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BUILDINGS AND THE SUBJECT OF SCIENCE

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THE ARCHITECTURE OF SCIENCE

The Architecture of Science means many things to the authors whose work is assembled here. We are (collectively) trying to understand the alternately harmonious and tense, but always compelling relationship between alchemists, natural philosophers, and scientists on one side, and those charged with the centuries-old task of constructing the built world on the other. How do the buildings of science literally and figuratively configure the identity of the scientist and scientific fields? Conversely, how do the sciences procedurally and metaphorically structure the identity of the architect and the practice of architecture?

To emphasize just how diversely science has been architecturally sited and architecture has been “scientized,” we have quite deliberately mixed historians of science, historians of architecture, historians of art, architectural theorists, sociologists, architects, and scientists—you have before you papers diverse in method, style, period, and subject. In a sense, it could hardly be otherwise; our object of inquiry is too multiform. There is, for example, no single transtemporal, transcultural entity that is “the laboratory” that would include all spaces from the alchemist’s secretive basement array of furnaces through the clinical research hospital to the \$10 billion Large Hadron Collider outside Geneva.¹ There is no single way in which science is invoked within architectural theory and practice, and no single method by which architecture facilitates, appropriates, displays, and gives identity to the scientific processes contained within its walls.² Historically, spaces for the production of knowledge about nature have ranged in type from castles to industrial factories, university groves to corporate headquarters. Even within a given genre

of buildings, there is no simple unity. Some hospitals evoke a church or alms house, whereas others call to mind sprawling suburban malls. Some laboratories shoot up with modernist fervor ten, twenty stories into the air; others branch horizontally in quasi-historical reference to nineteenth-century mill towns.

Just as the category of the scientist alters across time, so too does that of the architect. Within the history of architectural practice, there has been, as several of our authors tell us, a long history of "scientism"—a fiercely sought (and equally fiercely contested) ambition to make architects themselves into mirror images of the science their buildings sometimes contain: architecture as physics, biology, or ecological science. But if architecture is not a subcategory of the natural sciences, architecture and architects do appropriate scientific practices, materials, theories, and values in a constant reworking of disciplinary identity.

There is no reductionist message, then, to the essays in this book, nor, given the heterogeneity of our subject, could there be. In a hypertext introduction, there would surely be many different ways to group these essays: One could, for example, sort them by discipline, segregating the work of architectural historians from that of architectural theorists, or putting the architects together and isolating them from the historians or sociologists of science. Intentionally, however, we have chosen to group the essays thematically, very deliberately straddling disciplinary fences. Their variegated authorial backgrounds notwithstanding, I aim, in this introduction, to view these essays through the prism of the subject: What can architecture tell us about the changing identity of the scientist? And conversely how can science inform us about the shifting identity of the architect?

I find especially helpful the work of Francesco Dal Co as he explores the relation of the modern subject to the notion of "home" and the city. For theorists like Ferdinand Tönnies, Oswald Spengler, and to a certain extent Werner Sombart, place and dwelling held a preexisting attachment to the world, an organic connectedness of the home to the landscape that was irrevocably separated by the city. Against this nostalgic position, Dal Co pits Emmanuel Levinas and Martin Heidegger's argument that dwelling always presupposes a difference, a separation from the surroundings. It was *never* otherwise. Our sense of "place," even before the city, is not an outgrowth of some "natural" space. Rather, it is the other way around, as Dal Co puts it: "Without dwelling there can be no place; it is construction that evokes the place and transforms the space."³

Extending and transforming this reasoning about home and city to the places of science, we can put aside the idea that there was once a "natural," purely individual subject position for the scientist that was destroyed by the expansion of the laboratory into its large-scale, industrial form. Instead, we can ask of each age: "What kind of scientist, doctor, or viewer of science does a certain kind of laboratory, hospital, or museum architecture presuppose?" There is an analytic, design side to this question: Are the "scientific dwellings" (so to speak) constituted such that they are appropriate for individual, small group, or mass work? Are their spatial divisions permanent or flexible? Are the symbolic

elements of architecture such that they link the space to libraries, offices, factories, homes, or churches? There is also a psychological-sociological side of the question: How does the architecture act as a guiding, daily reminder to practitioners of who they are and where they stand? By exposing the adjacency and distance between disciplines, between theorists and experimenters, between patients and doctors, between the scientist and the public, the built world helps define how scientists see themselves. Architecture can therefore help us position the scientist in cultural space; buildings serve both as active agents in the transformation of scientific identity and as evidence for these changes.

Conversely, several of our contributors not only explore whether architects are, were, or ought to be “scientists,” but more probingly, they demand that we reassess the image of scientific practice against which that question is posed.⁴ The architects in this volume are looking to design in ways that renounce a too functional, scientific conception of laboratory design; the architectural theorists reject the idea that architecture can or ought to be assimilated to a particular scientific “method”; and our architectural historians distance themselves from a narrow definition of technology. Examining the history of architects’ vision of science can tell us a great deal about the evolving sense of architectural self-identity.

In different ways, and in strikingly different registers, the following twenty-two chapters explore the means by which architecture and science define one another through their encounter. We are after the scientific subject inhabiting the scientific edifice and presupposed by it; and we are after the architectural subject that has itself been drawn in the confrontation with science.⁵ Who is it (and who ought it be) who steps into the alchemical chamber designed after the secret alchemical hieroglyph? What identity attaches to the patient who walks into a medical center qua mall to purchase genetic tests? What kind of scientist comes to work on the swing shift of the data analysis team at Fermilab? When architects structure a molecular biology laboratory with contiguity in space between mouse-based genetics and virology, their decision facilitates certain moves in biological research and contributes to the identity of a field. When electrical engineers’ workspaces join those of physicists, or when Renaissance women are excluded from a natural history collection, space is manipulated to concentrate the meanings crystallized around the science of a given time. It is through appropriation, adjacency, display, and symbolic allusion that space, knowledge, and the construction of the architectural and scientific subject are deeply intertwined. These studies—“Of Secrecy and Openness: Science and Architecture in Early Modern Europe”; “Displaying and Concealing Technics in the Nineteenth Century”; “Modern Space”; “Is Architecture Science?”; “Princeton after Modernism: The Lewis Thomas Laboratory for Molecular Biology”; and “Centers, Cities, and Colliders”—move through a general chronological framework, yet at the same time raise common issues and questions that span time and thus serve to link the different sections of the book.

