The cases are progressively more complex in their semiotic functioning. While written accommodations generally follow the rhetorical conventions Jeanne Fahnestock has described, those exhibits incorporating visuals and haptic modes with strong representational and interpersonal functions complicate further our understanding of how exhibits frame science, its practitioners, and the public in relation to those practitioners and practices. The ways in which these representational, interpersonal, and textual meanings are possible to combine together can be understood as the conventionalized experience that an exhibit affords through its available means. Whether the exhibits’ content focuses on the processes or products of scientific inquiry,
each case in this study demonstrates that museum accommodations tend to represent the methods of science as ways of arriving at certain knowledge, verified by empirical evidence that is seated in the physical body; implicitly, then, these exhibits introduce the visitor to the performance of a scientific self, whereby they can develop the “techniques of the self” required to be a scientist.

*The Science of Mummies* at Cincinnati Museum Center’s Museum of Natural History and Science

In this section, I conduct an analysis of an exhibit from the exhibition, *The Science of Mummies*. A relatively small exhibition, *The Science of Mummies* is structured, spatially, around one particular artifact—the mummified remains of a human child named “Umi”—but thematically focuses on processes of scientific inquiry and, in particular, technologies and tools that facilitate those processes. *The Science of Mummies* is spatially organized to encourage movement between an external area and the inner “tomb” of real mummified human remains. Conceptually, and physically, the exhibition’s pathways funnel visitors from exhibits on the general “science of mummies” toward specific information about Umi and the devices and processes used to generate that information. Outside the “tomb,” written descriptions dominate exhibits’ displays; entitled “What is a Mummy?,” “How are Mummies Studied?,” “Mummy Chemistry,” and “The Science of Mummies,” these explanatory labels accompany a flat-screen television projecting a CT scanned image of Umi’s bones. Around the corner, a digital computer exhibit entitled, “What’s Under Wraps: the Story of the Hidden Amulets,” follows a highly structured “choose your own adventure” narrative of the various amulets
found with Umi and their meanings in ancient Egyptian culture. In a vestibule between the external area and the tomb, visitors can watch a brief video detailing the collaboration between Cincinnati Art Museum, University of Cincinnati Hospital, and the Cincinnati Museum Center that was required to produce the new scientific knowledge about the mummy. Inside the “tomb” room is the mummy itself, under glass and displayed opposite a three-dimensional “printed” version of its skeleton (Figure 32). Text-heavy labels inside the “tomb” present information about the specific mummy’s cartonnage and amulets, and more explanatory labels with digital images outline how different paleoimaging techniques were used to generate scientists’ ideas about Umi’s specific case.

Figure 32: Umi’s Cartonnage (foreground) and 3D Replica of Umi’s Bones and Amulets (background)
An explicit goal of the exhibit is to explain the scientific process as it is applied to study the lives and deaths of individuals from the ancient past. The exhibits’ written texts primarily frame the scientific contents as *phenomena* and *processes* and *tools* and *procedures*. The *Science of Mummies* at MNHS stands out from the other exhibitions in this study for its “meta-scientific” content: the exhibition’s theme focuses, ostensibly, on explicating *science as a process*, rather than simply offering up existing *reported, stable fruits of scientific labor*; the written texts in this exhibit aim to characterize science as a set of methods, some of which use tools, to generate facts about mummified human remains. The extended metaphor of “looking” persists throughout the exhibition’s visual and written components.

**Praising Certain Science: Exhibits Fusing Scientific Practice, Persona, and Tools**

I focus in this section on a single integrated visual and verbal exhibit from *The Science of Mummies* entitled, “‘Listening’ to Ancient Secrets from Mummies at the Bioanthropology Research Institute.” The exhibit consists of two integrated texts (Figure 33): the first combines writing that divides into categories the “paleoimaging” devices used to study mummies—photography, radiography, endoscopy, CT scanning, and magnetic resonance—accompanied by a series of columns with images illustrating each device and examples of the products of its application. This display of paleoimaging devices provides general context about tools of scientific inquiry that are elaborated in specific examples in the exhibit’s second component: this component combines two columns of paragraphs with a series of corresponding images generated through
paleoimaging. In particular the text explains what facts about ancient life have been revised or uncovered by using the image as evidence. This exhibit’s written texts demonstrate a relatively straightforward example of scientific accommodation as theorized by Jeanne Fahnestock in “Accommodating Science.” However, studying this particular exhibit with social semiotic theory supports a more detailed explanation of how science center exhibits, designed to induct novice audiences into the conventions of scientific inquiry and practice, may validate an outdated conception of scientific practice and epistemology. Additionally, understanding the potential effects of visual and verbal science accommodation provides context for understanding exhibitions’ haptic modes of communication and their role in shaping the science in exhibitions.

On the exhibit component entitled “‘Listening’ to Ancient Secrets from Mummies at the Bioanthropology Research Institute,” framing text reads: “The Tools of Paleoimaging: Combining these tools allows us to see what can’t be seen” (Figure 33). Under this label, each paleoimaging tool is described in relation to its powers of looking, recording, and refining scientists’ vision: photography is used for “seeing what is”; radiography allows for “looking through”; endoscopy facilitates “looking within” and CT scanning “refin[es] the view,” with magnetic resonance contributing “additional details.” While other exhibits in the surrounding area present more detailed descriptions of paleoimaging, and specific examples, such as CT scanning and endoscopy, the “Listening to Ancient Secrets” exhibit contains no written texts or visual cues that realize a textual function, directing the audience to read those other, contextualizing exhibits. Rather, the
exhibit acts as a stand-alone taxonomy of paleoimaging types and uses, presenting a conceptual structure through which viewers can understand the constituent parts.

Under each vision-based tool and heading is a column of images either representing the tool, such as a photograph of a camera or a CT scanner, or images produced by using the tool. The written text above each column presents the tools as a
natural extension of the scientists’ own embodied acts of looking and seeing, “seeing what is,” “looking through,” etc. This sense of fusing person-with-machine is increased with the support of the photographs, which present the devices and their products. Only one image of the fifteen even includes scientists in the frame, suggesting that visitors engage with these representations as real examples of what these devices—and by extension their users, the scientists, “see.” Further, in the case of the first column, displaying cameras and photographs, the written text encourages the visitor to accept an ontological claim about what these devices allow us to do: “seeing what is.” This representation of cameras invokes strongly the conventions of the common sense coding orientation; its placement, first in a series, also encourages the visitor to accord the other imaging devices and their functions a similar ontological status. This series of columns functions as an integrated visual and verbal taxonomy of scientific seeing, laying out what Carey Jewitt and Rumiko Oyama refer to as a “conceptual structure”: “…[conceptual structures] represent participants in terms of their more generalized, stable or timeless ‘essences.’ They do not represent them as doing something, but as being something or meaning something, or belonging to some category, or having certain characteristics or components” (134). Specifically, the images in this part of the exhibit are not interesting for their actual composition or subject matter; rather they symbolize the kind of “seeing” that the scientist can do with each tool. This sense is magnified by each image’s “contact” with the viewer, where each image is “offered” to the viewer for consideration, inviting the visitor to assume that their experience of seeing the images analogizes the kind of “seeing” that is done by the scientist.
Significantly, the written texts in the second display, located perpendicular to and below “The Tools of Paleoimaging,” continue the theme of looking by more explicitly encouraging the audience to understand human-and-technological looking as a synthesized activity. Paleoimaging is rhetorically framed as an *extension* of the scientist’s natural gift of observation:

> “*With the technologies* available today, researchers can *look inside* a mummy and *uncover hidden clues* as to how that individual lived and died. To the *trained eye*, illnesses, injuries, diet, and even embalming practices, *become apparent*. Here are examples of *discoveries* made using various paleoimaging technologies.” (emphases added; “Listening to Ancient Secrets from Mummies at the Bioanthropology Research Institute,” *The Science of Mummies*, CMC)

Researchers are the agents of the described actions: they “look inside” and “uncover hidden clues,” that allow their “trained eye[s]” to identify illnesses, injuries, and other “discoveries.” Use of the phrase “trained eye” not only collapses the separation between scientist and imaging device, it also condenses the lengthy processes of training and research required to develop the expertise needed to interpret the images. The written text implies that simply by looking carefully, illness, injury, and diet “become apparent,” divulging their true causes and rationales under the scrutiny of the trained eye. These facts, they encourage visitors to believe, were always there, waiting to be “discovered,” rather than interpreted from visual data created through a mediated representational system.
Through fusion of the scientist-observer and her imaging tools, the exhibit represents scientific inquiry metaphorically in an accessible manner—an audience that measures “truth value” of day to day experience by visual confirmation would certainly find this characterization both compelling and accessible. Yet there may be a problem in identifying too narrowly the processing of scientific “seeing” with the conventional understanding of “seeing” used to confirm phenomena in everyday life. Using this metaphor, particularly the notion of the scientist/tool’s “trained eye,” the exhibit represents the scientist as a “genius of observation,” where all that is required to produce scientific concepts is for one to look carefully.

