What buildings do[1]

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Keep the weather out? Make money for architects and contractors? Walls to hide behind? Display wealth or good taste? Sites for productive labor and entertaining leisure? Establish ownership? Store stuff, or sell it? Prevent some people from coming inside? Prevent others from leaving? Buildings do all that, and much more. It is surprising that they have been so rarely theorized by sociologists.[2]

Buildings stabilize social life. They give structure to social institutions, durability to social networks, persistence to behavior patterns. What we build solidifies society against time and its incessant forces for change. Simmel mentions that the "significance of space for social formations lies in its capacity of *fixing* their contents."[3] Brick and mortar resist intervention and permutation, as they accomplish a measure of stasis. And yet, buildings stabilize *imperfectly*. Some fall into ruin,[4] others are destroyed naturally or by human hand, and most are unendingly renovated into something they were not originally.[5] Buildings don't just sit there imposing themselves. They are forever objects of (re)interpretation, narration and representation – and meanings or stories are sometimes more pliable than the walls and floors they depict. We deconstruct buildings materially and semiotically, all the time.

It is no contradiction to say that buildings stabilize social life, and at the same time they are vulnerable to wrecking balls or discourse. Buildings – like just about everything else sociologists study – sit somewhere between agency and structure, as Winston Churchill famously said (of the bombed Houses of Parliament and their importance for democratic institutions): "We shape our buildings and afterward our buildings shape us." Churchill's maxim anticipated by several decades sociologists' obsession with processes of structuration and

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reproduction, an obsession that could perhaps elevate the built-environment to a place of theoretical significance in the discipline. This article starts out with Giddens and Bourdieu, focussing on the significance each attaches to built-environments. Three concepts are then retrieved from the sociology of technology, each useful for understanding a building as the object of human agency *and* as an agent of its own: heterogeneous design, black boxing, and interpretative flexibility. Finally, these concepts are deployed in a suggestive empirical analysis of the Biotechnology Building at Cornell University in Ithaca, New York, initially occupied in 1989. A discussion of why science-buildings (and especially those for biotechnology) are opportune for revisiting issues of structuration and reproduction precedes the empirical analysis.

A line from Durkheim provides grounding for this study: "Structure itself is encountered in *becoming*, and one cannot illustrate it except by pursuing this process of becoming. It forms and dissolves continually; it is life arrived at a certain measure of consolidation."[6] Cornell's Biotechnology Building is a site for people and organizations to define themselves and pursue their goals, but also one where those meanings and purposes get structured and constrained. The new and distinctive networks that biotechnology comprises, are, I suggest, *becoming social structure* in and through the design and construction of new research centers like the one at Cornell. The Biotechnology Building becomes the architectural means through which this reconfigured science gets "built-in" and stabilized – but impermanently so. The social structure of biotechnology is shaped by choices made during the design of the building – for example, what people and functional activities are included or excluded, and how are these allocated in architectural space? The finished and occupied building measures a reorganized set of institutional arrangements, interpersonal relations and research practices now routinized and normalized into a more stable, enduring and constraining form. Still, from the day its doors opened, Cornell's Biotechnology Building has become something other than what its designers envisaged and something more than what got built – as users and visitors see in those walls a diverse range of significations.

Structuration, reproduction, and built environments

Giddens and Bourdieu recast structure and agency as a reciprocal or recursive relationship of mutual constitution and presupposition – not as autonomous forces connected by cause-and-effect. Actors' practices are, at once, the substance (medium) and the outcome of structure. The need to privilege either agency or structure in accounts of social order and historical change evaporates once it is seen that individuals shaped by structure simultaneously shape those circumstances. For both theorists, buildings are an integral element of structuration and reproduction, as they are for many geographers.[7] Giddens especially is committed to bringing space back in: "the contextuality of time-space, and especially the connections between time-space location and physical milieux of action, are not just uninteresting boundaries of social life, but inherently involved in its constitution or reproduction."[8] Among Bourdieu's earliest and most famous empirical works is an analysis of the design of the Kabyle house,[9] an exploration of how spatial arrangements of domestic places reproduce essential social and cultural elements of Berber life – for example, the gendered division of labor.

As a matter of theoretical principle, Giddens and Bourdieu would probably agree with geographer Nigel Thrift's characterization of buildings as simultaneously made and capable of making. A built-up region is "the 'actively passive' meeting place of social structure and human agency, substantive enough to be the generator and conductor of structure, but still intimate enough to ensure that … human beings are not lost."[10] Still, what each theorist writes specifically about built environments appears at times to undermine the simultaneity and interplay of structure and agency in buildings. Giddens veers toward assigning theoretical privilege to human agency, as buildings become what people actively do with them; Bourdieu veers the other way, seeing buildings merely as external and autonomous forces structuring social practices with no obvious or necessary involvement of knowledgeable agents.

For Giddens, "locales provide for a good deal of the 'fixity' underlying social institutions." The structuring force of built-environments comes from the spatial and architectural routinization of everyday interactions: the design of familiar places evokes and steers patterned behavioral responses. "The substantially 'given' character of the physical milieux of day-to-day life interlaces with routine and is deeply influential in the contours of institutional reproduction."[11] But how? Giddens is reluctant to ascribe autonomous agency to built environments, and instead makes them dependent upon interpretations and uses by knowledgeable humans. He ignores the possibility that buildings may preempt or preclude agents' conscious apprehension, interpretation or mobilization, and that they can structure practices without necessarily requiring actors' knowledgeable involvement.

For example, Giddens explains his preference for "locale" over "place" specifically because the former "refer[s] to the *use* of space to provide settings of interaction."[12] The structuring capacity of a house does not lie in the arrangement of "physical properties" such as doors, walls and windows; "a 'house' is grasped as such *only if the observer recognizes* that it is a 'dwelling' with a range of other properties specified by the modes of its utilization in human activity."[13] And: "a setting is not just a spatial parameter, and physical environment, in which interaction occurs: it is these elements *mobilized* in interaction."[14] In the preface to a book that he describes as "well-documented and persuasive," Giddens endorses the idea that "location is only socially relevant – and this is crucial – when filtered through frames of reference that orient individuals' conduct."[15] At the extreme, the physical side of built places becomes almost irrelevant for social practices. Giddens defines "disembedding" as "the 'lifting out' of social relations from their local context," a prevalent feature of modern societies in which "place becomes phantasmagoric … [and] does not form the parameter of experience."[16] Buildings – and the places they make – apparently lose their distinctive social efficacy.