Architecture begins at the door, and that door, as Georg Simmel argued a century ago, is both a statement of connection and of separation.⁶ Where “modern” science happens is often (too simply) assumed to be open space, doors ajar and ideas available to all. Medieval science was a closed affair (so the story goes) until suddenly the sunlight radiating from Galileo, Descartes, and Newton flooded the scene, collapsing the shadowy secrecy of the alchemist and replacing it with the published, daylight knowledge of modern science. But neither architectural nor scientific knowledge changed quite that way. Among others, Steven Shapin has shown us the more ambivalent nature of this openness: how Gresham House, site of Boyle’s early experiments, was not by any means open to any comer. Gentlemen—and the term had a multiply restrictive meaning—would pass through where others were excluded.⁷ The essays by our first group of authors show further that the doors of science swung open selectively, and the passages revealed upon entrance were by no means public streets.

Paula Findlen begins with the natural history collection of the Renaissance naturalist Ulisse Aldrovandi; she asks, Who came? Who saw? Not women. Of the many who inscribed their names in the guest book, almost all were men. The “hairy girl” from Spain came, but more as an exhibit than a visitor.

Two issues immediately come to mind. The first is the matter of simple exclusion: At the most elemental level, if women were not allowed to view (much less maintain) natural history collections, the modality of their exclusion from natural philosophy in the early Renaissance becomes clearer. Second, and more subtly, the very act of excluding women from certain sites of knowledge impressed a symbolic set of associations on the natural history collections themselves and so conditioned the gendered patterns through which natural historical knowledge was understood. Alberti’s writing (as Findlen so remarkably shows) made this transparent by codifying gender-defined access to domestic space. Alberti’s ideal patrician household contained adjacent bedrooms for husband and wife (with a “secret door” to allow conjugal visits). Off the husband’s bedroom was his study; off the wife’s bedroom, her dressing room. The ethos underlying such sentiments was pervasive, even absorbed by some women, as they strove to locate spaces and subjects appropriate to themselves. Moderata Fonte’s imaginary female academy was set in a (properly feminine) garden, not in the masculine location of the museum. In so dividing architectural space, the ever more feminized domestic sphere acquired a specifically gendered identity for the prosecution of natural historical knowledge.⁸

Like Findlen, William Newman is not at all convinced that the shift from secrecy to openness came easily—if at all—into Renaissance culture. In a pathbreaking article in 1986, Owen Hannaway contrasted the plans for a chemical house of Andreas Libavius with the secret, “elitist” alchemical laboratory of Tycho Brahe.⁹ To Hannaway, every architectural nook and cranny of Tycho’s castle, isolated on a small island in the bay of

Hven, spoke to a traditional princely power and privileged knowledge, and as such stood for the older order of science. Where Tycho's island fortress excluded the public, Libavius's laboratory stood in the heart of the city and welcomed visitors. Where Tycho saw the laboratory as an extension of the textual obfuscations that impeded the entrance of the uninitiated and unworthy to the realm of alchemical knowledge, Libavius (Hannaway contended) wanted openness. Tycho became a recluse; Libavius's plan was to act as philosopher and *paterfamilias*, as a citizen in town and an inquirer into nature. In the architecture itself, Hannaway's argument went, one could see the end of the alchemist and the beginning of the chemist.

Newman views this architecture differently, and he shows persuasively that far from being a harbinger of everything modern, Libavius saw himself as restoring faith in authority against the rebellious, chaotic interventions of the Paracelsans. Indeed, Libavius's self-identification with the older alchemical tradition becomes manifest when we observe that, as Newman demonstrates, the alchemical monad (the master alchemical symbol) actually stood as the fundamental design element of Libavius's laboratory. Far from instantiating civic duty, on Newman's reading, Libavius's laboratory was built to mark in the walls themselves the most secret transmutational scheme of all: the hypersymbolized drive to the philosopher's stone. In the *sanctum sanctorum* of Libavius's lab, certain furnaces were to be separated "from the crowd." There were sites to which no one is admitted "except one quite close to perfection." Nor did such ambivalence towards openness perish at the end of the Renaissance: As Shapin has shown, even seventeenth-century laboratories were not open to just anyone. Simmel's "open" and "closed" spaces turn out to be nuanced concepts indeed, each containing elements of the other.¹⁰

The conjoint issues of architectural, epistemic, and social access Findlen, Newman, Shapin, and others raise throw into question the very notion of "openness" in post-Renaissance science. Yet, the rhetoric of openness was clearly present at the origins of (sixteenth-century) modern science. Where did this rhetoric come from, and how was it tied to the idea of empiricism? These are the questions that Pamela Long addresses, and to respond to them she takes us back to classical uses of "openness" in the world of architecture. Long shows us that to the Roman architect Vitruvius (20s B.C.E.), architecture was not distinct from other practices that later would have been classified variously as technical or engineering: clock making, machine operation, and the rational and practical aspects of construction. Vitruvius favored openness in print and experimentation (in the sense of trying out); he detested stolen writings and tirelessly defended the need to make precepts explicit. All this sounds, on the surface, quite "modern," but one needs to listen carefully, as Long does, to the context in which Vitruvius was writing. In the politically unstable last decades before the common era, Augustus was working furiously to bolster the legitimacy of his rule, and his temple-building program was designed to secure the authority of priests and ancestor worship, as well as his own claim to power. For Vitruvius,

stealing text from past authors was a breach of etiquette against ancestors and authority; openness in the use of sources stood as an act of filial devotion.

Long tells us that the belief that architecture was bound to the conduct of governance was new in the Renaissance. Architectural symbolism went further: As Vitruvius saw it, each type of ruler (tyrant, magistrate, and so on) ought to build according to different styles. This architectural knowledge, said fifteenth-century architect Leon Battista Alberti, could come only from a just combination of study of the past, innovation in the present, and the “limpid, clear, and expeditious” development of argument. Unlike the higher-born Alberti, Filarete was trained as an artisan, and he had a different case to make for openness. In his “ideal city” of Sforzinda, Filarete insisted that artisanal be joined to “learned” knowledge—he published guides to everything from blast furnaces to stainless plaster. But openness here was tied to an abandonment of guild secrecy in favor of princely patronage. For some architects, openness was indeed linked to empirical work, on the surface an ethos usually associated with early modern science. Looked at carefully, Long concludes, natural philosophers of the sixteenth century were indeed struggling to define themselves through openness, but in doing so they were building on a long tradition of architectural proclamations of openness from antiquity through the Renaissance.¹¹

PART II: DISPLAYING AND CONCEALING TECHNICS

What happens when architecture builds around—literally encloses—the technical? Norton Wise explores this concretely in his tour of the English-style gardens that appeared in nineteenth-century Germany. After the Prussian defeat of Napoleon, architects and statesmen urgently sought a symbolic, cultural representation of their new victorious identity. One prominent celebratory structure was an ostentatious use of the steam engine to create an “English” landscape architecture by powered waterfalls, artificial streams, and forced irrigation. Disguised engines both hid and displayed industrial might.