Lorraine Daston and Peter Galison’s analysis of the origins of the concept of objectivity, suggests that the model of the “genius observer” scientist emerged during the Enlightenment, wherein specific methods of scientific inquiry were popularized. Exercising practices of both mind and body, this era’s model of the “scientific self” was a “true savant” whose disciplined looking would, through “directed and critical exercise of attention…extract truth-to-nature from numerous impressions as the smelter extracts pure metal from ore” (203). This exhibit in The Science of Mummies not only represents science as conducted through careful “looking” for existing “facts” to be “discovered,” it eliminates for the audience the “numerous impressions” that are required for the scientist to acquire her “trained eye.” It also attaches to scientific looking the visitor’s own sense of pleasurable looking that is experienced by engaging the exhibit’s visual and verbal content. By encouraging the visitor to identify their own experiences of visual, common sense confirmation of data—i.e. confirmations of the “state of the world” based on sight,
as in, “look, the water is boiling,” “the baby is sleeping,” etc.—this exhibit conveys in its
description of the processes scientists conduct with their tools a dated, and currently
unaccepted, model of scientific inquiry and practice that is framed as pleasurable, in part,
because of the facility with which it can be achieved.

Through the interpersonal function of the exhibit’s components, that
representation of science invites visitors to experience wonder and praise the
achievements of science and the scientists. This social function is realized through the
exhibit’s specific stylistic features—in particular the verbal text’s “modalities”
(Fahnestock) and what the visuals’ “modality markers” (Kress and van Leeuwen).
Textual modalities are “hedges, [or] qualifications…that suggest the information
conveyed is not indisputable,” for example, when “the wording draws attention to the
availability of evidence or lack or it” through constructions such as “‘may,’ ‘seems,’
‘suggests,’ and ‘appears to be’” (Fahnestock 343). The absence of such qualifications
leads to greater certainty in the claims made, which is much more common in
accommodations of science than in original scientific reports. The omission of such
hedging in the exhibit texts allows the written text to invite praise for the representation
of science as a process of careful looking and knowing. Examining carefully an
additional pairing of text and image in the second exhibit component illustrates the
interpersonal function of exhibits’ written texts in fostering identifications with science as
an awe-inspiring process of looking and knowing (Figure 34):

The hieroglyphs on this 4,000 year old mummy’s coffin suggested that
it was a male priest. Research demonstrated that the mummy, named
Pa-Ib, was in fact a women [sic] around 30 years old when she died.

Of particular interest was the route of brain extraction. The imaging information indicated that the usual route of brain extraction was missed as the embalmer passed his instrument through the nose. Veering to the left, the instrument entered the skull through the adjacent eye orbit. We have begun to discover more variations in the route of the brain removal in Egyptian mummies than previously thought. (emphases added; “‘Listening’ to Ancient Secrets from Mummies…” “The Science of Mummies,” CMC)

The first sentence on this label presents the weakest modality term, “suggested,” which is attributed not to a scientist’s interpretation of hieroglyphics, but to the hieroglyphics themselves. In contrast, the support of the CT scan image allows for unqualified claims about the reality of the mummy’s situation: “research demonstrated” the “fact” that the mummy was female, not a male priest at all. All other verb forms in this text are presented in simple past tense, and the embalmer’s actions as he extracted the brain are narrated as if witnessed by an observer in the moment. But interestingly, the observer in that sentence is the imaging information itself.
Conferring this observing agency onto the imaging information makes it appear to speak for itself, and also serves, later in the text, to once again conflate scientist with tool. The closing text, “We have begun to discover more variations” once again confers agency on the scientist(s), and the events “witnessed” by the imaging information become one incidence of the “variations” that scientists have “begun to discover.” A museum visitor familiar with the conventions of the abstracted coding orientation might understand that individuals interpreted the information “indicated” by the images (likely supported by months or years of research). But without that familiarity, the text works to valorize the practice of science represented in the exhibit as the careful observation of the scientist-as-machine or machine-as-scientist, supported by the naturalistic coding.
orientation’s assumption that seeing and observing is equivalent to knowing. The omission of hedging (except in the characterization of the hieroglyphics’ earlier—and incorrect—interpretation of the mummy’s sex) increases the certainty of these claims and serves to valorize this process of science for its ability to “discover” now-settled “facts.” The visitors is invited not only to marvel at the way that paleoimaging allows for the revision of mistaken beliefs (e.g. “We have begun to discover more variations…than previously thought”) but also at the ways these technologies produce more correct knowledge than that possessed by witnesses in the mummy’s contemporary era (recall, the embalmer himself “missed” the “usual” route to the brain).

Perhaps it is unsurprising that this text invites visitors to praise this practice for its ability to derive settled facts since, as Fahnestock argues, scientific accommodations must demonstrate to the audience the value of scientific results, and “…only certainty can be the subject of panegyric” (338). But attended to the interpersonal function of the text’s accompanying visual, a CT scan of the interior of the woman’s skull, reveals the complexity of engaging multiple coding orientations in one integrated text, and the ways that this multiplicity allows the visitor to engage the exhibit with the conventions of the coding orientation they find most pleasurable, discounting or ignoring the most difficult or unfamiliar conventions.

The text describing the route of brain extraction is captioned with text that directs the viewer to look at the accompanying CT scan image, displayed to the right of the image (Figure 34): “Computed Tomography (CT) 3D Volume Rendering with cut-away view showing route of brain removal.” At first glance, the image appears to be iconic, in
that its representational function realizes an actual thing: the interior of the mummified woman’s skull. The image is reminiscent of an anatomy dissection cutaway or a natural history museum specimen; the skull and brain cavity are recognizable, if only because of common sense familiarity with human anatomy. An arrow points to a hole that the reader is instructed, in the text, to view as the “route of brain extraction” (although seeing the hole as an “eye socket” and not “the nasal cavity” requires the text’s representational function to scaffold its visual representation). Contrasting these familiar attributes are the artificiality of the 3D rendering and the image’s use of graded shades of brown. These abstract elements exemplify Kress and van Leeuwen’s assertion that images may realize multiple interpersonal functions simultaneously: the CT scan is recognizable both in the common sense coding orientation as well as the abstracted coding orientation, since the image employs modality markers from each.

Recall that an image’s “modality,” as theorized by Kress and van Leeuwen, refers to the perceived “…truth value or credibility of…statements about the world,” (155). In their schema, each coding orientation has its own set of criteria for determining a visual’s “reality value.” The commonsense orientation is based on the ways an image’s modalities “mark” it through contextualization, representation, depth, brightness, and illumination, and that the markers most closely replicating those of photographs will be perceived as the most “real.” Kress and van Leeuwen argue this is so because of the present assumption, in Western culture, that photographic representation mimics the way humans see and know: “Seeing has, in our culture, become synonymous with understanding…the world ‘as we see it’…has become the measure for what is ‘real’ and ‘true’” (163). The
CT scan can be interpreted as presenting the markers of the naturalistic coding orientation because its representation appears to be iconic—resembling an anatomy dissection. Yet the image is also prominently marked by modalities of the abstracted coding orientation. In contrast to the common sense orientation, in the abstracted, an image’s reality value is assessed according to its utility, “…on the basis of [its ability to show] what things are like generically or regularly. [Scientific realism] regards surface detail and individual difference as ephemeral, and does not stop at what can be observed with the naked eye. It probes beyond the surface of things” (Kress and van Leeuwen 158). The CT scan’s representation may be read as iconic, but it also represents something we cannot actually see: unless we were to cut open the mummy’s skull, we could not see inside it; yet, even if we could, what we would see likely wouldn’t resemble the image. The depth of perspective lent by the 3D rendering, the absence of any physical context for the image, and the monochrome brown color modulation all mark the image as most legible to those familiar with the conventions of the abstracted coding orientation.

Because the CT scan image is marked by modalities from both the common sense and the abstracted coding orientations, it can be viewed as functioning to induct visitors familiar with the common sense orientation into the abstracted orientation. In combination, the interpersonal functions of the text and CT image synthesize the scientists’ textual inferences about scientific practice and ancient embalming practices, generally, with observations made from the specific representation of the cut-away image of the brain. Luc Pauwels has suggested that visual representations can facilitate knowledge transfer by “summariz[ing] or synthesiz[ing] empirical findings or a
theoretical line of thought” (Pauwels 19). I suggest that the representational, interpersonal, and textual functions of this exhibit’s texts and images realize together a “mediated experience” that concretizes the identification with science as a practice that fuses scientist, method, and instrument, through the reality value of the supporting image. The integrated text speaks to the “…multiplicity of ways in which artists can relate to the reality they are depicting and ‘define’ reality in general,” and demonstrates some of the complexities of science accommodation in museum exhibits (Kress and van Leeuwen 171). Together they additively corroborate and encourage the identification with science as a practice of careful observation by the machine-scientist who discovers “facts”: the textual message is verified by an image that speaks with the “reality value” conveyed through our common sense orientation’s criteria for truth-making. By employing markers of the common sense orientation to describe the conventions of the abstracted coding orientation’s methods of inquiry, the exhibit equates the two orientations’ criteria for establishing truth.