Others have read Giddens the same way. Hannah and Strohmeyer suggest that Giddens's analysis of space "leaves structure 'nowhere,' a fiction … ultimately … put inside personality (memory traces, mutual knowledge) within practical consciousness."[17] Storper accuses Giddens of "a radical denial of structure" by failing to appreciate that "the material foundations of structures are real and are to some extent autonomous from interaction."[18] For Soja, "spatiality becomes a passive mirror/container to the forceful play of human agency."[19] Sewell's otherwise useful emendation of Giddens's theory of social structure nevertheless sustains his view that buildings are what people actively do with them. The design of the physical factory structures social life by exposing the abstractions of capitalism in a material form that "teaches [people in society] capitalist notions of property relations." For Sewell, buildings *reveal*: their role in structuration is to bring into the actual world of material resources otherwise merely virtual cultural schemas; "[they] are *read* like texts."[20] Sewell may be half-right. Buildings (factories or laboratories) do as much to structure social relations by *concealing* as by revealing, and therein lies their distinctive force for structuring social relations and practices. Once completed, buildings hide the many possibilities that did not get built, as they bury the interests, politics, and power that shaped the one design that did. Soja concurs, suggesting further analysis of "how space can be made to hide consequences from us, how relations of power and discipline are inscribed into the apparently innocent spatiality of social life."[21] Buildings may preempt certain kinds of strategic action among agents, and so stabilize a social arrangement.

Bourdieu does not share Giddens's reluctance to see buildings as independent of human hand and mind, but along the way the forces of human agency in designing and defining buildings disappear from his analysis. Buildings become *objectified* history: systems of classifications, hierarchies and oppositions inscribed in the durability of wood, mud, and brick.[22] The powerfully reproductive force of built environments is laid bare in Bourdieu's study of domestic spaces among the Berbers of Algeria,[23] which begins with a detailed description of the evidently standard-issue Kabyle house:

> The interior of the Kabyle house is rectangular in shape and divided into two parts, at a point one-third of the way along its length, by a small openwork wall half as high as the house. The larger of the two parts, approximately fifty centimeters higher and covered with a layer of black clay and cowdung which the women polish with a stone, is reserved for human use. The smaller part, paved with flagstones, is occupied by the animals.... Above the stable is a loft where, next to all kinds of tools and implements, quantities of hay and straw to be used as animal fodder are piled up; it is here that the women and children usually sleep, especially in winter...."[24]

The arrangement of space and domestic activities expresses in objective form a set of symbolic oppositions and hierarchies that also order the societal divisions and cosmogony of the Kabyle – none more important than male/female.[25] Sounding not unlike Durkheim and Mauss, Bourdieu suggests that "Socialization instills a sense of the equivalences between physical space and social space ... and thereby roots the most fundamental structures of the group in the primary experience of the body."[26] In the Kabyle house, the smaller of the two rooms is female space, the larger is male – and each is associated with characteristics that in effect define the differences between men (high, light, cooked, dry, culture) and women (low, dark, raw, wet nature), and the rights, responsibilities, and powers of each. The female space is the place for animals, water jars, animal fodder, sleep, sexual intercourse, birth, and death; male space is for humans (especially guests), fire, lamps, cooking utensils, and the rifle (male honor). Each of these mundane objects, and the practices associated with them, are part of a symbolic system and take their meaning only through their opposition to other parts or places. The opposed spaces inside the house are separated by the main pillar (made from a forked tree trunk), which supports the largest horizontal beam. The pillar is female, the beam male, and the fork is aligned upward toward the beam, in a position to receive fertilization from the beam above, and so express at that architectural point the union of man and wife, the adjacency of male and female space.

Bourdieu's study of the Kabyle house is flawed by its palpable commitment to the French "structuralist vulgate"[27] – a flaw not fully rectified in his later efforts to reposition this early empirical analysis in his mature theoretical frame. The research was carried out by a "blissful structuralist," Bourdieu tells us, when Levi-Strauss's binary oppositions promised to give nomothetic order to the apparent bloomin' buzzin' confusion of observed practices and beliefs.[28] It yields an incomplete picture of buildings. What is left out? Bourdieu says nothing about the *design* of "the" Kabyle house as a *verb* – the inevitable choices made in the construction of any human edifice. There is little sense that anyone planned for the houses to look a certain way, and Kabyle peasants seem incapable of reflecting creatively on the meaning of their built spaces or on the possibility of their symbolic or architectural reconfiguration. Garnham asks of Bourdieu, rhetorically: "if our classification schemes are implicit, unconscious and arbitrary, what room is there for willed purchase on the social world?"[29] And for King: "Bourdieu has failed to take his own greatest insight seriously, and he has slipped into the very objectivism whose poverty he has done so much to highlight."[30]

Bourdieu avoids the level of conscious, intentional action for fear that its inclusion would lead ineluctably to subjectivist voluntarism. That avoidance paralyzes a sociological analysis of built environments by removing them from their knowing, motivated control by human agents. Of course, neither is it the case that buildings are *only* what people make them into (that was Giddens's flaw). It does not follow, however, that buildings never become the focus of such conscious apprehension and discussion, or that agents are never capable of articulating just what they are trying to accomplish through the design of a building. Yet Bourdieu moves in this direction. For example, in the original analysis of the Kabyle house, he tells us that the symbolic classifications remain unarticulatable as "informants are unable to produce [them] spontaneously because they take them for granted."[31] His "agent-proof"[32] analysis is explicit: "the internal organization of space [is] never being consciously perceived as such – still less deliberately planned – by those who inhabit it."[33] Later analysis of these same empirical materials does little to bring a full-blooded agency to bear on the question of built environments. In *The Logic of Practice*, Bourdieu writes: "objectification in institutions guarantees the permanence and cumulativity of material and symbolic acquisitions which can then subsist without the agents having to recreate them continuously and in their entirety by deliberate action."[34]

Plainly, a complete sociology of buildings requires Giddens+Bourdieu. Analysis must respect the double reality of buildings,[35] as structures structuring agency but never beyond the potential restructuring by human agents. Giddens's generic methodological injunctions are worthy guides, nevertheless: an *institutional analysis* of buildings as structuring forces must sit along side of the analysis of *strategic interaction* in which buildings become the focus of conscious negotiation and interpretation.[36] But neither he nor Bourdieu offer conceptual tools sharp enough for picking apart the empirical realities of buildings (in particular) as simultaneously shaped and shaping. Help comes from recent work on the social construction of technological systems.