But Wise’s Prussian-English garden was also a hidden, subtle aesthetic, one that self-consciously sought to avoid the British “Coketowns” while alluding to both material and spiritual elevation. Cloaked in the exterior of mosques and Italianate villas, the steam engines were technology, but technology tamed by culture. Here was where a Hermann von Helmholtz could “grow up”; indeed, a generation of scientists and industrialists built on their experience of this landscape to forge a new science of work. To walk in the German English steam garden was to feel oneself both at one with nature and in command of it; it was to reinscribe in nature the self-fashioned identity of an older Prussian culture and to join to it a contemporary identity of modernity and power.¹²

Nineteenth-century German science was not all sited amid steam engines and pseudoclassical ruins, however. As Myles Jackson shows in his exploration of glassmaking in the Benedictine monastery of Benediktbeuern, the identity of the German optician

could be both antique and modern, secret and open, industrial and craft centered at the same instant. Joseph von Fraunhofer, known to every physics student for the last century and a half for his study of the physical properties of light, made his prisms far from the famous urban physical institutes. Deep in the Black Forest, the Benediktbeuern monastery where Fraunhofer worked had both natural and human resources to support his science: wood, quartz, and workers (religious and secular) well skilled in the production and use of precision optics. Additionally, the physical architecture of the cloister itself was vital.

But the pairing of secrecy and openness reinforced a particular identity for Fraunhofer's optics. Making a great display of his techniques for measuring and calibrating prisms, Fraunhofer swung the doors open for important scientific visitors to witness the dark lines of the spectrum and the attainment of achromatism. Only then could Fraunhofer claim to be a "scientist" rather than a craftsman. At the same time, other doors slammed shut: No one—under any conditions—was going to be ushered into the quasi-sacred site of the glass fabrication house itself. Covert guild practices fused with proprietary as well as national secrecy and a transformed monastic silence. Architecture permitted this separation by the disposition of closed and open spaces, but more importantly, the symbolic history of the cloister naturalized such a distinction. Like Newman's alchemical laboratory or Findlen's natural history collection, Fraunhofer's "lab" was ostentatiously open *and* shut—a scientific showcase with a hidden back room.

Display continued in natural history museums, of course, the museums that over the course of the eighteenth and nineteenth centuries came to replace the curiosity cabinets of the Renaissance. Two of the most prominent types of museums that came into existence were natural history museums and anthropological museums, and our next two essays turn to these. In the first, George Stocking examines the often acrimonious debate between Otis Mason, curator of anthropology at the United States National Museum, and Franz Boas, then an immigrant scholar from Germany. At stake was what one might call the meaning of adjacency, the conceptual significance of artifact arrangement. Mason believed that similar artifacts were found around the world because similar circumstances gave rise to similar responses. Given such an outlook it made sense, for example, that in the National Museum, all rattles were grouped together: Why separate them? Boas argued vehemently against the view that artifacts could stand as universal constituents of a universal culture; instead, he contended that practices could be grasped only in separate, culturally "complete" collections.

One can see in Stocking's depiction of these two visions of the architecture of artifacts two very different cultural contexts. On the one side was an American vision of a world in which identity could be forged around universalist notions of human capacity. On the other stood the powerfully inscribed German concern with *Rasse* and *Kultur*, even if in Boas's hands such categories were molded into a relativistic anthropology. But Stocking's story continues. An ambitious new museum building was planned at Oxford

in the 1960s, a museum to house the collection of some 14,000 objects donated by General Pitt Rivers, a contemporary of Mason and Boas. The architects chose an ideological pastiche: Circumferential rows would display objects of a certain type, while radial sections would exhibit diverse objects from a specific geographical area—although Stocking might not put it this way, it was Boasian in r and Masonian in θ , a never realized British compromise between American amalgamation and German tribal purity. In this decades-long architectural struggle, we encounter not only attempts to formulate tribal and human development, but also the traces of the anthropologists' own battle over the purposes and identity of their profession.

Like Stocking, Sophie Forgan excavates a fascinating comparative story by examining two nineteenth-century museums: Richard Owen's Natural History Museum, and the Museum of Practical Geology in Jermyn Street (London).¹³ The Jermyn Street Museum was designed to educate the public not only about the "natural" geographic riches of the British island, but also about the economic benefits that resulted from the commercial exploitation of these natural resources. Museum rooms exposed the local riches of different districts, and even the walls spoke of British origins, through facades of Yorkshire dolomite or red Peterhead granite. Some of the great disputes of British stratigraphic geology became displayed fact as the museum presented layers of minerals divided according to one or another theory. Forgan shows us how the galleries became a horizontal representation of a geological section: One could walk through geological time, from the Lingula Flags or Cambrian through the Permian, Jurassic, Eocene, and Oligocene epochs. The space of the museum, marked by fossils, became the symbolic space of geological history and a microcosmic representation of Britain's national existence. Here was the museum as map and flag.

In contrast to the Jermyn Street Museum, the Natural History Museum was designed not as a map, but as an architectural representation of the natural historical convictions of its first director, anatomist Richard Owen. Current zoology stood to the west, paleontology and extinct species to the east; the "spine" of the building bore vertebrates, and the skeletal design of the whole reflected the Cuvierian conception of the order of nature. According to contemporaries, the Natural History Museum was a well-ordered "biography" of nature and nation, writ in stone. Each museum reflected the cultural and scientific preoccupations of its designers and directors; but once built, each served as a powerful guide in the construction of the identity of natural history as a discipline. The inescapable gap between a national geology and the supposedly transcendent character of science is, to a certain degree, imaginatively bridged by the solid existence of national museums of natural history.

From their origins in private rooms of contemplation designed to bolster Renaissance aristocratic privilege, national museums became, in the nineteenth century, spaces that conveyed ancient permanence and the modernism of national power. Walking

through the natural history museums, the museum-goer and scientist alike surveyed an orderly world acquired by empire. Natural history gave order to the diversity of that world, and in the architectural materiality of museums, scientific displays helped define what science was, and where it was going.

PART III: MODERN SPACE

If scientists use architecture to fashion and refashion their identity, the converse is also true. As Sophie Forgan argues elsewhere in her essay, nineteenth-century British architects enlisted scientists not only for their contribution to building principles, but also as symbolic allies in the architects' own struggle for an identity distinct from that of engineers and builders. But the mutual positioning of symbolic orders as complex as science and architecture could never remain a purely strategic alliance. Adrian Forty makes it clear that the metaphorical vocabulary of science enters into architecture in ways so familiar to us as to be practically invisible—and yet these scientific tropes express the way architecture is conceptualized and received.