Of course, part of the reason that the CT scan can encourage the audience’s valorization of this representation of scientist and scientific fact is because the image also contains markers of the aesthetic coding orientation, which is “used in contexts in which the pleasure principle is allowed to be the dominant: certain kinds of art, advertising, fashion, food photography, interior decoration, and so on. Here colour is a source of pleasure and affective meanings, and consequently it conveys high modality…” (Kress and van Leeuwen 165). As a participant in the leisure industry, the science center, as I have shown in my previous chapters, actively seeks to make the museum experience a
“context in which the pleasure principle is allowed to be the dominant.” As such, each of the museum’s spaces and experiences, including its multimodal exhibits, will contain markers of the aesthetic coding orientation. When an exhibit’s written and visual texts present markers of multiple coding orientations, the ones that become most prominent or salient to viewers are likely to strongly influence their identifications with science. In the next section, I provide a description of the exhibition, *Life: the Story of You*, to scaffold my analysis of one of its haptic exhibits, which through its salience makes prominent a complex, but equally incomplete message about scientific inquiry.

*COSI’s Life: the Story of You*

*Life: the Story of You* is organized around the characteristics that “make us human”: “mind,” “body,” and “spirit,” combine to relate “the story of you” (Figure 35). Color-coded signs loosely divide the exhibition hall into these three areas, although several exhibits “spill over” or appear in other sections. In addition to organizing the space visually, the signs provide a written meditation on their section’s theme.
The “path” of entry and movement through the exhibit is somewhat determined, since colorful signage in the hallway funnels visitors into the “body” section first, where they are greeted with exhibits that demonstrate and explain heart rate, strength, flexibility, and human nutrition. Greeting visitors as they enter the exhibition, these “body” exhibits face the glass-walled “Labs in Life,” which are laboratory spaces occupied by Ohio State University researchers. The “Spirit” section of the exhibition focuses on burial and cremation practices in western and non-western traditions, and present audio/video narratives about real peoples’ experiences of childbirth and death. “Body” is overwhelmingly the most represented category; among the many exhibits under this heading are a three-dimensional plaster model of the progressive stages of human labor and delivery; a portion of decaying food under an air-tight bubble, demonstrating the process of decomposition. “Mind’s” displays focus on sensory perception, and optical
and aural illusions. Exhibits like its haptic “praxinoscope” demonstrate motion illusion, while the “heat grill” demonstrates how the brain may be “tricked” into experiencing the sensation of heat. An “echo-free room” invites visitors to experience the sound of their voices, absent the ever-present echo we rarely notice, and a set of headphones demonstrates how our brains determine the location of sources of sound around us. In the next section, I focus on two of these exhibits from the “Mind” section: the “praxinoscope,” primarily, and the “echo-free room,” to explore how they draw visitors from one coding orientation to another, making some associations with science more salient than others.

**Learning to Look (and Feel) Like a Scientist: The Affective Prominence of Haptic Exhibits**

While the written texts, mechanically-derived images, illustrations, and photographs make up a significant portion of the visitor’s experience in science center exhibits, they do not work alone to realize scientific identifications in the science center context. The communicative channel that museum professionals interviewed for this study cited as most vital for an exhibition’s success with visitors, is the “hands on activity,” or what I refer to as the “haptic” mode. In psychology and physiology, haptic touch refers to our “ability to experience the environment through active exploration, typically with our hands, as when palpating an object to gauge its shape and material properties” (Robles-De-La-Torre 27). I extend this definition to explore how object manipulation facilitates haptic communication: the construction or transfer of concepts or ideas through object manipulation, often in concert with verbal and visual texts.
Haptic techniques of display, known in museum studies as “hands on,” participatory, or interactive techniques, are the bread and butter of science exhibits; Victor J. Danilov has described them as one of the defining traits separating science centers from other kinds of museums: “[Science centers] are best known for their contemporary rather than historic perspective and their reliance on participatory exhibit techniques rather than objects of intrinsic value” (emphasis added, Danilov viii). He describes the “participatory techniques” as encompassing audio and visual elements, but emphasizes that “pushing buttons, turning cranks, lifting levers, and other interactive methods are commonly used to attract and involve the museum visitor,” as well as to communicate information (emphasis added, 5). This synthesis of attraction, involvement, and communication is central for understanding haptic exhibits’ semiotic function and the identifications with science they make available.

Exhibits in COSI’s Life: the Story of You exhibition illustrate the semiotic concert of verbal, visual, and haptic modes of communication that realize both scientific concepts and particular affective identifications with those concepts. Examining in depth the representational, interpersonal, and textual functions of one particular optical illusion exhibit, the “Praxinoscope,” illustrates the manner in which multimodal exhibits may layer conceptual meanings with affective associations. In particular, my analysis suggests that the prominence of these haptics’ semiotic function in the exhibit context may override (potentially) more nuanced characterizations of science represented in written or visual texts.
Consisting of a haptic and a textual component, the praxinoscope device, and its accompanying explanatory label, this exhibit aims to illustrate a particular type of optical illusion: a motion illusion (Figure 36). The explanatory text introduces technical terms and employs nominalization to reconstrue an everyday experience as a scientific phenomenon:

“The praxinoscope is an example of a motion illusion. If the hands in front of the mirror are similar enough, and the platform moves quickly enough, then you see the image of a single hand slowly changing shape. This phenomenon is called apparent motion, and it allows you to see motion in a series of still images such as cartoons and movies. Experiments have shown that this apparent motion is indistinguishable from very rapid real motion. In other words, if the motion is rapid enough or the still images compressed enough, your mind cannot tell whether the motion you’re perceiving is real, or just an illusion.” (emphases added, “The Praxinoscope: a Flip Book in the Round,” COSI)
This label introduces several technical terms, including “praxinoscope,” “motion illusion,” and “apparent motion,” and defines them in common sense language. The text’s grammar also contributes to the transformation of these everyday processes into evidence of abstract phenomena: the *process* of the rotating hands and platform, described using
twenty-nine commonsense words, is distilled into a single, concrete thing: apparent motion. In doing so, the text’s representational function brings into being the scientific phenomena by condensing the everyday terms into technical ones through nominalization. What the visitor perceives then “becomes a world made out of things, rather than the world of happening” (Halliday 82). Additionally, apparent motion is framed as both an abstract scientific phenomenon (a “thing” that has no material presence), as well as a part of our everyday experience, observed daily in cartoons and television (a concrete thing with definitive material presence). This rendering from abstract to familiar also performs an interpersonal function, orienting the visitor to the concept (and to how they ought to feel about science’ ability to explain the concept). Television is no longer a simple form of entertainment, but rather a wondrous illustration of how such an everyday experience, using these new conventions for understanding reality, can be reframed as an experience of esoteric phenomena. As in the case of the text in “Listening to Ancient Secrets,” the praxinoscope’s verbal explanation introduces visitors fluent with the common sense orientation’s criteria for truth-making to those in the abstracted coding orientation. Everyday, active verb forms are used to describe the concept with no hedging or qualifying modalities. The descriptions of motion illusions’ functioning, using everyday terms, invite the visitor to accept these phenomena as concrete facts, determined by the ways “experiments have shown” them to function. By rendering the familiar into the abstract, and the abstract into the familiar, phenomena esoteric as apparent motion and motion illusions become part of our daily lives.
Of course, the very essence of an optical illusion is that, according to common sense, it appears as though one reality is happening—the hand is moving—but the written text asks us to view this “happening” through different criteria for determining its “reality value.” The technical terms are introduced, framing the phenomena according to the criteria of the abstracted orientation. The reality of “the hand is moving”—what the text tells the reader that their mind perceives—is reframed as, “experiments have shown that your mind makes it appear as if the hand is moving; in reality, it is not.” This second position is significantly more abstract than the initial description of a moving hand. While it is abstract, it also makes an ontological claim about what is “really” happening, describing the mind as capable of perceiving either “real” motion or “illusory” motion rather than exploring how the brain produces the experience of perception or the assumptions behind oppositions such as “real” and “perceived” motion. These ontological claims, made in the abstracted orientation, position science as the arbiter of what is “real,” of what “really IS.” The affective orientation involved in this interpersonal function also echoes that of the labels in “Listening to Ancient Secrets”: visitors are invited to marvel at how scientific conventions can enrich existing explanations of perceived phenomena through the reality-criteria of their common sense coding orientations (“it seems to be moving” says our commonsense, but science assures us, “it is not”).

The exhibit’s verbal description also serves an important textual semiotic function—that is, it structures how the written, visual, and haptic elements “hang together” as an integrated multimodal text. One particular sentence in the explanatory
label particularly realizes this function, contextualizing the visitor’s visual and haptic experience of the praxinoscope. The commonsense description of “apparent motion” is structured as a conditional statement: “If the hands in front of the mirror are similar enough, and the platform moves quickly enough, then you see the image of a single hand slowly changing shape.” The next sentence supplies the syllogism’s warrant: “a phenomenon called apparent motion” accounts for the “slowly changing shape.” Framed as a description of the praxinoscope’s function, the conditional structure functions interpersonally as a demand. Although it is not framed as an imperative, the demand requires the visitor to employ a deductive logic that motivates the visitor’s physical manipulation of the praxinoscope device and informs how they process the result of that manipulation: through the combined actions of haptic engagement (spinning the praxinoscope) and visual perception (seeing the hand change shape), the warrant for the conditional statement’s validity (apparent motion) is confirmed. The visitor’s embodied visual experience of apparent motion, then embodies the warrant for the syllogism.