Buildings as technological artifacts

A different sense of buildings comes from seeing them as "walk-through" machines. Buildings are technological artifacts, made material objects, and humanly constructed physical things. To see them this way brings buildings within the compass of a promising theoretical orientation developed initially for the study of machines. The focus is on the recursive qualities inherent in technological artifacts, at once, the product of human agency and a stable force for structuring social action. Buildings, as any other machine or tool, are simultaneously the consequence and structural cause of social practices.[37] Three concepts developed in constructivist studies of technology will be useful for a better understanding of the design, use, and evaluation of the Cornell Biotechnology Building: heterogeneous design, black boxing, and interpretative flexibility.[38]

Design is heterogenous in two respects. First, design is both the planning of *material* things and the resolution of sometimes competing *social* interests. Walls and joists are arrayed so that a building is able to stand up, but eventual owners or occupants must also be able to see space that suits their needs. The interests of powerful voices in the design process are etched into the artifact itself. Put another way: the design process is simultaneously the representation of an artifact in graphic, verbal, or numerical form, *and* the enrollment or enlistment of those allies necessary to move the artifact toward a material form – what Staudenmaier has called the "design constituency."[39] Indeed, the enrollment of investors, patrons, consumers, managers, eager publics, regulators and vendors is accomplished *through* the design process itself: an evolving artifact is shaped to fit the wants and needs of those who must be on board to move it off the drawing board.

Machines – and buildings – "take on themselves the contradictory wishes and needs of humans and non-humans."[40] MacKenzie's study of missile guidance systems designed largely at M.I.T.'s Draper Labs suggests that "the external social world had to be engineered so that support was generated and sustained for the large and expensive activity."[41] Law and Callon's analysis of the TSR 2 aircraft shows a reluctance to let design become either a social or material necessity: "rather than being purely technical, it was thoroughly and throughout informed by social considerations. Thus the design of the wings was not simply a function of the theory and practice of aerofoil design but was also influenced by the (socially given) requirement for a long range aircraft that they also be designed as fuel tanks.... [But] it was not always the social that defined the technical. Thus by 1961 the designers had concluded that the proposed aircraft was going to be too heavy to achieve a take-off roll of 500 yards."[42] Although some designs for the overweight plane packed in the interest-laden demands of all the designing parties, nobody's interests would be advanced if the thing could not get off the ground. Neither the social (power, interests) nor the material (physical, mechanical) are so stable that they can serve as bedrock causes of design trajectories.[43] As an artifact takes shape, designers transform the physical and mechanical worlds (make the aircraft lighter) and each other's goals and interests (maybe we could tolerate planes with a shorter range).

Second, design is heterogenous in that designers who sketch out material artifacts also create human users and even an entire society among which the machine or building can thrive. To some degree, every design is a blueprint for human behavior and social structure, as well as a schematic for the "thing" itself. Designers necessarily theorize about social life at least as much as sociologists do: in order to design the contents of a machine that will fly, designers must decide which patterns of human behavior and institutional arrangements they must respect as intransigent, and which are malleable enough to conform to the demands of the artifact itself. Woolgar, looking at the design of computer software, calls this "configuring the user."[44] Even as social interests of voices powerful in the design process take material shape in the emerging plan, the artifact itself reflects and defines an appropriate social world of users. Winner says: "our instruments are institutions in the making."[45] For example, French engineers designing photoelectric lighting kits for use in Africa found themselves "inscribing this vision of (or prediction about) the world in the technical content of the new object."[46]

Some designs get built. What once was a malleable plan – an unsettled thing pushed in different directions by competing interests during negotiation and compromise – now attains stability. Many possibilities become one actuality. Constructivists use the term "closure" to describe the transition of plastic plans into obdurate machines or buildings. The resulting "black box" secures a material artifact *and* those social relations now built into its design.[47] Once sealed shut, machines are capable of steering social action in ways not always meaningfully apprehended by actors or necessarily congruent with their interests or values. Setting aside philosophical quandaries about intentionality and sentience, constructivists ascribe machines agentic powers not reducible to or explained away by human action. Chandra Mukerji offers an example that links technology to built environments, in a way that calls attention to the structuring force of material objects net of their narration or attributed meanings. She considers Louis XIV's Versailles Gardens, and its role in displaying and buttressing the power of the crown: "We should try to approach material culture without reducing objects to instantiations of discourse or realizations of cognitive representations," and to avoid "the disappearance of the material world behind language."[48]

Material artifacts structure social action in three ways. First, technology insinuates itself into the goals and plans of human agents, becoming an "obligatory passage point"[49] – an indispensable and unavoidable gate somewhere in the middle of a human project. People find it necessary to cooperate with machines, forced (often unknowingly) to satisfy the demands and expectations of these non-human agents, in order to satisfy their own needs and wants. Second, material artifacts stabilize social action by concealing the politics and interests inherent in their design behind interpretative registers that focus on instrumental efficiency, cost, or possibly aesthetics. The structuring capacity of machines thus becomes transparent: so long as they "work," people ordinarily are asleep to the diverse interests they were designed to promote – what Winner calls "technological somnambulism."[50] The artifact becomes, for its users, a black box: "regarded as just performing its function, without any need for, or perhaps possibility of, awareness of its internal workings," a "thing whose contents have become a matter of indifference."[51] Third, artifacts stabilize social action by increasing the costs of subsequent tinkering or innovative use. The size of Parisian subway tunnels could have been enlarged almost effortlessly seventy years ago when they were still on the drawing board. Recently, in order to accommodate larger suburban trains (R.E.R.), millions of francs and years of inconvenience were necessary to remove and repour concrete.[52] Material artifacts accumulate momentum[53] and sunk costs through their continued use, and that also compels human users to continue to act in conformity with the machines' requirements – even as they forget why the thing was designed and built that way.