Think, Forty directs us, of the metaphor of "circulation." William Harvey first developed the concept in his physiological studies of the heart in the seventeenth century. Yet the usage of "circulation" within architecture did not occur for centuries: Suddenly, in the latter part of the nineteenth century, buildings came, in the architectural imaginary, to resemble physiological systems, and passages in buildings transmuted into pulsating arteries and veins. Whereas it is easy to see buildings as, in fact, like the body, Forty asks us to step back, arguing instead that nineteenth-century architects like Eugène Viollet-le-Duc wanted this enclosed self-sufficiency, and the physiological circulation metaphor bolstered their desired autonomy. (They could have chosen an interactive metaphor like respiration.) Similarly, one can, and Forty does, pursue architects' deep attachment to mechanical metaphors (used not as structural dynamics but as a means of expressing form): compression, stretch, tension, torsion, shear, equilibrium, along with centrifugal and centripetal forces. Traceable to the aesthetics of Hegel and Schopenhauer, mechanical metaphors came into widespread use with Heinrich Wölfflin. Later critics, including Colin Rowe (writing on Le Corbusier) or, more recently, Peter Eisenman boosted such mechanical metaphors to new heights.

Perhaps, Forty suggests (following Alberto Pérez-Gómez), the interwoven premodern identity of architecture and science before the 1700s made the analogic function of scientific metaphors superfluous. On this reading, the very existence of scientific mechanico-circulatory metaphors signals the separation of architecture from science. Modern architecture therefore revealed its identity through the scientific language on which it drew for expression, an identity simultaneously turning toward science and acknowledging its separation from it.

To restrict “science” to the natural-scientific sphere of biology, chemistry, and physics, however, would be to miss entirely the significance of the notion for one of the leading modern architects of the Bauhaus, its often neglected post-Gropius leader, Hannes Meyer. Michael Hays makes this clear in his essay, showing that for Meyer, the German sense of *Wissenschaft* embraced far more than the natural sciences. In particular, Meyer’s scientized architecture linked the practice of the discipline to the aspirations of scientific Marxism. True, architecture would embrace the calculational physics and physiology of the day, but science itself folded into a social and historical network of forces, and history itself unfolded into the socialist future. Hays argues that in Meyer’s design of the Swiss Petersschule, Meyer was striving to eliminate the architect’s personality and the traditional art of facture in favor of a scientized engineering. Meyer’s was, in the strongest possible sense, a modernist intervention, an attempt to reorder people’s daily experience of the world. By producing communal spaces, spaces that referred only to the rational calculus of a new way of life, Meyer wanted architecture to reshape us and so the order of society. Architecture went all the way down, so to speak: Architecture was the physical world that rebuilt the psychological and social subject who inhabited that world. The result was the new, “modern man.” For Hays, this modern man held a new subject position within Meyer’s architecture, that of a rationalized life, and it was precisely a rationality embedded in the order of scientific Marxism.

As I have argued elsewhere, the “unaesthetic aesthetics” of the Dessau Bauhaus went hand in hand with a technocratic Marxism, an “unpolitical politics,” and a new scientific “unphilosophical philosophy.” Rudolf Carnap, Otto Neurath, Philip Frank—the left wing of the Vienna Circle—made common cause with left-leaning Bauhäusler, seeing in their logico-empirical epistemology a form of *Neue Sachlichkeit* that they hoped would supplant traditional philosophy. Radiating outward from Vienna and Berlin, this movement held together by offering the architects a form of scientific justification, while providing the new “antiphilosophy” a grounding in the wider modernist movement.¹⁴

It is a commonplace in architectural history to contrast the enthusiastically scientizing worldview of the hard-edged Bauhaus with the recalcitrant early-twentieth-century American architects, who were far less willing to pursue the aesthetic possibilities of the modern machine age. More specifically, the cliché is this: Americans, in their own unself-conscious, pragmatic, and unreflective way, had produced a vast technical infrastructure from grain silos to machines of mass production. But only in European hands, the cliché continues, could this engineering know-how be converted into the cultural modernism that transformed the meaning of architecture and society. Emily Thompson dissents, offering a very different picture of the way science joins the modern American building. She is interested less in building exteriors than in the interior uses of technology: modernist scientific architecture from the inside out, not the outside in.

Thompson’s focus is on sound.¹⁵ In the nineteenth century, there were many scientific principles of acoustics, but not much success in applying them to the practical art

of controlling sound in buildings. Around 1900, Harvard physicist Wallace Sabine was enlisted as an acoustic consultant to help create the sound for a concert hall for the Boston Symphony Orchestra. He developed a mathematical formula that predicted the frequency-specific reverberation times as a function of a room's volume and the absorptive power of its specific materials. Sabine's success in Symphony Hall launched other acoustic-architectural collaborations, including the development of new sound-absorbing building materials such as Akoustolith and Celotex.

Thompson shows how these new materials were increasingly employed, not simply to control sound, but to eliminate noise. Against the cacophony of modernism, psychologists, physicists, and urban progressives identified noise abatement as a means to create better workers by improving mental health, concentration, and productivity. Buildings like the New York Life Insurance tower exemplified this interior modernism, a modernism, Thompson argues, that worked like a chrysalis, moving outward toward the exterior. And, instead of architects evoking or applying "science" to their designs to render them modern (à la Meyer), she shows architects and scientists working intimately together to create both new architecture and new science. The union of acoustic science and architecture reshaped what it meant to be an architect and a scientist at their intersection, at the same time that it altered the "modern experience" of the inhabitants of these rationalized concert halls, apartments, and offices.

As Allan Brandt and David Sloane demonstrate, hospitals in their various forms were also quasi-public institutions; like symphony halls, hospitals carried their own disciplining message to patients and doctors, inscribing idealized patterns of comportment on both. In Brandt and Sloane's words, the hospital stood in a mediative position between science and public culture, and thus situated, offered a unique window into the architecture of science. Understanding the manifold designs of the American hospital as it developed from the 1800s to the present offers insight not only into that institution, but into the authority structure of scientific medicine itself. For though the current prevalence of hospitalization in our lives makes the institution a fixture from birth to death, it was not always so. In the nineteenth century most American health care was received in the home, the hospital being a site only for the most dire circumstances: for the poor, and for those without family or friends. Disease within the hospital made it a feared place, and the architects of the early hospital struggled, not always successfully, to alter that stigma. During the nineteenth century, neither medical research nor science had a prominent place in the hospital; the institution was above all a charitably funded refuge for the dispossessed. Its architecture reflected and reinforced the patient's supplicant identity, and simultaneously its pavilions represented a bulwark against the "bad air" theory of disease.

Charles Rosenberg has shown how the move to construct hospitals vertically built on a shift from the bad air theory to the germ theory of disease; pavilions isolated patients from wafting bad air, but such isolation was not necessary if germs were the danger

and they could be killed through sterilization.¹⁶ And within these new towers of medicine, so Brandt and Sloane contend, antiseptic, diagnostic, and monitoring technologies altered the practice of medicine. The vertical, "functional," research-teaching hospital of the early through mid-twentieth century became the standard site of biomedicine.