The praxinoscope’s haptic element—the platform which the visitor must grasp and spin—itself demands that the visitor set into motion the platform in order for the phenomena to come into being, to be available for visual confirmation. This haptic exhibit, by its design, “demands” visitors’ attention and action, construing its available meanings differently than either texts or visuals. In contrast to visuals, the interpretation of which can be described as “spatial analysis of a static image,” “haptic sensing…involves the integration of a variety of sensory and motor signals over space and time.” (emphasis added, Henriques and Soechting 3042) For the motion illusion to be
seen, for it to *exist*, the visitor must first grasp the praxinoscope platform and then spin it. A human participant is required to both *produce* and *experience* the phenomenon of apparent motion that the Praxinoscope demonstrates. Since the exhibit text tells us that a cartoon or a film presents the same phenomenon, the praxinoscope device itself is actually not required for the concept to be understood—people have an everyday touchstone on which to base their interpretation. But the haptic device realizes the phenomenon through a visual display in which the visitor’s action *produces* the phenomenon and her *embodied experience* of it serves as empirical evidence confirming its existence.

Similarly, the “Echo-Free Room,” also located within the “Mind” area of *Life*, is meaningless, just another room, unless the visitor meets the exhibit’s demand for action: the visitor’s vocalization within the sound-proof space is followed by the uncanny perception of her own voice, sans its ever-present echo (Figure 37). The “Praxinoscope” and the “Echo-Free Room” each have verbal explanations that rhetorically frame the embodied experiences as productions or evidence of scientific phenomena, but the participant’s action is what *produces* the phenomenon, and her embodied *sensation*—visual or aural—following that production confirms evidence of it—I “see” the apparent motion precipitated by my spin of the praxinoscope’s base; I “grasp” the (fairly abstract notion) of the “absence of an echo” following my vocalization. The text may explain *what* it is, but without an individual to *experience* it, the phenomenon does not exist.
Haptics like these that demand action from a visitor for the concept to be visually or aurally realized, differ from the kind of “interactive” quality that visual engagement with objects on display in vitrines might have; of course, the display of a fossil or an ancient tool is meaningful only through the visitor’s perception of them. But in the example of the haptic exhibits I study here, this model of substantiating phenomena only becomes possible if the visitor accepts the exhibit’s demand.

Haptics like these do not just demonstrate phenomena, in the sense of showing; rather, they substantiate them—giving literal substance to the phenomena by locating the participant’s physical body as the seat of the phenomenon’s empirical validation. Luc Pauwels tells us this bringing-a-concept-into-being is a characteristic feature of scientific
representation: “Visual representations in science may refer to objects that are believed to have some kind of material or physical existence, but equally may refer to purely mental, conceptual, abstract constructs and/or immaterial entities” (emphasis in original, 2). The visitor embodies the representation of these exhibits’ displays of “immaterial entities,” of “echo” and “apparent motion.” Part of what makes the visitor’s experience of this embodied representation so compelling is the haptic exhibit’s interpersonal function. The visitor’s active response to a haptic’s demand results in an experience that condenses the “integration of a variety of sensory and motor signals over space and time” (Henriques and Soechting 3042). While the action to produce the phenomenon and the embodied experience of it are separated in space and time, the sensation seems to nearly co-occur with the action, compressing the action producing the phenomena and the sensation of its empirical confirmation into a near-simultaneous revelation. The pleasure of this embodied revelation can be analogized to an auditor’s experience of an rhetor’s use of enthymeme: “enthymemes give pleasure because their maxim like injunctions come to the audience as dramatic revelations” (Rosenfield and Mader qtd. on Sheard 784). It’s not difficult to then understand how these haptics function to encourage visitors to view as praiseworthy their role in producing such pleasurably revealed science. Haptic devices’ affective characterization of science, realized through its interpersonal semiotic function, dominates the exhibit’s semiotic function. It is exhilarating and exciting to believe that such significant scientific concepts and phenomena might be reached with such facility. And let’s not forget the visceral pleasure of the actions themselves, absent any framing of the verbal texts: it is enthralling to watch a series of still images come to life through
apparent motion. By making these abstract terms available according to the “pleasure principle,” the interpersonal functions of these haptic exhibits invite visitors to understand scientific phenomena according to conventions of the aesthetic coding orientation. In the context of the exhibition, abstract phenomena are rendered familiar as part of the “everyday”; they are confirmed by embodied, enthymemetic revelation as being “real,” and are immensely pleasurable for these reasons. Recall, the aesthetic coding orientation is “used in contexts in which the pleasure principle is allowed to be the dominant…Here colour [among other aspects of ambience] is a source of pleasure and affective meanings…” (Kress and van Leeuwen 165). In these science center exhibits, the pleasure principle is not only “allowed” to be dominant, it is intended and designed to be the primary outcome of the science center experience.

In their study of science education, Gunther Kress, Carey Jewitt, Jon Ogborn and Charalampos Tsatsarelis emphasize that the classroom environment and the special context of the science lesson play important roles in transforming objects, through action, into sources of science knowledge. In this special context, the materials and equipment students interact with become conventionalized and their actions with them are transformed into “routinized scientific actions or ‘ritual’” that produce knowledge sanctioned by the authority of the teacher and the science classroom (75). In science centers, haptic exhibits, too, have become “conventionalized forms” that may produce meanings similarly to objects in the science classroom. As I demonstrated in the first chapter of this project, science museums have developed, over time, their conventionalized modes of display which address domains of response that are shaped by
visual culture. Similarly, the epistemological allegiances embedded in those conventions of display—such as the sense that scientific knowledge represented in museum display is certain, or that science and technology possess an aura of the divine—are part of the immediate context shaping the semiotic function of museum exhibits. In addition, the immediate visual context is also shaped by more immediate, individual experiences in the museum: exhibit visitors will have already spent a great deal of time being exposed to affective associations with science through their visual approach to the science center’s physical building and their navigation through its interior spaces. These experiences invite the visitor to accept the science center’s authoritative ethos, increasing their receptivity to its accompanying celebration of scientific and technological achievement and applications. By manipulating and engaging haptic exhibits, the science center context suggests, visitors will bring forth scientific knowledge sanctioned by the science center’s authoritative ethos.

By accepting the haptic exhibit’s interpersonal demand for the visitor’s action, the visitor acts to produce the phenomenon and, almost simultaneously, confirms through their embodied sensation the validity of the textual interpretation of the phenomenon. In this way, haptic exhibits invite visitors to perform practices analogous to a scientist’s methods for testing scientific hypotheses. Daston and Galison have addressed the role of the scientist’s body in producing objective science, arguing that such “techniques of the self” are themselves historicized and have been “…built up, reinforced—through concrete acts, repeated thousands of times in a myriad of fields in which observers struggled to act, record, draw, trace, and photograph their way to minimize the impact of
their will.” (Daston and Galison 38). These haptic exhibits, through the cleverness of their designs, erase the need to perform repetitions of embodied experiments in order to produce and interpret natural phenomena. Such exhibits then offer implicit instruction in how science is performed that is supported by verbal texts’ representational and interpersonal functions and valorized through visual and haptic modes’ interpersonal synthesis of concept, common sense, and pleasure. Such a synthesis erases the self-disciplined repetition of acts, observations, measurements, and data interpretation that contemporary scientific culture requires for the development of the scientist’s “trained judgment” or “objective” eye. Such an erasure leads to a throwback portrayal of science, hearkening back to the Enlightenment’s gifted natural philosophers whose “directed and critical exercise of attention could extract truth-to-nature from numerous impressions” (Daston and Galison 203). The interpersonal function that valorizes this impression through pleasurable, enthymematic revelation renders this version of science both visceral and memorable, bolstered by the authoritative and epideictic ethos of the broader science center experience.

The Carnegie Science Center’s RoboWorld

These haptic exhibits’ valorization of an erroneous representation of scientific inquiry is based, in part, on how they may realize semiotic functions independently and separately from visual and verbal modes. One may spin the praxinoscope without reading the text, experiencing the pleasure of the visual experience and the exhilaration of being the agent initiating the phenomenon. These enjoyments don’t require that one read about apparent motion or motion illusions. But some multimodal exhibits may marry together
more intimately their channels of communication, demanding through the realization of their interpersonal and representational functions, that the visitor engage all of the modes’ semiotic functions in order to understand fully the exhibit’s conceptual meanings and affective associations, thereby rendering a more complex explicit and implicit message about scientific practice and the kind of knowledge it derives.

*RoboWorld* introduces visitors to several exhibits that demand the visitor’s engagement with all their semiotic modes to realize their affective and cognitive meanings. The exhibition explores both the concepts of the robot and robotics as well as their applications, organizing its displays spatially around the defining robotic processes of “thinking,” “sensing,” and “acting.” For example, the “acting” section features “Hoops,” a robotic arm used previously to weld car parts, now reprogrammed to make basketball free-throws with 98% accuracy; nearby, “RobotRx” scans barcodes to read, process, and fill drug prescriptions. Exhibits include written labels and signs, illustrations, and haptic components, and several allow for the opportunity to watch and interact with real robots.