To stop here would leave machines and buildings as guarantees of a social structure beyond the reach of human agents. If everything went according to plan, the society envisaged by designers as most likely to advance their interests would be frozen in place by now-constructed artifacts. That rarely happens, one suspects: the structuring force of technological artifacts is measurable but not limitless or permanent. Once unleashed by designers and builders, artifacts become available for later reconfiguration as they are returned to the hands of human agents for more or less creative redefinition, reevaluation and even re- (or de-) construction.

Reconfiguration may be *discursive* or *material*. In the first instance, the black box is left unopened, but it is shrouded in novel interpretations and assessments. The concept of "interpretative flexibility" captures the idea that the meaning of an extant artifact is contingent and variable, never fully determined by the intent of designers or by the technical requirements or capabilities of the machine itself. The idea that artifacts "represented different things to different people" is found consistently in studies of aircraft, fluorescent lamps, bicycles, bakelite, computers, radiological medical instruments, cochlear implants, and technologies used in "safer sex."[54]

In other instances, a black box is pried opened and the artifact is materially remade – or destroyed, possibly abandoned to the junk heap.[55] This kind of reconfiguration is heterogeneous in that the artifact is undone both materially and socially: wires are disconnected and rerouted into new circuits, just as the networks of human individuals, groups and organizations linked together to sustain the original form are also sundered. When Africans began to tinker with the insides of photoelectric lighting kits designed and constructed in France, they also reconfigured the end user from a docile servant of the artifact who is dependent upon distant French expertise to a co-manufacturer (not just consumer) of the lighting kits.[56] The focus of such studies is on "variations in relative solidity and durability of different sorts of materials" – bearing in mind that strong or weak links may be variously human and social or material and technical.[57]

So: what justifies this excursion into constructivist studies of technology? If the abstractions of "structuration" and "reproduction" are to become more friendly for empirical analysis, then perhaps we need a few concepts in the "middle range."[58] Heterogenous design, black boxing and interpretative flexibility are useful for watching how buildings – like any other technological artifact – become the targets of human agentic practices while at the same time their structuring structures.

Cornell biotechnology as strategic research site

The design, construction and operation of a single new laboratory building for biotechnological research in Ithaca, New York would seem an *odd* place to resolve theoretical issues of structuration and reproduction. The research site is a good one for two reasons.

The significance of place for science has lately been appreciated.[59] Sociologists once believed that scientific truths "floated free in the air,"[60] detached from material moorings in the bodies of investigators, the wires and tubes of experimental instruments, or the doors and walls of laboratories. Durkheim distinguished religion from science precisely in terms of the situatedness of the former and the placelessness of the latter: "Religious beliefs … show the imprint of the soil upon which they are formed; today, the truths of science are independent of any local context.'[61] A sea-change in sociological thinking has thoroughly contextualized scientific practices and products, so that the manufacture of scientific claims and their reception as truthful representations are now matters to be explained by *local* causes – from the biographies of researchers to the architectural circumstances of their workplaces.[62] Still, whatever residue of Durkheimian idealism might linger on makes science-buildings into a "hardest case" for demonstrating that space and place are fundamentally involved in the reproduction of social life.

How do buildings matter for science? Scattered empirical evidence suggests that architectural layouts and geographic location have effects most obvious in the patterns of social interaction among working scientists. Allen's ten-year study of large R&D organizations links the (i) architecture of laboratories and offices to (ii) patterns of face-to-face encounters to (iii) casual communication and finally to (iv) scientific or technical performance. Two specific findings are noteworthy: the probability of weekly face-to-face communication among two researchers or technicians drops dramatically as the distance between their primary workspaces increases; scientific or technical performance is positively associated with the frequency of "chance encounters" among those working on different projects or in different teams, and these unexpected "I just ran into…" meetings are encouraged by the strategically central location of "interaction promoting devices" such as washrooms, coffee machines and photocopying centers.[63]

The significance of the design of research buildings for science extends beyond their role in structuring local interaction and communication patterns. In Durkheimian fashion, research space mirrors the social organizational units of science: buildings give material embodiment – a kind of institutional reality – to disciplines or specialties, and to subunits such as theorists or experimentalists. As Durkheim and Mauss could say of the Wotjobaluk ("this division [of the camp] into spatial regions is … closely linked to the essence of the social organization of this tribe"), so Galison can say of the floorplans of scientific laboratories: 'we are witnessing a physicalized architecture of knowledge.'[64] Laboratory buildings for chemistry or physics provide not just square footage for research and teaching; they convert the abstraction of "discipline" into something more palpable, stable, and enduring. The Jefferson Physical Laboratory at Harvard (completed 1884) "offered a setting for physical research, and with it the institutionalization that the discipline needed to progress."[65] Kohler argues that the location of laboratories primarily for research (not just clinical testing) "within the medical and surgical services of large hospitals" was more effective (during the 1920s and 1930s) for institutionalizing the fledgling discipline of biochemistry than locating facilities for pure research in academic campus settings.[66] Moreover, arrangements of space inside research laboratories reproduce the divisions of labor and even status hierarchies among a discipline's practitioners. In physics buildings, it has become "routine to put theorists on the top floor" and instrument shops in the basement – not just for functional or practical reasons: at the Stanford Linear Accelerator, "an experimentalist would probably feel awkward among the theorists, who have more status. The third [top] floor is very much the domain of the directors, theorists and their staffs."[67]

Buildings matter for science in a semiotic sense as well: "physical environments can express social meanings by acting as a system of signs."[68] The cultural meanings of "science" arise in part from what we read in(to) laboratory buildings and other sites of scientific work, such as museums, hospitals, zoos, botanical gardens, and libraries. Hanaway compares two early modern laboratories, using their floorplans "as a guide to explore the intellectual and ideological roots of a new mode of scientific life."[69] Tycho Brahe's castle-observatory-chemistry lab at Uraniborg is a secluded retreat from public life and civil society, and the scientist within is isolated in a world of scholarly contemplation of the eternal verities of divine things. The lesser-known chemist Andreas Libavius drew up plans for a "Chemical House" to be located not walled apart but within a city, designed for a scientist seeking engagement in public life, willing to shoulder civic responsibilities. A tension between contemplative and activist faces has been a part of science in the four centuries since.[70] Late Victorian university science buildings, through their factory-like rows of laboratory benches sited in open rooms that maximized visibility, "impose[d] proper discipline" on potentially unruly students.[71] More recently, two campus-based science buildings created significantly different identities for academic biotechnology, one the face of corporate incubator, another the face of promising undergraduates.[72] "Buildings can be viewed as statements," and what the physical spaces of laboratories have proclaimed is as diverse as the cultural space of science itself.[73]