With the coming of the 1960s and 1970s, these modern towers of medicine were viewed with an increasingly critical eye, no longer as sleek exemplars of efficiency and science in the Bauhaus-internationalist spirit, but rather as oppressive, machinelike monsters. Architects, doctors, and community boards set about taking down the monoliths, rescaling them to human proportions, recasting the patient as consumer, the doctor as "health provider," and medicine as commodity. The modern tower has become a mall. When patients enter this "postmodern hospital," they come neither to be disciplined into a morally improved state, nor to be "operated upon" by the medicine machine; they come to comparison shop. In this world of consumer medicine, the very categories of disease and health alter, along with the shifting, ever reconstructed identity of patients who purchase and doctors who provide.¹⁷

PART IV: IS ARCHITECTURE SCIENCE?

In many of the essays presented here, we see an immediate concern with the modalities by which architecture functions in the identity formation of science and scientists. But there is a reciprocal and equally important question alluded to in the essays by Forgan, Thompson, and Hays: How does science function in the self-understanding of architecture and the architect? In this section, we bring this question to a head: Is architecture a science? Was it once or ought it aspire to be? Antoine Picon, Alberto Pérez-Gómez, Kenneth Frampton, and Denise Scott Brown critically interrogate the scientific aspirations of architects and, more generally, the architectural endeavor.

Picon suspects part of the contemporary concern for science-architecture links emerges from a certain nostalgia for a cultural unity that cannot hold, if it ever did. Instead of searching for a simple unity or an architecture that merely "reflects" the scientific, Picon locates both architecture and science in a broader cultural frame encompassing both. In one example, he identifies a characteristic way of thinking in the early modern era: Scientific and technological practice all came to invoke a notion of "analysis" of wholes assembled from primitive parts, where these parts were taken as human products, not natural atoms. D'Alembert considered Newton's inverse square law, for example, to be an "element" of physics, and the engineers of the Ecole des Ponts et Chaussées counted flat decks and bridge piers as "éléments" of construction.

In a more contemporary case, Picon indicates how differently architecture functions in a world in which the very meaning of a "technological artifact" is uncertain. An automobile, for example, is no longer defined as a discrete object of steel, rubber, and glass, but instead, a "computer on wheels," a node in a vast electronic network. For Picon,

such amorphously extended quasi-objects cannot be counterposed against the human, and instead technology becomes an environment, a landscape, a background in which we live. Architecture responds to this new techno-environment of things through a variety of strategies that blur the traditional dichotomies of order-disorder, rationalism-lyricism. Rem Koolhaas plays with intermediate scales between buildings and urban development; Jean Nouvel crystallizes technological landscapes by playing with moving surfaces of light and texture as if they were computer images. Whether in the eighteenth or the late twentieth centuries, Picon concludes, the identity of the architect is neither derived from technology nor divorced from it, but coexists with it within a larger culture that defines both.

Alberto Pérez-Gómez is less sanguine than Picon about the harmonious relation between the technological and architectural worlds. For Pérez-Gómez the story begins in the territory of antiquity explored by Pamela Long, where architecture and science constituted a single endeavor. Following Edmund Husserl, Pérez-Gómez locates the fundamental epistemic break of modernity in the seventeenth century, with Galileo and his successors. On the far side of that break is the life-world (according to Husserl), the “only real world, the one that is actually given through perception”;¹⁸ on our side of the break is the quantification of nature, the creation of a “formula-world” in which idealized magnitudes and their functional relations come to count as all there is. In Husserl’s view, once this transformation from life-world to formula-world has taken place, the further elaboration of science may be productive, but at root, philosophically, it is more of the same: Galileo writ large and wide.¹⁹

Pérez-Gómez builds on this Husserlian metaphysical periodization. Before the Galilean break, architecture and science (he states) “were linked at the very inception of our Western tradition.” Plato’s *Timaeus* was the prototype for both architecture and science; architecture and science revealed truth by embodying the proportional relations of the cosmos. Only with the Galilean break does architecture become an instrument for accomplishing goals; only then, in the hands of late seventeenth-century architect Claude Perrault, does architecture become a search for “most probable” solutions and mathematically exact deductions. To Pérez-Gómez, who is frankly normative, all subsequent attempts to identify truth with science and science with application are doomed to superficiality. As an alternative, Pérez-Gómez proposes, architecture must be grounded through language in “history (stories),” a history that could be humanity’s and architectural theory’s “true normative discipline.”²⁰

Like Pérez-Gómez, architect-historian Kenneth Frampton vividly summons up scientific instrumentalism appropriated by twentieth-century architects, but for Frampton that instrumentalism emerges more sociopolitically and more recently than for Pérez-Gómez. From Alexander Klein’s ergonomic housing of 1923–31, with its resonant Taylorism, to Richard Neutra’s and Alvar Aalto’s biotechnics of the 1940s and Sven Hesselgren’s late 1950s (proto) semiotic exploration of the language of modern architecture,

these nominally scientific attempts to conduct architecture by means of computer-aided studies, topological analyses, or bioclimatic calculations leave Frampton cold.

At root, the problem for Frampton is the underlying acceptance of the scientific program of an analysis of subsets and parts and the concomitant lack of attention to the larger "big picture" of the negative effects of science/technology/capitalism on the global environment that all these projects represent. To Frampton, these problems cannot be solved by any science or scientific architecture, since any such enterprise would, by definition, break the problem up into pieces and miss it in its entirety. He proposes, instead, that a solution must be found in the development of a critical theory of architecture that would redefine architecture's identity; this new repoliticized identity must, like architecture itself, be constructed from the ground up, piece by piece.

Although she approaches the scientism of architecture as a practitioner-theorist, not as a historian, in her antireductionism Denise Scott Brown concurs with Picon, Pérez-Gómez, and Frampton. Recalling her own education amid and experience with the assault on architecture by the scientism of the 1960s, she writes that "in architecture we are dogged by the model of the sciences." Social planners of the 1960s as well as the computational designers of the 1990s are all, she charges, bent on dismantling the architect's craft and artistic methods. Frampton argues similarly: A computer program can minimize adjacency problems, but it can do so only by ignoring the myriad other factors an architect must bear in mind. Scott Brown, intriguingly, represents the antipode to Hays's depiction of Hannes Meyer. Where Meyer desperately wanted architecture per se to vanish in favor of the engineer's rational calculus, Scott Brown sees just this impulse as the most destructive attitude possible for designers of the built world.

Instead of scientism, Scott Brown calls explicitly for architects to draw upon the far more romantic image of science sketched in the rhapsodic reflections of humanist-biologist Lewis Thomas. Scott Brown cites Thomas's *Lives of a Cell* approvingly: "Solutions cannot be arrived at for problems . . . until the science has been lifted through a preliminary, turbulent zone of outright astonishment. Therefore, what must be planned for, in the laboratories engaged in the work, is the totally unforeseeable." In this sense of the scientific, Scott Brown endorses the merging of architecture with science: the chaos of the charrette as laboratory discovery, not architecture as applied protocols of computer rationality. It is particularly appropriate, then, that Scott Brown's architectural firm, Venturi, Scott Brown and Associates, was commissioned to build the Lewis Thomas Laboratory, the "case study" of this volume. It is to that site that we now turn.