Haptic exhibit components, like those that sense body heat or motion in the “Sensor Stations,” are the most visually prominent attractions, although they are paired with written explanations throughout the exhibition. The “thinking” section contains, among others, includes an “Air Hockey-Bot” that visitors may challenge to a game, although the computer’s processing speed makes it difficult to win since it can calculate the puck’s position up to 100 times per second. The exhibit areas are visually demarcated by lit, colored screens surrounding white-painted support structures; corresponding color-
coding is used on written label texts, but movement between sections is fluid and visitors may see visitors in other sections at any time (Figure 38).

Many labels indicate that the robots were produced by researchers at local universities and technology institutions. An explicit aim of the exhibit is to “…inspire the leaders of tomorrow in math and science - what better way to do that than to create the ultimate robotics experience and showcase the technology that will lead us into the future?” (Carnegie Science Center “About the Exhibits”)
Embracing Complexity: Directing Attention, Signposting, and Interlocking Meanings in Multimodal Exhibits

One of RoboWorld’s exhibits that embraces the potential for multimodal complexity to demand the visitor’s engagement with all its communicative modes is entitled “Take a Spin.” The exhibit’s components include a rotational sensor, a written explanation of the sensor’s purpose and function, and a diagram of the sensor highlighting the relationship between its segments and the binary system that translates the light/dark color information into computer coding (Figure 39). To a greater extent than either the Science of Mummies exhibit or the haptic exhibits in Life: the Story of You, this exhibit requires that the visitor go beyond parsing representational and social functions in written, visual, and haptic modes. To achieve full semiotic realization for the concept of “rotational sensor sensing” as it is presented, the exhibit’s textual functions require that the visitor relate and synthesize the representational meanings realized in the three different modes in particular ways. Rather than simply illustrating or referencing a written claim (as in the case of the “Listening to Ancient Secrets” exhibit) or demanding the visitor’s embodied confirmation of a described phenomenon (as in the Praxinoscope exhibit), the exhibit requires a recursive engagement with written text, illustration, and haptic device before the concept of rotational sensing can be fully realized. This exhibit demonstrates the most complex form of multimodal science accommodation, but also requires the greatest degree of prior experience with the abstracted coding orientation. It therefore suggests a continuum of complexity on which scientific accommodation operates and suggests limitations for the age of audience members who may successfully access science in this manner.

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The rotational sensor’s written label contains no technical terminology except for
the one term it seeks to introduce—*rotational sensor*:

“Not all robots use vision systems in their work. So how does a ‘blind’ robot know where it is moving? This *rotational sensor* reads light and dark sections of a disc to determine how much it—and any object it is attached to—has rotated. Each pie-shaped section of the disc has a different light and dark pattern, representing part of a 360° full rotation. By identifying the light-dark patterns, sensors determine how far the disc
has moved. Rotational sensors can be used in a robot’s joints to track its position or in its wheels to determine how far or fast it is moving. For instance, the pattern of dark-dark-dark-light (represented as 0-0-0-1) shows the disc has rotated between 22.5° and 45°. If the robot receives a 0-0-0-1 signal from the sensor, it knows its arm has rotated to that position.”

(Italics in original; Carnegie Science Center, RoboWorld, “Sensing”)

The label ought to be quite readable for those familiar with conventions of the common sense orientation; yet, although it contains no words that score higher than a 7th grade reading level, this text is remarkably difficult to parse due to its lexical density, or the proportion of “content” words that the sentence contains. Halliday argues that lexical density is one of scientific discourse’s characteristic traits, but that it can present difficulties for learners. Learners familiar with everyday speech, he reasons, struggle with science’s high incidence of lexical words or content words, compared with everyday speech. Lexical words are those that convey information and are usually nouns, adjectives, adverbs, and main verbs (non-helping verbs). Conversely, “function words” express grammatical relationships between lexical words but express little information themselves (Alami, Sabbah and Iranmanesh 5366). A sentence we might use to speak about everyday occurrences contains far fewer lexical words than scientific language and conveys less information (Halliday 76). For example, “I never worry too much about studying for tests” contains 3 lexical words out of 9, a third of the total number of words. According to Jean Ure, everyday speech tends to contain about 40% lexical words, while written texts tend to have more than 40% (cited in Johanssen 65). Two sentences from the
rotation sensor label contain a far higher percentage of content words—12 of 20 (60%) and 8 out of 13 (62%), respectively: “Each pie-shaped section of the disc has a different light and dark pattern, representing part of a 360° full rotation. By identifying the light-dark patterns, sensors determine how far the disc has moved.” The high percentage of content words marks the language as scientific, and requires that the reader keep track of not just one light/dark pattern, but several different ones, as well as understand how each represents a portion (but how big a portion?) of a 360° rotation. Into just a few sentences is packed the concept of (non)visual sensing (interestingly, the robot may be “blind” but the visitor experiences the rotation sensor visually) as it maps on to the concept of rotation. In itself, the lexical density of the sentence exacerbates the concept’s abstract nature, as does the use of the special mathematical expression (360°) and the implied, but not directly referenced, binary numeral system. The density of the sentences alone, combined with the special expressions—discipline-specific uses of terms such as “rotation” and “sensing”—mark the “truth-value” of this written label as abstract.

Although the rotational sensor’s text omits the complex technical terminology that often marks scientific discourse, its text includes words that, although not immediately read as “technical” are indeed polysemic. Because of their inclusion within the complex grammatical formations that indicate the abstracted orientation, they are framed with the potential to be interpreted scientifically. Several of the content words in this description may be technical terms related to the field of robotics or may be used in the everyday sense. There seems to be some switching back and forth, in and out of the abstracted orientation and into the common sense orientation: the word “blind” is set off in
quotation marks when it is used to describe a robot, suggesting that it is meant to be understood metaphorically, in the conventional, everyday sense. Yet we are told that the rotational sensor “reads light and dark sections of a disc”; while it is possible that the text’s composer has also used the term “read” metaphorically, it is unclear whether “read” also has a technical meaning in the context of robotic sensing. Written texts here then function interpersonally to realize markers of both common sense and abstracted coding orientations. The label also contains a reference to a highly technical term, the binary numeral system, despite the fact that it is not referred to by this name: “For instance, the pattern of dark-dark-dark-light (represented as 0-0-0-1) shows the disc has rotated between 22.5° and 45°. If the robot receives a 0-0-0-1 signal from the sensor, it knows its arm has rotated to that position.” Introducing the technical term, “binary numeral system” would certainly increase the difficulty of the text, but omitting any explanation of these special expressions renders the text highly abstract.

The textual function is integral for realizing the exhibit’s overall representational concept of the rotational sensor, and each of the modes more explicitly executed this function in terms of providing verbal and visual sign posts that connected together verbal and visual concepts: text directs attention to the diagram; the diagram directs attention back to text, which finally demands the manipulation of the haptic device. Tracing each mode’s textual function as it supports the realization of each mode’s representational function emphasizes this exhibit’s combination of modes. The written description of the binary numeral system functions, textually, to direct the visitors’ attention toward the diagram of the disc that illustrates the special expressions’ patterns of dark and light.
“Each pie-shaped section of the disc has a different light and dark pattern, representing part of a $360^\circ$ full rotation. By identifying the light-dark patterns, sensors determine how far the disc has moved.” Unless the visitor has an intimate familiarity with binary numeral systems, or rotational sensors, to fully realize the written text’s representational meaning the visitor will likely have to turn to the diagram for illustration; additionally the use of “each pie-shaped wedge of the disc,” directs the visitor to attend to this specific disc, not an imagined or generic disc. And the “light and dark pattern,” and “part of a $360^\circ$ full rotation” are special expressions synthesized in the text. Directing the visitor’s attention to the diagram gives those expressions a visual representational existence, rendering them concrete and giving the verbal text a visible referent.

The sensor disc diagram shows a circle subdivided into 16 black-and-white wedges; lime-green vector lines extend out of several wedges to draw the visitor’s attention to numerical labels associating the wedge’s visual pattern of black-white with its corresponding combination of 1s and 0s, realizing examples of the symbolic relationship of black = 1 and white = 0. One slice in particular is set off from the rest by red lines demarcating it from the others. A green line forms a vector drawing attention from this wedge to another chunk of explanatory text, which is written in the same lime-green shade as the diagram’s binary labels, forming a visual relationship of continuity between the diagram’s numerical labels and this written explanation. This text reads, “Each pie-shaped segment of the disc is 22.5° wide (16 sections = $360^\circ$). The dark sections of the disc = 0, while the light sections of the disc = 1. Every segment has four light or dark subdivisions which represent a four-digit number made up of 1s and 0s.
Starting from the section closest to the center, the four sections in this pie-wedge = 1-0-1-0." The text represents verbally what the disc illustrates visually; the text also functions textually to direct the visitor’s attention back to the wedge demarcated with red by explicitly directing the visitor’s attention to “the section closest to the center,” which represents a specific spatial location on the disc, rather than the general binary numeral relationship. The numerals 1-0-1-0 in the explanatory text are written in red, also visually paralleled with the diagram, which also uses red on the wedge that is connected to the explanatory text via a green vector line.