Finally, buildings matter for the perceived credibility of scientists' claims about nature. For example, the perceived authenticity and reliability of scientific knowledge claims is tied to the situatedness and geographical conditions of their production, specifically, to an architecturally (and socially) achieved combination of public and private space.[74] On one hand, experimental laboratories are open places where phenomena – cells, quarks, intelligence – are rendered visible, using procedures and instruments available in principle to inspection by any skeptic. On the other, laboratories are excluding spaces, designed precisely to control or discipline phenomena by protecting them from potentially destructive intrusions of natural pollutants or social threats. Scientists are not supposed to carry out their investigative work in secret, but neither can transit across the threshold between experimental space and ordinary society/nature be promiscuous. Shapin finds roots of such an architecture of credible and authentic knowledge in seventeenth-century "houses of experiment," sites for the new experimental philosophy of Hooke, Boyle, and other participants in the Royal Society. In contrast to the "individual philosopher in his study [or] the solitary alchemist in his 'dark and smokey' laboratory," practitioners of the new science required that places of experiment be "easy of access" – but not just to any witness. These houses of experiment were residences of *gentlemen*, open to other gentlemen whose "presumed moral equality" "guaranteed the reliability of experimental knowledge. In other words, gentlemen in, genuine knowledge out."[75] That carefully controlled input-output was accomplished in part by the doors to the houses of experiment, and by the conventions surrounding their passage.[76]

Contemporary scientific workplaces are "far from being just the physical space where experiments are conducted." The walls of the laboratory demarcate a space where both natural and social orders are reconfigured: nature inside is no longer wild but disciplined, and people inside become machines for measurement. Knorr-Cetina concludes that "the laboratory is itself an important agent of scientific development," and from its rearrangement of relationships between actors and environments comes "epistemic profit for science."[77]

But why are science buildings for today's *biotechnology* in particular a good site for investigating their role in stabilizing social practices? Biotechnology is as old as brewing beer and as revolutionary as designer genes, Dolly, and the Human Genome Initiative.[78] The capacity to manipulate life has been scaled up to an unprecedented degree in recent years, as evidenced by present abilities to insert genetic material from one species into an organism from another. The benefits or liabilities of such prowess are of less pertinence here than the social structural and institutional realignments that constitute the integument for these new techniques. In a word, biotechnology is life science in a "new key." And the design and construction of new physical facilities for university-based biotechnology stabilizes (to a degree) novel networks and associations of individuals and organizations that make up this realm of scientific practice. There are three such realignments.[79]

First, the boundary between basic and applied research is blurred or erased, as linkages among university scientists, state governments, and private corporations assume tight new forms. The research of university-based life scientists – now a compressed[80] sequence of discovery, invention, patenting, licensing, manufacturing and marketing – has become *interesting* for many outside the lab: venture capitalists eager to cash in on investments in biotech start-up firms; managers of large corporations in chemical, pharmaceutical, agricultural, and medical products industries; and state governments hoping to nurture all this job- and revenue-generating enterprise within their borders.

The campus-based biotechnology research center – typically housed in a gleaming new building – is the lynchpin that ties this emerging social structure together. To be sure, such mutual dependencies among university scientists, capital, and the state are hardly unprecedented (the microelectronics revolution was fomented in the same set of associations), not even in the biological sciences. Agricultural experiment stations often located at land-grant universities are typically state financed, and their plant breeding programs are closely aligned with seed companies and manufacturers of fertilizers, herbicides, and pesticides.[81] But most molecular biologists, geneticists, and biochemists doing biotechnology choose to remain in their university labs and define their science as basic research, even as they connect to biotech start-up firms or large corporations by serving as consultants or scientific advisors, acquiring equity holdings, entering into patenting and licensing arrangements, and accepting from them grants, contracts, and student fellowships.

Although biotechnology has become a new *industry*, the key to its growth remains in campus laboratories of academic scientists, for several reasons. (A) The pace of translating scientific findings into commercial products has sometimes not been as fast as once anticipated, and start-up firms and large corporations would rather let academic scientists conduct far-upstream, often pig-in-a-poke research while reserving their own expensive facilities for work on processes or products nearer to marketability. (B) The costs of facilities for upstream university research has been assumed largely by state governments, who – during the 1980s – fought amongst themselves to build the perfect biotechnology center that would do for Ithaca or New Brunswick or Rockville what microelectronics did for Silicon Valley. (C) Universities as social institutions carry their own credibility and authority, which is transferred along with new knowledge or products into marketplaces – where unruly consumer or environmental groups might ask "is it really safe and effective?" The selling of biotechnology to suspicious publics is helped along by locating the provenance of such possibly risky wonders at universities – home to scientists perceived as truth-seeking, and disinterested. Ivy walls confer a legitimacy (on claims, on spokespersons for nature, on predictions for the future) that corporate R&D labs never can, although the reverse risk of tainting the supposed purity of universities by corporate lucre is ever-present. This new social structure of biotechnology would seem to be win-win-win: states buy economic development, academic scientists get new labs and corporate research funding, and corporations cheaply acquire findings with commercial viability – along with a skilled labor force of scientists and technicians trained at someone else's expense.

Two other realignments follow in the wake of these cozy biotechnological assemblages of universities, corporations, and the state. Ancient disciplinary boundaries are torn apart. Campus buildings originally designed to house biology here, chemistry there, and physics down the street now become impediments to biotechnological research that demands practitioners, skills, and equipment from all three disciplines (and more, such as "informatics"). But this multidisciplinary melding is highly selective in moving only parts of historic disciplines into the new space for biotechnology. With the molecularization of biology, organisms become systems and life becomes a code – a reduction that moves inquiry away from studies of process and form. Those segments of the life sciences who speak the language of "tech transfer," "through-put," "momentum," and "synergies" often find themselves in relatively luxurious research space when compared to their colleagues whose work has less immediate economic value.