PART V: PRINCETON AFTER MODERNISM: THE LEWIS THOMAS LABORATORY

What then of the architecture that surrounds the contemporary site of scientific production? To explore the relation between laboratory builders and users, we turned to a single building, the Lewis Thomas Laboratory for molecular biology at Princeton University.

We assembled commentaries by an exterior architect (Robert Venturi of Venturi, Scott Brown and Associates), an interior architect (James Collins, Jr., of Payette Associates Inc.), a former director of the laboratory (Arnold Levine), and a sociologist of science who has focused on the uses of space in science (Thomas Gieryn).

A laboratory, Venturi argues, is no place for heroic architectural gestures, no proper site for a masterpiece. Diminishing distraction, *GENERIC ARCHITECTURE* (as Venturi calls it, capitals in original) ought be flexible in its design, able to accommodate the shifting allegiances of research groups one with the other.²¹ In planning for the Lewis Thomas Laboratory, he believed that there was no place for the “expression of function” as the Bauhaus would have had it. Now the building had to *accommodate* functions. Whereas the modern age of industrial architecture could use the machine as a literal model of efficiency and rationality, in this age after modernism, Venturi asserts, “industrial and engineering/structural imagery of space is incidental for now, while an ornamental/symbolic imagery of applique is valid for now.” Symbolism is explicit where modernist dogma would deny it or make it implicit; decoration is celebrated where the modernist claimed to be stripping it away; and function, instead of determining form, is collapsed into a flexible pragmatism. Neomodernism in the architecture of the 1990s did involve a revival of engineering, but it was as “engineering expressionism,” “in the end, an ironical architectural vocabulary based on industrial imagery as industrial *rocaille*.”

Equally instrumental in designing the Lewis Thomas Laboratory was James Collins, Jr., of Payette, since the building’s interior would determine most immediately how the scientists would use and move through their laboratories. Early in the project, Tom Payette had walked Levine and Venturi through the Fairchild Biochemistry building at Harvard, a project recently completed by his firm. Spaces in the Fairchild building were linked visually by glass and, unlike the “traditional modernist” laboratory, natural wood was used to “humanize” the environment and to give the building a luxurious quality previously quite foreign in laboratory spaces. Brandt and Sloane emphasize how the architecture of medicine has shifted to keep pace with the corporate ethos of the 1990s; “pure” science with its myriad links to biotechnology would not be left behind with its identity mired in the drab, functionalist metal and concrete factory labs of the 1950s.

Aside from the texture of surfaces, the new laboratory design also reflected the changed realities of funding. As Collins describes it, the shift from foundational to government funding entailed the need to support (architecturally) spaces that would allow the kind of interdisciplinary collaboration that the government wanted to support. Spending constraints meant a focus on ease of maintenance: access to charcoal filters, ductwork, and data network cabling trays. Cooling requirements and the acidity of organic and chemical waste presented other constraints. Payette grouped the service technologies around a central shaft (which aided maintenance) and kept the researchers near the windows, in more “liveable” space.

Arnold Levine, recruited by Princeton to spearhead the revival of its department of molecular biology, did not have fond memories of working with architects. As a young researcher at the University of Pennsylvania, he recalled toiling in a laboratory built by Louis Kahn.²² Fried by the sunlight, Levine and his graduate student colleagues pinned newspapers on the windows to cool themselves and save their experiments. Kahn was furious at this desecration of the building and ordered Levine to cease and desist. Now that Levine was directing a laboratory to be designed *ab initio*, he would not repeat that experience. Venturi's "accommodation" suited Levine's search for a mixture of flexibility and humanity. (Venturi's own complex formal and ideological relationship with Kahn began when Kahn was on Venturi's thesis review board, and Venturi went on to work in Kahn's office for nearly a year.) "Molecular biology is a blue-collar science," Levine writes, a science that involves working long hours at repetitive labor seven days a week. Levine wanted spaces where these "blue-collar" scientists could enjoy their fourteen-hour days, meet in small and large groups to talk about results, and combine teaching and research.

The structure of the building as a whole was driven by the technology of research, the instruments that bound together activities more than any analytic schema ever could. So on the third floor, one would find microbial genetics groups using microorganisms; on the second floor, cell division would find its home, with a focus on viruses linked to cancer; and on the first floor would be developmental biology and mouse-based genetics. Recounting the dramatic tale of the discovery and analysis of the tumor-suppressing protein (p53), Levine concludes that the physical space made it possible to increase collaboration, finding "the same genes in bacteria, yeast, worms, flies, frogs, mice, and humans. That brings the first, second, and third floors together for joint meetings, shared graduate students and common research themes." It became possible for researchers, architecturally associated, to define an identity for genetic research that cut across sectors of biology too often splintered one from the other.

When Thomas Gieryn agreed to study the Lewis Thomas Laboratory, he decided to throw its features into relief by contrasting it with another molecular biology laboratory—also designed by Payette Associates Inc.—the Center for Advanced Biotechnology and Medicine (CABM), a facility shared by Rutgers University and the University of Medicine and Dentistry of New Jersey (UMDNJ).²³ Like many other authors in this volume, Gieryn explicitly navigates between an architectural determinism on one side (architecture determinative of the science conducted inside) and an architectural indifference on the other (architecture irrelevant to the science contained within its walls). In the place of these reductive binaries, Gieryn argues that the architecture should be seen as constructing a cultural and institutional identity for the new biotechnology it housed. For example, when a tunnel joined CABM to UMDNJ, Rutgers insisted on an aboveground passageway known colloquially as "the leash." No one might use it but, as the UMDNJ Dean commented to Gieryn, the passageway was "[a] [half] million dollars' worth of symbolism." CABM was, as Gieryn puts it, an architectural meiosis, pulled in two directions by the conflicting force centers of UMDNJ and Rutgers.

As Gieryn relates, metaphors multiplied: To boosters of the Lewis Thomas Laboratory, it was an Elizabethan manor house, an old schoolhouse, a New England factory, whereas CABM supporters saw their lab as a temple, a showplace, and a Lord & Taylor among Kmart's. In this age of postmodernism, the symbolic dimension may be more self-announcing and playful than in the age of Bauhaus functionalist edginess, but symbolic allusions are clearly always activated, from the isolated Renaissance study to the sprawling postmodern mall-hospital.²⁴

As the architects and their clients worked through the design of these biotechnological laboratories, struggles over their referential structure were anything but incidental. Venturi himself hoped the laboratories would abandon modernism's celebratory functionalism and become in the process more than a scientific site: "Perhaps the conventional scientific laboratory within this definition is the prototype for a valid and vivid architecture for now as a whole." That "whole" becomes ever less metaphorical when one contemplates the massive laboratory-cities of the high energy physics centers that have become the exemplars of twentieth-century big science.