Figure 40: Rotational Sensor's Haptic Device Component and Digital Reading of Degrees of Rotation
Finally, after navigating the visual-verbal semiotic back-and-forth of the diagram and its explanatory text, the visitor may return to the exhibit text’s application of the binary numeral system and the sensor disc to their specific application in a robot. The text reads, “If the robot receives a 0-0-0-1 signal from the sensor, it knows its arm has rotated to that position.” Like the conditional structure in COSI’s Praxinoscope exhibit, this explanation functions textually to direct the visitor to confirm each of the synthesized visual and verbal representational meanings through manipulation of the exhibit’s haptic element. For the concept of the rotational sensor to fully be realized, the visitor must physically grasp the “handle” of the sensor, the “object attached to the sensor” and rotate it, observing the disc’s motion and conducting an observational “before-and-after” comparison of the display projecting a the four digit binary code (on the left) and the degrees of rotation registered in response to the visitor’s manipulation (on the right).

The visitor must read the label to understand the concept of “rotational sensor,” but to fully realize the exhibit’s interpersonal meaning, they must understand how the diagram of the disc visually represents both the spatial concept of rotation, and its color-coded application of the technical computer language system denoted by the 0s and 1s of the binary numeral system. Finally, to realize the concept of rotation on the disc, the visitor must grasp the handle and rotate it. The text of the rotational sensor label is lexically dense, and contains special expressions, and semantic leaps, all requiring some prior familiarity with the conventions of the abstracted coding orientation for full comprehension.
The visuals depend on and assume that the visitor understands the text, and that the visitor will know how to interpret the visuals and relate them back to the written concepts. The ability to parse the written text, let alone to resolve the spatial and conceptual relationships realized in the written and visual texts’ textual functions, requires fluency with the abstracted coding orientation. This exhibit, while not explicitly using any terminology higher than a seventh grade reading level, realizes meanings through its synthesis of each mode’s representational and textual functions that are inaccessible according to the criteria of the common sense coding orientation. Alone, each of these modes functions according to common sense “truth-making” criteria, but it is the synthesis of their meaning-making functions that renders this exhibit so highly abstract in its available meanings.

A visitor who fully parses the layered representational meanings realized in this multimodal exhibit has given it significant attention, concentration, and time. Only the rather flip and misleading text at the bottom presents representational meaning that is immediately recognizable in the common sense orientation that all visitors entering the museum will possess: “It’s like Twister® for robots!” This analogy immediately downplays the abstract and complex nature of rotational sensing that is implicit in the multiple-levels of representational meaning embedded in the exhibit. It also allows the small child (closer to the ground and therefore closer to the bottom of the label where the Twister text is presented) to connect the black-and-white disc—a circle!—with a touchstone of their daily lives—a color-coded game involving processing colors and motion—and to concretize this association by physically engaging with the sensor by
spinning it and watching the numbers change. The interpersonal function of the text and
the haptic elements, then, are likely to be the most prominently realized semiotic
meanings for children: associate this concept with the fun of a game you enjoy and are
familiar with; make something happen by spinning this disc and watching the numbers
change as evidence of that something. The highly abstracted coding orientation marked
by the synthesis of written, visual, and haptic texts is defused by this representational
meaning—appealing to the sensory coding orientation—and the surrounding visual
context which implores visitors, particularly children, to see all this science stuff as fun,
factual, and feasible.

Conclusion: What these Science Center Exhibits tell us about Science
Accommodation and Multimodality

The written texts found in these science center exhibits represent scientific
phenomena and concepts as a series of concrete, certain facts about reality that must be
“uncovered” by a scientist. The texts represent the scientist’s modes of inquiry as the
careful observation and inference of the “genius of observation.” The visual and haptic
exhibit components tend to reinforce these representations of science by inviting the
visitors to, themselves, adopt the position of the scientist: through their actions, they
produce the phenomena (or evidence of the phenomena) and confirm its empirical
existence through their embodied sensation. This embodied confirmation also results in
pleasurable enthymematic revelation, inviting the visitor to valorize the discovery of
these marvelous facts and simultaneously delight in the facility with which they are
revealed and explained.
These accommodations of science—conceptual and affective—rely on exhibits’ multimodal harmonization of common sense, abstracted, and aesthetic coding orientation conventions. Each mode may realize modality markers of one or another, but the explicit purpose of science center exhibits is to combine them in a synthesis of the aesthetic, intellectual, and everyday. The reason that these orientations become so intertwined within the context of the science center exhibits is partly down to wider cultural assumptions about how scientific knowledge is made now. Michael A. Cavanaugh has described the difficulty that the “public” has in discerning the difference between knowledge-making in day-to-day life and knowledge-making in scientific contexts:

science and commonsense are not totally antithetical, for in a knowledge-based society, commonsense is increasingly tutored by “packed-down science.” Thus the man on the modern street “sees” the roundness of the Earth, and his common sense “knows” that the heart is not the seat of emotion and that werewolves do not exist. Such “conventional wisdom” is primarily a fact, not of individual psychology, but of membership in a certain kind of society. The organized process of gaining, and warranting, knowledge, differs from the ability to use it in packed-down form, or the ability of Everyman individually to validate what he knows” (186)

Michael A. Cavanaugh has described this trust in our everyday experience to sanction “truth” as a “folk epistemology of common sense empiricism.” Haptic exhibits seemed designed for the specific purpose of blurring the distinction between the “organized practice of gaining, and warranting knowledge” and the process used by the “Everyman
individually to validate what he knows.” But my larger analysis of science center contexts and science display suggests that we must look beyond, and around, the exhibit to fully explain how accommodations function in this context.

The representation of science as a process of arriving at certain facts through embodied observation and inference resonates with historical, and valid, ways of making scientific knowledge in the museum context. As I demonstrated in my first chapter, science museums in the nineteenth century were seen by many as presenting certain natural knowledge, sanctioned by God’s divine “order” for the natural world. Similarly, I demonstrated in my historical review that scientific displays during the Enlightenment period were believed to divulge, under close visual arrangement and scrutiny, explanations for biological organisms’ functional parts as well as relationships among those structures. When experimental science moved to universities in the late nineteenth century, science museums maintained much of their earlier techniques of display, which were then consumed by visitors who then also took their children to museums, and so on.

The point is this: the historical visual culture surrounding and inside science museums has affected the ways that science center exhibits make meanings available to visitors today. The immediate context of the science center itself—where interior spaces and images outside exhibits represent valorous achievements of science and technology—prime the visitor to experience them in this way. As a result of this contextualization of exhibits’ science accommodation, we ought also to consider how these terministic screens—the verbal, visual, and haptic modes that comprised multimodal exhibits—are themselves unstable over time and in time. They select and
deflect *different* realities depending on the visitor’s experience of the immediate context as well as their immersion in the wider, historicized visual culture of science outside the museum experience. This synthesis of wider and immediate context with a close reading of the semiotic realization of exhibits’ scientific accommodation may help us better understand the nature of museums’ epideictic ethos and its fraught relationship with its subject matter, which I take up in my conclusion.
Chapter 6: Conclusion: The Epideictic Ethos of Science Centers: Problems and Possibilities

This study has demonstrated that the motives behind the epideictic rhetoric effected in science centers is a product of the history of visual culture and its relationship to using science exhibits to make meaning in museums. In particular, I have shown that, between the mid-eighteenth and mid-twentieth centuries, the purpose for museums and exhibiting science inside museums changed in response to changing ideas about how scientific knowledge should be made and where it should be made, and who should have access to what kinds of science. As science museums gradually were forced to relinquish their allegiance to knowledge production, education and science-appreciation emerged as purposes that would allow them to maintain relevance in the public sphere. This shift in motivation—celebration and education rather than forensic explanation of phenomena or causes—ought to map out to a shift in rhetorical action. But by preserving the same modes of display and the same orientation to objects as sources of knowledge-production speaking ‘truth-to-nature,’ natural history museums and science centers reproduced a recurring rhetorical situation between auditor and communicative device—the exhibit—which sought to achieve public education and appreciation by the same modes of display used to inform the development of (now defunct) theories of scientific inquiry. While the content of this study’s exhibitions and their constitutive exhibits may be modified to address changing theories or ideas, that content tends to adhere to the persistent scientific
theories that remain unchanged—gravity and acceleration, general physiology and anatomy, mechanical principles of force—moreover, their exhibits’ communicative form reaffirms the power of objects to access and realize these concepts and theories, offering implicit theories of scientific inquiry that assumes objects can easily manipulated to divulge evidence of scientific phenomena. If simple appreciation of science—excitement, inspiration, and motivation to learn more about it—is the goal of most science centers, is there any harm in accommodating science in this fashion? Perhaps.