An equally ancient link between university-based scientific research and teaching is, with the biotech revolution, slowly decoupled. Bringing along the next generation of molecular biologists and geneticists is a drag on the accelerated path from exploration and discovery to patents and profit. Moreover, with heightened secrecy in an atmosphere increasingly shaped by concerns for competitive advantage, stu-

Figure 1. Exterior view of CBB.

dents around the lab become potential leaks. Such risk may be offset, however, by the need for cheap labor (historically provided by students and post-docs) to do sometimes mindless repetitive tasks narrowly-drawn by commercial agendas. This process may bear little resemblance to the unencumbered and loosely guided explorations that once marked most graduate training in the sciences.[82]

Martin Kenney probably understates the matter when he suggests that "biotechnology is the cutting edge for the creation of new social relationships, though it is still unclear what the final stable configuration of these social relationships will be."[83] The question for me is not *what* biotechnology is becoming, but *how* its stabilization is accomplished. It is through the design and construction of new science buildings on campus that the new game, new players and new rules of biotechnology move from something ephemeral to social structure – and here is one such building.

Three moments of a science building

Planning for the Cornell Biotechnology Building (hereafter: CBB) began in 1983.[84] The architects – Davis, Brody and Associates of New York City – were chosen in late 1984, and ground was broken on June 27, 1986. The building was first occupied in July 1988, and it was

Figure 2. Interior view of research space.

formally dedicated at a ceremony on May 15, 1989 attended by the Governor, CEOs from major corporations in the state, representatives of the Army and the National Science Foundation, Cornell scientists and dignitaries, and me.

The building has 171,000 gross square feet (95,530 actual or usable square feet) divided into five levels. Its exterior shape – sheathed in white, with windows of swimming-pool blue – is a triangle with a sawtooth hypotenuse (to provide more offices and labs with natural light). The CBB is located in a "biology quadrangle" near the center of the Ithaca campus, adjacent both to the endowed "arts" college and the statutory "ag" college. The total cost of the building was $34 million dollars, or about $200/GSF. Construction financing was provided in part by a $20 million New York State Division of the Budget appropriation to the Urban Development Corporation and in part by Cornell with financing through the New York State Dormitory Authority. Operating costs are borne by Cornell; other money for operations was in the early years provided by Kodak, General Foods, and Union Carbide.

The CBB houses just over 300 scientific, technical, and clerical workers. Two Sections of Cornell's Division of Biological Sciences – Biochemistry, Molecular, and Cellular Biology; Genetics and Development – have their administrative offices and most of their faculty scientists in the building. To distribute faculty in labs throughout the buildings, the scientists were divided into six research groups: prokaryotes, cellular eukaryotes, drosophila/development, cell biology, membranes, and biophysics/x-ray crystallography. The building also houses Cornell's Biotechnology Program – administrative offices (including technology transfer) and seven "research facilities" (fermentation, DNA synthesis, electron microscopy, etc.).

My analysis is organized around three "moments" of the Cornell Biotechnology Building, as it moves along a gradient from agency to structure to agency. I call them moments to avoid the unwanted conclusion that these are sequential stages in a linear movement toward some final destination; instead, the moments in effect exist simultaneously as potentials for how buildings are apprehended by analysts and actors (or how buildings preclude certain kinds of apprehensions). Human agency is most obvious during the design of a place, and that is the first moment. Agency shifts (analytically) to the building itself once completed and occupied – my second moment – as it structures and stabilizes Cornell's biotechnological spaces. In the third moment, agency returns to people when the building is narrated and reinterpreted – discursively made anew.

Moment one: Designing scientists

The new science building at Cornell is a machine for manufacturing biotechnology. A sociological interpretation of its architecture focuses on the mash of social and material forces brought into the negotiations over what spaces will go where. In a sense, the "final" design became what it had to become for construction to commence: it had to satisfy the interests of a wide range of designers – architects, biologists, environmental safety officers, and University trustees – as well as the equally insistent demands of the Ithaca landscape – rock, gravity, and snow. The design process is also the negotiation of what biotechnology would become at Cornell: which research specialties belong, which instruments will grow or shrink or become obsolete, should teaching be as vital as technology transfer? The design is a social theory of a future science, rendered architecturally. "Every blueprint can be read as another *Prince* [i.e., Machiavelli's]: tell me your tolerances, your benchmarks, your calibrations … and I will tell you who you are afraid of, who you hope will come to your

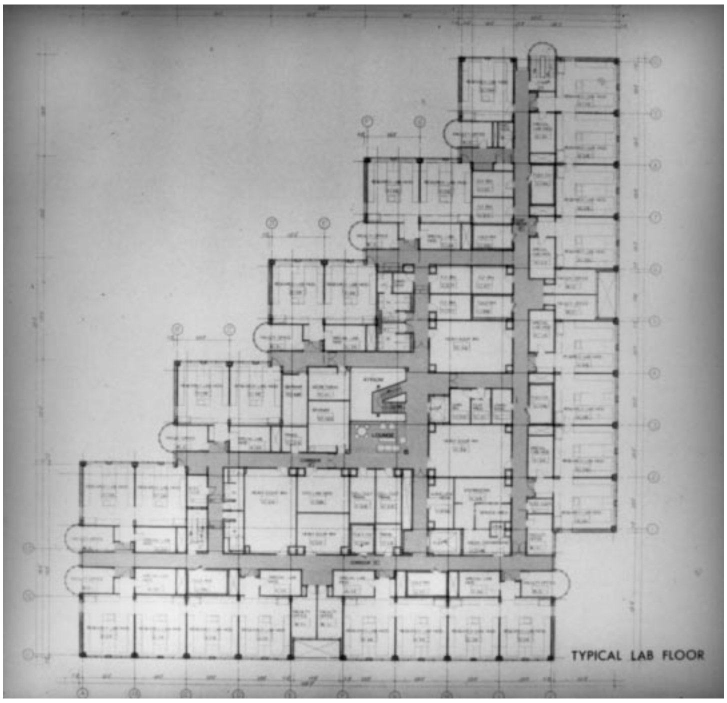

Figure 3. Floor plan.

support, who you decided to avoid or ignore, and who you wish to dominate."[85]

At the moment of design, the CBB is at its most pliable. A room or wall comes or goes with a simple erasure or single keystroke. The human agency in a building is most apparent now: intentions are translated into programs and sketches, as meaningful choices are negotiated. The building is literally in the hands of designers, to mold into a sufficiently suitable artifact that stands up and stands for their interests. One task is paramount for them all: to bring their diverse plans and schemes into brick-and-mortar existence. This requires a negotiated mix of insistence and compromise, whereby interests and purposes are resolved in and through a palimpsest of floor plans, only the last of which gets built. But the *structuring* force of a building is weak during design – and that, too, is by design. Parties to the planning of the place want to keep things fluid in order to move it – via compromise and stonewalling – ever closer to something that will not just work but work best for their interests. That malleability or plasticity, however, weakens the power of an artifact to structure social life – to constrain or enable behavior and institutional patterns.