PART VI: CENTERS, CITIES, AND COLLIDERS

Physicist and sculptor Robert R. Wilson's Fermilab (Fermi National Laboratory, built in the late 1960s in Batavia, Illinois) for the study of particle physics is about as different as it could be from Arnold Levine's Lewis Thomas Laboratory (LTL): Wilson, acting in a dual role of architectural supervisor and scientific director, celebrated modernist architecture, whereas LTL defied it. Where the LTL is essentially a shoe box in footprint with three floors of laboratory space, the Fermilab campus revolves around a massive inwardly sloping tower, and architectural issues arose in reference to this building and the various supporting structures that dotted the campus. Wilson presents his image of the professional architect, however, in much the same suspicious light as Levine. Both were terribly afraid that the architect would ignore the real working conditions of the experimental scientist. But where Levine was reacting against Louis Kahn, Wilson dreaded the intervention of the Atomic Energy Commission (AEC) builder-architects, a team he viewed as producing nuclear physics structures "looking cheap and being expensive."

For Wilson, the preferred direction was up. A high-rise avoided the clutter of many small buildings, centralized all physics and engineering functions, and offered a magisterial view over the Illinois plains. His template, clearly, was that of urban modernism: His favorite "model" building was the New York office tower of the Ford Foundation with its open, green atrium and extensive use of glass. Referring back to Forty's gloss on circulation, one can see in Wilson's Fermilab tower a circulation design par excellence: Self-enclosed, it created a world in which the engineers, theorists, and experimentalists could move back and forth without undo reference to the outside.

Moshe Safdie, the architect commissioned to design the (now unfunded) Superconducting Super Collider in Waxahachie, Texas, positioned his own design against Wilson's Fermilab. Wilson wanted to build up and strip away the miscellany of many low buildings. Safdie aimed to build out to fill an even more enormous space; he relished the assemblage of different styles and sites. To Wilson, verticality meant clean lines and the vigorous circulation of modernity; to Safdie, horizontality meant organic unity and a gently chaotic, urban sense of place.²⁵

Safdie saw the Wilson tower drained of some of its energy as it had to support industrial buildings alongside the proton tunnel. Instead, Safdie strove to build horizontal interactions along a "street" that would mimic the random but concentrated foot traffic of an urban center. If Wilson learned from the massive, climate-controlled, atrium-centered Ford Foundation building, Safdie much preferred the European Center for Nuclear Research (CERN) located outside Geneva, Switzerland, with its horizontal disposition of buildings each of which grew up organically around the well-defined central facility in which library, administration, and main auditorium were located. But maintaining a center in the much larger Waxahachie facility was easier said than done. With a circular ring 54 miles in circumference, the experimental sites where the interactions of interest would occur were many miles from any central facility. But if the center couldn't hold "naturally," then it was up to the architect to create it. By using the cooling pond to create a sense of place, a central set of buildings would offer a public face to the east (education center, hotels, and villas) while the west side of the pond would host offices and laboratories. The private sector would grow organically, in layers, like the expansion of a mill town; this time, though, the spontaneity was planned.

Caroline Jones and I conclude these chapters with a comparative exploration of the specific architectural spaces in which art and science were restructured during and after the Second World War. In many ways prewar scientists and artists both saw themselves as essentially solitary in their confrontation with nature. By the mid-1940s, that isolated self-understanding, previously reinforced by small-scale labs and studios, began to break down as both scientists and artists encountered patterns of work and places of production altered by the vast factory production quotas of firms like Albert Kahn Associates and the Austin Company. Physical plants, social ordering, and a new subject position entered together in the government-sponsored factory-laboratory exemplified by Oak Ridge, Hanford, and Los Alamos. Neither laboratories "modeled" on industry nor industries "modeled" on laboratories, these city-sized laboratories fused as a hybrid of the two.

In our reading, despite these changes, "big science" laboratories and factory-studios of the 1950s and 1960s were still tied, if in an unstable way, to a single focal point; there remained a director, a constructed creative apogee from which the full deployment of machines and personnel would originate. But this organization altered as particle physics entered an age of distributed data during the mid-1970s and as artistic efforts turned to site-specific work around that same time. With elected and rotating executive councils re-

placing a single physics leader, with an ever-shifting team of 2,000 PhDs distributed over hundreds of net-linked laboratories, it was no longer even possible to think of a particle physics experiment as organized around a single piece of equipment, much less a single individual. As earthwork artists shifted attention away from any studio toward the “back and forth thing” between earthwork sites and photographs, films, plans, and sketches of those sites, the art object, the singular artist, and the studio all diffused. As Jones and I argue, authorship and authorial identity in these spatially dispersed worlds of physics and art are unstable, contested, negotiated, and in the end never fully specifiable.

It is our collective hope that this volume will encourage a great deal more inquiry into the encounters between architecture and science. For example, science studies, in its enthusiasm for the study of space and the spatial production and distribution of knowledge, clearly has much to learn from architectural studies. Architects along with architectural historians have set a standard for study of the formalism, facture, and historical analysis of the built world that science studies has by and large missed. Architects, too, are always grappling both implicitly and explicitly with sociological concepts of how their structures channel human action; we still know relatively little about how the sociology of scientific knowledge fits into or clashes with architectural plans and intentions. Conversely, science studies has by now assembled a vast literature on the history and diversity of research practices. Yet the results of this work have barely been incorporated into the literature of architecture practice; to date, architects, historians, and theorists of architecture have largely worked with highly schematized images of scientific work in which a few kinds of finished products (e.g., Galilean, Newtonian, or chaos theory) have stood in for all of scientific practice. Nonetheless, it may be useful to end this introduction with the words of the scientific philosopher Rudolf Carnap, who in 1926 addressed the Dessau Bauhaus, where he had come in large measure to celebrate its new architecture: “I work in science and you in visible forms; the two are only different sides of a single life.” If we can understand the limits to such a statement, if we can understand where and when it could and could not be uttered, we will have understood a great deal more about the subjects of both science and architecture, in all the many senses of “subject.”