On February 4th, 2014, a public debate was held at the Creation Museum in Petersburg, Kentucky between Bill Nye, the science communicator famous for his role in the children’s television program, “Bill Nye the Science Guy,” and Ken Ham, the founder of Answers in Genesis as well as the Creation Museum. Over the course of almost three hours, the two men presented arguments responding to the question: “Is creation a viable model of origins in today's modern scientific era?” Ham challenged Nye to the debate after Nye asserted publicly, in late 2012, that teaching creation science was “harmful to children,” and that its advocates were damaging science education in the United States by reducing its competitiveness in the global science arena: “We need scientifically literate voters and taxpayers for the future.” (Nye)

There are two key aspects of Ham’s argument in the debate that are useful for grounding this project’s conclusions: First, the key points of Ham’s argument were supported by his use of the stasis of definition—defining science as a set of practices in two distinct categories: “observational” and “historical” science—and his appeals to the authority of famous scientists who ascribe to the creation origins narrative. And second,
commentators’ mixed responses to the debate; several science bloggers suggested that Nye had done well because of how clearly he had explained the science of evolution:

“Bill Nye also did well…objectively speaking. He presented science, science, science and more science. He presented the science clearly, convincingly, chose his examples well, [and] personalized the discussion…pulling out a fossil he had picked up earlier in the week!” (Laden). But other writers, such as Michael Schulson, were disappointed with Nye’s performance, suggesting he sounded like “a clueless geek, even if his scientific points were valid.” Further, Schulson contends, beyond the debate itself, Nye lost in the grander scheme because, “thanks to the existence of antagonists like Nye, creationism is both profitable and, by all appearances, kind of fun. And profitable, fun activities tend to stick around, no matter what their moral hazards” (Schulson).

In his opening remarks, Ham defines science as “a state of knowing, knowledge,” and differentiates between two kinds of science, “experimental” or “observational” science and “historical” or “origins” science. According to Ham, experimental/observational science is the driving force behind the development of new technologies, antibiotics, medicines, and vaccines; it is conducted “using observation, measurement, experiment, and the formulation, testing, and modification of hypotheses” (Answers in Genesis). He differentiates experimental/observational science from what he calls “historical science, knowledge concerning the past,” which he asserts cannot be equated with experimental/observational science because “when we’re talking about [biological] origins, we’re talking about the past…we weren’t there, you can’t observe that.” “True” experimental/observational science, Ham implies, is “concerned-only-with-
“what-we-can-touch-and-see science” (Schulson). Because past events—evolutionary or divine—are not observable, Ham emphasizes, this is sufficient support for giving (at least) equal attention to the “biblical account of origins” (Answers in Genesis). Further, he takes public school textbooks to task for equating observational/experimental and historical science: “They arbitrarily define science as naturalism and outlaw the supernatural. They present molecules-to-man evolution as fact. They are imposing the religion of naturalism/atheism on generations of students” (Answers in Genesis).

Throughout his presentation of this extended definition of science in his opening claims, he makes appeals to the authoritative ethos of scientists at respected institutions. To bracket and validate his own definitions, Ham plays video testimonials wherein the scientists narrate their credentials and avow their belief in a creation account of the biological and geological origins of the world by having them. What makes Ken Ham’s definition of science and his use of ethical appeals compelling to his audience? Why does Nye’s (and other scientists’) use of logical appeals (“science, science, and more science,” as Laden says) to argue for the veracity of evolution science fail to lay this wider cultural debate to rest? An insight into these questions lies in my exploration of science center rhetoric.

Schulson suggests that, although Nye’s explanations of science were “valid,” Ham won because his explanation makes origins creation appear to be, like “a football or baseball game…kind of fun.” The affective appeal of his straightforward characterizations and definitions of science resonates with the affective appeal framing these science center exhibitions. Further, I contend that Ken Ham’s definitions conflation
of “experimental” and “observational” science, his ethical appeals to “noble” scientists, and his ability to frame creationism as a “fun” explanation, akin to “a football or baseball game,” can be read as based on the same domains of response invoked in these science centers’ built spaces and the pleasure of enthymematically-revealed “facts” in science centers’ exhibitions. This is not to suggest that they are necessarily similar in terms of their content or their explicit message about the value of science (although Ham does praise experimental science and the benefits of its technological and medical “fruits,” resonating with some explicit messages in the science centers). Rather, Ham’s definition of science and his affective appeals echo these science center exhibits’ implicit messages about the processes and products of scientific inquiry, the “folk epistemology of common sense empiricism” that instructs visitors to believe that careful observation and inference can produce affectively-satisfying scientific explanations. And his ethical appeals to scientists’ authority resemble, too, these exhibits’ valorization of “noble scientists” who can master those processes to “discover” new concepts. These equivalencies may be a consequence of science accommodation as it is executed in these science centers and elsewhere, for memorializing in the epideictic genre that which is, by its nature, primarily forensic.

The science center exhibits in this study tend to present an account of scientific knowledge and practice that is warranted by an object-based, folk epistemology of common sense empiricism; the science center’s built spaces then produce an atmosphere confirming the value of that account for its affective appeal, and its suggestion that visitors can easily “master” this process and its products that are a part of their “everyday
lives.” Designers often intentionally incorporate these affective appeals into exhibits, but such appeals are also epideictic functions performed by science centers’ architecture, geography, built spaces, and exhibitions. These immediate material “scenes,” meld with wider cultural exigences into material “agencies,” the means through which the “consubstantial space” of the science center contains and infuses experiences of “science” with a collective, epideictic ethos. That “constellation of purposes” frames the epideictic encounter where the science center functions as an agent of rhetorical instruction, which Dale Sullivan describes as

...a mature member of the culture [that] creates an aesthetic vision of orthodox values, an example (paradeigma) of virtue intended to create feelings of emulation, leading to imitation. As such, epideictic instructs the auditors and invites them to participate in a celebration of the tradition, creating a sense of communion. (118)

The science center buildings and built spaces presents an “aesthetic vision” of science appreciated according to the “orthodox values” that motivated the construction and institutional mission of the building. Visitors to the center are then directed by that aesthetic vision to celebrate the rhetorical tradition of science that the exhibits recapitulate through their multimodal representations. Cynthia Miecznikowski Sheard has suggested that such epideictic functions have a “tendency toward ‘idealization’,” by their nature: “By bringing together images of both the real—what is or at least appears to be—and the fictive or imaginary—what might be—epideictic discourse allows speaker and audience to envision possible, new, or at least different worlds” (770). Visitors are invited
to view the “folk epistemology of common sense empiricism” as warranting the careful observations and inferences by which the “noble scientist” creates new knowledge, the noble scientist whom they should emulate. The tradition of science inquiry embedded in these exhibits brings together an explanation of science—“what is…or appears to be”—that invites visitors to envision a future world where they might, as scientists, easily discover what is. The epideictic semiotic functions in science centers’ built spaces then further sanction, celebrate, and reinforce those messages. The buildings’ location in the community promotes it as a public vision of that community’s future.

It would be unjust and untrue to suggest that science centers are the only accommodators of science framing science in this way. School instruction has been critiqued for promoting a perception of science as arriving at certain fact rather than contingent knowledge: “…in the process of textbook simplification, findings become explanations, explanations become axioms, and tentative judgments may become definitive conclusions” (Raths qtd. in Taylor 161). Laboratory exercises tend to be laid out as a sort of deductive illustration of facts laid out in the textbook (e.g. “do these calculations, and follow these steps to combine these elements and produce compound X”). I contend that students must proceed far into higher education (or even postgraduate education) to encounter characterizations of scientific practice and product that emphasize its contingent nature and the labor involved in acquiring trained judgment necessary for its production. Further, scientists would most likely wish to retain the cultural authority that is connected to popular assumption that science arrives at truth, and I suggest that many (though not all) scientists themselves hold the position, even if they
do not own it publicly, that their methods, theories and practices *do* arrive at ultimate truths about the natural world.

Clearly, science museums share a great deal of company in their celebration and popularization of an idealized version of science—beautiful, valuable, noble, and *easy*—that may also inspire people to pursue science careers later on. Through their epideictic functions, both schools and museums teach young people to identify as their own the social values of science as a practice that realizes progress, that is aesthetically beautiful and fun, and which is done quite easily through minimal exertion of mental and physical energy. By conveying only the facts we accept as true now via the “folk epistemology of common sense empiricism,” school science also obscures the *labor* involved in scientific research by reporting only the theories and facts that are accepted now. The student’s visit to the science center, then combines that message with the epideictic science engaged in the “leisure” activity driving the motivation for a museum visit. There, too, the enthymematic revelation of facts and the celebration of that form of inquiry erases the labor, difficulty, and frustration behind developing the trained judgment and “techniques of self” which scientists must acquire and deploy to generate new scientific knowledge today. Such a practice makes Ham’s “baseball game” approach to science that much more appealing, and leaves students frustrated and disappointed when they, perhaps in a college laboratory course, encounter the more intellectually challenging practices and theories required to actually *do* science today. The labor-free “folk epistemology of common sense empiricism” also leaves science-advocates at a disadvantage in philosophical debates, as in this chapter’s opening example, where Ham used definitions
of science and appeals to scientific authority founded on a similar appeal to empiricism, to make an argument that de-values the practice of science in wider culture, especially in policy-making debates. These expectations about scientific practice and products also may also circulate among individuals holding a great deal of power, motivating politicians and stakeholders to assume that science will, in an expedient manner, provide definitive, factual answers to policy-related science questions.