Which CBB would best satisfy the desires of all those with a say and stake in it? Three features stand out. First, the design of Cornell's laboratory module is standardized,[86] so that every scientist gets a space with identical size and configuration (1100 square feet for the research lab; 150 square feet for a faculty office). A cookie-cutter could have been used to carve out the arrangement of wet benches, desks, sinks, free wall and floor space for heavy equipment, gas jets, and electrical outlets in every one of the generic labs in the building. Throughout the many meetings and the endless paper trail, researchers' workspaces are consistently referred to as "standard lab modules" – the minutes of one early design meeting are typical: "each faculty member is being assigned an equal amount of space." What were the diverse problems faced by those who designed the CBB such that a standardized lab module emerged as the best solution?

Architects from Davis, Brody had several good reasons to prefer "one size (shape) fits all" to its alternative – i.e., a variety of custom-designed lab and office spaces tailored uniquely to the needs and wishes of eventual occupants. In architectural practice (as everywhere else), time is money. To clone a boilerplate design takes much less time than developing a dozen or more possibilities, each of which must then be tweaked to the satisfaction of end-users. Architects also lose time if their clients continue to be indecisive, ambivalent, or disputatious about evolving space programs and floor plans. The key to an efficient design process (from the architects' perspective) is to move the design team toward consensus as quickly as possible, so that the clockwork-like stages of any building project (program, schematics, design development, construction documents) can move along one to the next. With a modular or general design, the architects in effect must secure agreement on only one plan. Even though that one plan probably does not fully live up to the dreams of any of the scientists involved in the design process, it is probably time-efficient for architects to force their clients to sign-off on a single set of details rather than on myriad complex possibilities. At Cornell, architects constructed a costly mock-up of the proposed lab module in order to persuade scientists toward consensus, a useful strategy that would not have been economically feasible if the real labs were to be built in different sizes and shapes.

Cornell administrators, and their in-house architectural and facilities staff, had their own reasons to encourage the design of identical lab spaces throughout the CBB. For them, the challenge is to complete the building project at a cost no more than the money available to pay for it (a difficult trick, when scientists want "a Cadillac building on a Volkswagen budget," a metaphor repeated time and again). Economies of scale are achieved during construction if the University is able to buy large numbers of identical wet benches and cabinetry. Building maintenance and retrofitting is also less costly in a standardized building, not just because fixtures may be purchased economically in bulk as things wear out or become obsolete, but because the labor time of custodial and repair people is lessened if they need to become familiar with only one pattern. Moreover, as all university facilities managers know from costly experience, spaces that are custom designed for one faculty member become white elephants after those scientists retire or move. One told us about another Cornell building designed the wrong way: "Because they had individually-designed labs, and people left, and another one came and they had to re-do it again … it was very expensive."

It would seem, then, that a modular lab design would be least appealing in principle to the Cornell scientists themselves, who would be asked to fit their diverse equipment and research teams into the exact same box. As it happens, the generic lab was an easy sell, even to the biologists. The local culture of these scientists was strongly egalitarian: at no point in the design process was it even possible to argue that the more senior or accomplished faculty should get more or better lab space. One told us: "Relative to other places I've been, this is much more equitable because a beginning assistant professor, who doesn't have more than one graduate student, gets the same amount of space as someone who's got ten." In addition, and more interesting, the standardized lab module made it easier for these scientists to justify their acute need for a new science building. After all, the rule for faculty at Cornell and probably every other university is "demand more space and new facilities, incessantly and vociferously!" So, for Cornell administrators, the question became: why respond to heartfelt appeals for new digs from *these* biochemists, molecular biologists, and geneticists, while other faculty wait in line behind?

The winning answer took the form of a "consolidation argument"[87] that required the biologists to construct a new social space for themselves – academic biotechnology – that called attention to their commonalities. They argued from the start that the faculty and equipment constituing this imagined social space were now scattered all over the rangy Ithaca campus, creating inefficiencies, inconveniences, and obstacles. Biotechnology at Cornell would thrive only if its far-flung components could be brought together in a single place as a single institutional entity – a rhetoric whose persuasiveness is enhanced by a building whose workspaces would all assume the same architectural form. Modularity both measures and solidifies the in-common qualities of those biologists who would end up in the CBB.

One Cornell scientist told us: "I think … very early on, we came to the concept … that we shouldn't say … that genetics is here and biochemistry is there … since those units are very similar and have very shared interests … so we put those two groups on the same floor…. It wasn't that hard, anyway, because as I said, *it's all one building*" [my emphasis]. Another said, "One of the reasons that I think it [modularity] is very good is politics." An architect added, "At Cornell, they felt … that there is a tremendous amount of similarity in the work being done." In the face of stiff competition for precious University building funds, it is unlikely that the CBB would have gained priority if it had been proposed by a mixed bag of scientists united only by their separate desires for better labs. The CBB was designed to do much more: to bring into being academic biotechnology at Cornell, and to capitalize on the similarities and intersections of this set of scientists so obvious that it became essential to bring them together in a new facility.

Not all biologists would be able to fit inside the proposed CBB, and that problem sets up another reason why a generic lab design fits the bill for those scientists on the Building Committee (who were sure to get in). If modularity heightens commonalities among those slated for inclusion, it can also be used to heighten contrasts to those who will be left out – and to justify those exclusions as legitimate or even obvious. Neither microbiologists nor ecologists could claim space in the new building, in part because its spaces were not well-designed to suit their particular research needs. If the CBB had instead been designed with different lab spaces to satisfy every occupant, it might have been as easy for an ecologist or an environmental biologist to lay claim to a new lab as it was for a geneticist or molecular biologist (if you customized it for them, surely you can customize it for me…). Laboratory design is the negotiation of disciplinary boundaries: decisions about what parts of biology are necessary (or irrelevant) for biotechnology were settled as floor plans did the dirty work of saying "no" to some.