NOTES

1. The literature on the history of the sites of science, including the laboratory, is now vast. The following are useful entry points into the social, epistemic, and architectural functions of space: Gooding et al., eds., *Uses of Experiment*; Lenoir and Elkana, eds., “Theory and Experiment”; James, *The Development of the Laboratory*; Galison, *Image and Logic*; Galison and Hevly, *Big Science*; Schaffer, “A Manufactory of Ohms”; Gooding, *Experiment and the Making of Meaning*; Olesko, *Physics as a Calling*; Cahan, *Institute for an Empire*; Hermann et al.,

- CERN I* and *CERN II*; Heilbron and Seidel, *Lawrence and His Laboratory*; Kohler, *Lords of the Fly*; Smith and Wise, *Energy and Empire*; Lynch, "Laboratory Space"; Ophir, Shapin, and Schaffer, eds., *The Place of Knowledge*; Heilbron, "Churches as Scientific Instruments"; Heilbron, "Science in the Church"; De Chadarevian, "Country House"; Hughes, *American Genesis*; Murphy, *Sick Buildings*; and other references cited in the References.
2. As an entry into architectural history that has probed the relation between architecture and the techno-scientific domain, see Picon, *Architectes et ingénieurs*; Pérez-Gómez, *Architecture and the Crisis of Modern Science and Polyphilo*; Frampton, *Studies in Tectonic Culture and Modern Architecture*; Hays, *Modernism and the Posthumanist Subject*; Buddensieg, *Industriekultur*; Banham, *Theory and Design in the First Machine Age*; Giedion, *Mechanization Takes Command and Space, Time, and Architecture*; Forgan, "Context, Image, and Function" and "Architecture of Science and University"; Mark, ed., *Architectural Technology*; and Jones, *Machine in the Studio*. Discussions of intriguing new relations inaugurated by the shift from mechanical to information systems may be found in Kwinter, "La citta nuova"; and De Landa, *War in the Age of Intelligent Machines*. "Smart materials" may also precipitate new architectural-scientific discussions.
 3. Dal Co, *Figures of Architecture and Thought*, p. 38. For Heidegger, see "Building, Dwelling, Thinking" and "Art and Space."
 4. The historicization of the subject and subjectivity in the face of changing scientific practices is, of course, one of Foucault's main themes. One thinks not only of his explicitly architectural work associated with the Panopticon (*Discipline and Punish*) but also of "Les techniques de soi," among many other texts.
 5. The multiple meanings of "subject" are explored by Hubert Damisch in his important book *The Origin of Perspective*, and his own argument is that the Renaissance "perspective paradigm" determines a new subject (in the sense of viewer, in the sense of the structure of the painting, and in the sense of the artist's own position). "[W]hen man comes to terms with the symbolic order, his being is, from the very start, entirely absorbed in it, and produced by it, not as 'man,' but as *subject*" (p. 20; see also pp. 425ff).
 6. Georg Simmel, "Bridge and Door"; a fascinating alternative sociology of the door can be found in Latour, "Mixing Humans and Nonhumans."
 7. Shapin, "House of Experiment"; Shapin and Schaffer, *Leviathan*; Ophir, Shapin, and Schaffer, "Place of Knowledge."
 8. Findlen's work on gender, space, and Renaissance knowledge can be pursued in her *Possessing Nature* and her forthcoming *Fragmented Past*. Literature on gender and architecture includes Friedman, "Architecture, Authority and the Female Gaze"; Spain, *Gendered Spaces*; and Colonna, ed., *Sexuality and Space*.
 9. Hannaway, "Laboratory Design and the Aim of Science." On Tycho's laboratory design, see also Shackelford, "Tycho Brahe." See too Newman's careful study of George Starkey, an American alchemist, *Gehennical Fire*.
 10. See Shapin, *A Social History of Truth*.
 11. For more on the architectural dimension of the rise of the new science at the end of the Renaissance, see Long, "Architectural to 'Scientific' Outlook."
 12. On self-fashioning, see Greenblatt, *Renaissance Self-Fashioning*, and Biagioli, *Galileo, Courtier*.
 13. On Victorian scientific and museum architecture, see, e.g., Forgan, "But indifferently lodged. . . ." and "Architecture & Display"; and Stocking, *Objects and Others*.

14. Without doubt, the Bauhaus under Hannes Meyer was the single most influential and sustained attempt to integrate architecture and technical fields. See Galison, "Aufbau/Bauhaus" and "Constructing Modernism." Architectural histories of the Dessau Bauhaus can be found in Winger, *The Bauhaus: Weimar, Dessau, Berlin, Chicago*; Whitford, *Bauhaus*; Naylor, *The Bauhaus Reassessed*; Meyer, *Hannes Meyer 1889–1954, Architekt Urbanist Lehrer and Bauen und Gesellschaft*; and Hays, *Modernism and the Posthumanist Subject*. For more on the scientific-engineering approach to town planning, and the "systems" thinking about lighting, ventilation, and kitchens, cf. Blau, *Red Vienna*; Rowe, *Modernity and Housing*; and Cohen, *World to Come*.
15. See also Thompson, "Dead Rooms and Live Wires"; and Thompson, "Mysteries of the Acoustic."
16. Rosenberg, *Care of Strangers*. For more on hospital and clinic architecture, see Thompson and Goldin, *The Hospital*; Foucault, *Birth of the Clinic*; Forty, "Modern Hospital in England and France"; Prior, "Architecture of the Hospital"; Sloane, "Hospital Mall"; Sloane, *Mall Medicine*; Kramer, "Psychiatry in a Biedermeier Asylum"; and Fiset, "Architecture and Healing."
17. Anthony Vidler uses Donna Haraway's concept of the cyborg to introduce a new form of the architectural imaginary. As he puts it, "If, for the first machine age, the preferred metaphor for the house was industrial, a 'machine for living in,' the second machine age would perhaps privilege the medical: the house as at once prosthesis and prophylactic" (Vidler, *Architectural Uncanny*, p. 147). Vidler explores the contradictory impulses already embodied in domestic space as the home blurs boundaries between organic and inorganic, private and public, body and mind, human and technological; the hospital pushes that blurring even further and the mall-hospital Brandt and Sloane explore might well serve as a quintessential illustration of the Vidler-Haraway intersection.
18. Husserl, *The Crisis of European Science*, p. 49.
19. As Husserl states, "In principle nothing is changed by the supposedly philosophically revolutionary critique of the 'classical law of causality' made by recent atomic physics. For in spite of all that is new, what is essential in principle, it seems to me, remains: namely, nature, which is in itself mathematical; it is given in formulae, and it can be interpreted only in terms of the formulae" (*Crisis of European Sciences*, p. 53).
20. Pérez-Gómez, *Polyphilo*.
21. On these themes, see also Robert Venturi, *Iconography and Electronics*; Venturi, Scott Brown, and Izenour, *Learning From Las Vegas*; and Venturi, *Complexity and Contradiction in Architecture*.
22. On Kahn's laboratory work, see Anderson, "Louis I. Kahn."
23. Gieryn develops further the views he presents here in his forthcoming *Cultural Boundaries* and in "Biotechnology's Private Parts."
24. On early twentieth-century linkages between technical culture and architecture, see Buddensieg, *Industriekultur*.
25. For more on Safdie's views about city design, see his *City after the Automobile*.

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