Gordon Gauchat has shown that science has been increasingly politicized in the United States since the rise of the New Right, beginning in the 1970s. According to his study, religious groups and businesses make up a powerful sector of the New Right, and each questions the authority of science for different reasons: the religious for epistemological, moral and ontological issues (as I have suggested above), and businesses for financial and regulatory rationales (171). Gauchat suggests regulatory and advisory committee science done by the EPA and OSHA necessarily prescribes an adversarial relationship with business and corporations, who would rather adopt the most profitable means of operation rather than the most environmentally sound or safest (171). Although these same business-owners will likely accept the premises of science that produce new technologies and innovations for profits, we can see how the “folk epistemology of common sense empiricism” might be wielded in other situations to demand definitive knowledge before regulatory action is made. Debates about climate change—whether it is anthropogenic in nature, whether we should intervene to impose regulations on business or individuals now, later, or ever, whether these are even questions that *ought* to be debated in the popular media have, at least in part, to do with the strategic deployment
and manipulation of this common sense model of scientific practice. Believing and appreciating that science has public value is different from understanding how science is practiced and how members of its communities assess the legitimacy of a claim or theory. The centers in this study certainly offer affective experiences that encourage appreciation and elicit excitement about science, but they do not prepare visitors to debate attacks on science as an explanatory framework for past and future phenomena.

Science centers succeed at a certain kind of forensic debate into a noble practice that should be pursued. They teach us a way of arriving at scientific beliefs through an epideictic process, relating a method of inquiry that tells us that our everyday inference and reasoning is equivalent to what scientists do in their laboratories. Through the haptic exhibits we are taught to value this method of inquiry and see it as a noble practice enclosed by the affective frame of the science center. The multilayered analysis I have performed in this study has argued for the existence of a rhetorical tradition of science exhibits. That tradition produces a recurring rhetorical situation in the persistent, but plastic context of the museum institution, which is further influenced by the semiotic functions of its built spaces. I have argued that this tradition contributes to and concretizes valuable, but problematic cultural narratives and beliefs about what science is and what it does. The example of Ken Ham’s use of arguments, warranted by similar epistemological assumptions, calls attention to the politicized nature of science in contemporary American culture, and how perpetuating the “folk epistemology of common sense empiricism” both obscures the true nature of scientific labor and production, and devalues that labor and the status of the claims it makes.
What, if anything, can science centers do about this state of affairs? Science centers may depend on those same businesses that resist regulatory science to fund many of their exhibitions and programs. The Director of Strategic Initiatives at COSI told me that, in conversation about climate change, a funder for one of their new exhibitions stated, “I absolutely think that's made up, it's hokum.” Further, as economic forces have necessitated that science centers adapt their experiences to align with more standardized school curricula, they may have to become enmeshed explicitly in the evolution-creation debate. The Museum of Natural History and Science often has visitors from the Creation Museum who engage with the staff explicitly on the subject; in these conversations, staff have been instructed to respond, “This is what scientific evidence states and this is what our position is, but everyone's entitled to their own position” (Architect et al., MNHS). Several of the curators I interviewed suggested that they “don’t touch” politicized topics (Architect et al., MNHS; Director of Strategic Initiatives, COSI). When they must, they “let the science speak for itself”: “We're not going to get into a debate. We're not to take sides in any debate, we're going to make a statement that says, ‘Here's what the science says, here's what the science doesn't say. Here's what the science doesn't know’” (Vice President of Experience, COSI). My study has shown that, based on how science museums have developed, historically, and based on American culture now, to represent science apolitically is not possible. Both the means by which the science is represented, as well the material context of that representation, convey a message about how science is done, why it should be taken up as a career, and why it is valuable to the public.
To start, museum professionals might begin explicitly acknowledging and curating the historicity of science and the science center buildings and institutions themselves. Museums tours and programs could provide context to historicize the building and institution’s relationship to science and science education, and could make more explicit the relationship between the surrounding community and its scientific and technological development and practice. Exhibits, too, could incorporate more emphasis on the social and human aspects of science and scientific practice. Rather than simply incorporating videos of scientists alongside traditional haptic exhibits (as some museums already do), explanations in signage for haptic exhibits could explicitly acknowledge the epistemologies that undergird their function, and which are usually left implicit. For example, I can imagine a beautiful optics exhibit incorporating prisms and lights, and inviting visitors to explicitly imagine themselves in Isaac Newton’s position; such an exhibit could also introduce competing explanations that Newton (and his contemporaries) considered as possible explanations (as well as haptic elements to test those hypotheses), as well as the methods by which Newton arrived as his own, eventually accepted, theory.

Of course, exhibits in science museums adopting a historical perspective often already engage in this kind of social contextualization. Science centers, though, pressured to compete with other entertainment venues, even as they also are pressured to align to a greater and greater extent with school standards and outcomes, may sacrifice complexity for pleasure or for “pure” empirical concepts. But as this study has also shown, science centers are good at executing a complex task: making a subject that is
often viewed as dry, intimidating, boring, into one that is exciting. Science center professionals should not discount the power of these places, even as they acknowledge the complexity lent to the communicative task by the nature of the scene and the communicative medium. Curators and exhibit designers invested in representing science could also benefit from careful analyses of the Creation Museum’s exhibits, built spaces and displays, examining the logic warranting arguments in the exhibits and the affective appeals of the built spaces. How, if at all, do that museum’s attempts to make creation science “fun” echo the spatial and material semiotic functions of the science centers? Do their exhibits depend on the same folk epistemology of common sense empiricism? Answering these questions may further help museum professionals obtain a critical distance from their own practices, and help them to pinpoint more explicitly the aspects of their communicative media that might be tweaked to better suit their rhetorical purposes.

What should scholars of rhetoric and rhetoric of science take away from this analysis of the rhetorical power of (and in) these places? For one, this study suggests the value in taking a “long range” historical view for studying a communicative medium or genre. I have argued for the value in investigating the historical circumstances of exhibit development and how that history reveals a dialectic relationship between the exhibit, its use, and its context, generating a rhetorical tradition that has scaffolded and fixed into the exhibit-medium particular theories of knowledge-making. This study has also demonstrated the intellectual value of looking to institutional and architectural history to understand how material context influences institutions’ present and future rhetorical acts.
to address community exigences. Further, it tells us how the melding of the Burkean “scene” and “agency” produce rhetorical functions in the material spaces that enclose the rhetorical situations, and the ways in which those functions may constrain both what, beyond the written content, is realized through an exhibit’s multimodal communication. In the context of the wider institution of the museum, this study has also demonstrated how stakeholders’ rhetorical purposes for institutions may be constrained by the architecture that contains them; these constraints, further, suggest that the identifications we can invoke and rhetorical agency we can exert are shaped by our immediate material and social contexts, but also by the myriad factors converging to create and remove an institution’s rhetorical exigences throughout its history. When we consider material culture and the meanings made available in these unique terministic screens, particularly in museums, then, we must consider not only the moment in which an individual engages a specific idea or concept through an object, but how the history of engaging particular objects and ideas in particular places is engaged in that process. The epideictic functions of the science centers in this study are largely due to how stakeholders reimagined their architectures and built spaces as responses to wider political exigences.

These findings, though, also open up the possibility for a variety of other studies focusing on science centers and their rhetorical practices. As the political and social exigences addressed by science center institutions continue to develop, how will science centers and their exhibits and programs respond to those changes? A study of midwestern science centers’ programs and exhibitions designed after the year 2000 could begin to answer this question. A similarly useful study could engage this project’s
findings with a study of the rhetoric of science communicated to visitors in science center programs and casual exchanges between visitors and docents or floor staff acting as “explainers.” These conversations are memorable for visitors, but, unlike exhibits, their messages about science are ephemeral, and therefore may be made more explicitly political because evidence of the exchange is removed when the conversation ends. Such a study of these conversations and demonstrations would complicate my characterization of the nature of the messages about science and scientific inquiry by incorporating analysis of the messages that visitors definitively engage during their museum experience.

Examination of the “Research in View,” movement in science centers could also provide useful information about rhetoric of science accommodation and its intersections with space and place. “Research in View,” currently adopted at COSI and the Boston Museum of Science, places active laboratories inside science centers, making research practices visible to the public. Researchers who investigate child development, psychology, language, education, as well as other subjects answer visitor questions and can recruit individuals to participate in their experiments. Future studies of science centers could compare the rhetorics to which visitors are exposed in encounters as participants in those research studies or in casual conversations with the scientists and compare those exchanges with the communicative media of the exhibitions to better understand how conversations with scientists, educators, and engagements with “static” media compare in their representations of science. Studies of another bent might, alternatively, explore how research practices and reporting conducted in public view and
with the collaboration of the public differ, if it all, from similar experiments conducted in laboratories restricted from the public.

The politicized nature of science today suggests, too, that a valuable comparative study could be made between this study’s findings and a study conducted at science centers located in regions with greater diversity of political perspectives and opinions; such studies could track whether the political opinions of stakeholders in those regions relate to decisions to fund exhibitions with more explicit treatment of controversial topics. Studies of science centers in other countries and their representations of science would also provide invaluable comparative insight into science accommodation and its relationship to cultural attitudes and beliefs about science. Like the subject matter that they attempt, faithfully and earnestly, to convey, the subject of science centers is a moving target. This study has shown that, as much as the museum has produced a rhetorical tradition through its accumulated domains of response to the exhibit, the shifting demands, beliefs, and values of the wider culture necessitates a constant re-evaluation of the forces that influence and define science today and tomorrow. Scholars of rhetoric certainly have the intellectual tools and the flexibility required to take on this task.
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