Modular identical labs was as good a design/political solution for incoming biologists as it was for architects and Cornell administrators.[88]

Second, the CBB was designed and built to contain laboratories and offices (the same module) for visiting industrial scientists from biotechnology corporations, as well as research facilities providing technical services (like fermentation or DNA analysis) both to Cornell scientists and to commercial biotech operations elsewhere. Read the blueprint: who needed to be enlisted in order for this $34 million building to get off the ground? No matter how strong the case for consolidation was made by Cornell biologists, the University could not fully cover the cost of the new facility from its own coffers. Two sources of outside funding were tapped, and then secured by giving them a space inside the CBB. The State of New York joined the biotech feeding frenzy of the early 1980s, not wishing to be outdone by New Jersey or Maryland in luring high-tech jobs. The $20 million provided for the CBB through the State's Center for Advanced Technology program is an infrastructural investment in future economic development. Cornell scientists made the case that their kind of research in molecular biology, genetics and biochemistry (now consolidated into that new entity "academic biotechnology") was the pure science foundation from which marketable products, patents, profits, jobs and tax revenues would eventually emerge. Moreover, the technical services to be housed in the CBB could give biotech start-ups access to expensive equipment or scarce expertise that they might not otherwise be able to afford. "I think really… some of the administrators … thought that the State could be shaken down by representing biotechnology as the coming thing," a scientist told us. New lab space for Cornell biologists = economic development in New York.

Cornell also hoped to speed up technology transfer by enrolling major corporations into its Biotechnology Program (an administrative unit distinct from the University's research and teaching missions), and Kodak, Union Carbide, and Corning were involved in the early years. None of these firms was eager to sink capital into brick and mortar on the Ithaca campus: for them, a new laboratory facility that was not under their complete and private control was just too far upstream from marketable products to justify the risk. Still, these corporations had an interest in the CBB getting built, and for several reasons sought a beachhead inside. If one of their scientists could, say, spend a little time periodically shoulder-to-shoulder with the Cornell scientists, the firm would have a potentially valuable window on the cutting edge and could acquire certain research skills that are most easily transferred. Kodak, Union Carbide, and Corning might even be willing to *pay* for such strategic opportunities (by providing research grants, equipment, or support for students and postdocs), which gives Cornell a reason to allocate precious square footage to them. The CBB could become a "trading zone"[89] in which ideas and influences flow in both directions: industrial scientists could drop hints (or more) to encourage lines of inquiry with at least medium-term marketplace potential.

The design of the CBB is not only an architectural rendering of disciplinary boundaries among biologists. It maps out too the nebulous border between pure science and applied, between basic research and product development. One scientist responded: "The euphoria about biotechnology enabled the generation of this building … while in actuality 80 percent houses academic units that needed more space." New players, new linkages, new dependencies, new resource-flows … all of them in need of stabilization. An upstairs-downstairs logic at the CBB begins to structure these new arrangements, by bringing commercial concerns inside Cornell biotech while keeping them far enough away to prevent pollution of the pure search for knowledge. Cornell faculty scientists are upstairs, on the top three levels; the research facilities and labs for visiting industrial scientists are downstairs on the first level, waiting like cargo cult airstrips – a hope that if they are built, some needed money will come.

Third, something is missing from the CBB. Princeton's Lewis Thomas Laboratory served as a "reference building"[90] as the design team at Cornell contemplated and negotiated. Prominent spaces at the Thomas Lab are given to undergraduate teaching labs and a large lecture hall. Were these needed in Ithaca? Evidently not: there are no classrooms as such in the CBB, nor dedicated teaching labs. Whose interests were less imperative for getting this building off the ground? As the CBB was in its most pliable state, spaces explicitly for students moved in and out of reality. At first, Cornell scientists were willing to accommodate teaching labs and classrooms, if they did not come at the expense of space for research or the Biotechnology Program. Only the University itself, it seems, was really interested in buying teaching facilities in the CBB, but their pockets were not deep enough. At some point along the way, as patrons and clients were sorted out and budgets firmed up, teaching labs and classrooms disappeared from the program, never to return in sketch or floor space. The CBB is a *research* building. A planning document reads: "Undergraduate teaching functions are not programmed into this building; however, consideration must be made in siting to allow a functionally independent building connected to Corson-Mudd and Biotech … at a later date." Undergraduates could not be forgotten: teaching will be outsourced[91] to other nearby campus buildings, lessening the risk that students would be accidentally exposed to dangerous substances at the CBB.

Buildings in design measure the interests and powers of constituencies. The CBB becomes social structure in a gradually obdurate form: segregate microbiology from molecular biology, teaching from research; integrate molecular biology, genetics, and biochemistry as a new space itself wrapped up with commercial payoff and economic development. These abstractions are materialized as construction begins: the imagined social structure that guided design becomes increasingly impervious to alteration (as other possibilities are less easily apperceived).

Moment two: The white black box

Construction has been completed, the building has been dedicated, occupants and their equipment have been moved in. When the doors of the Cornell Biotechnology Building opened in 1988, the interests of its designers (patrons, owners, users, audiences, regulators, architects) took the largely unrecognized and unrecognizable form of walls and doors, ceilings and floors, fume hoods, and wet benches. The moment for negotiation and choice was past: if the building was once in the hands of its designers to bend and shape as far as their rhetorical skills and physical realities would allow, now it is they who are in the hands of the building, bent and shaped to meet its requirements. The building stabilizes the designers' vision of biotechnology, as it structures (fixes, routinizes) the social practices that will come to mark this new science. Decisions of inclusion and exclusion, for example, are now accomplished through the allocation of square footage and the distribution of keys: the social structure of Cornell biotechnology is built-in.

Now that the CBB has assumed its sedimented material form, *how* does it give stability to the emerging social structure of biotechnology – this science in a new key? Buildings structure social relations by concealing the arbitrariness of their design. The politics of the design process – the interests, power, constituencies, patrons, and purposes that came then to define biotechnology – have been etched into the walls, floors, and doors of the CBB, where they disappear. Once-imagined possibilities are precluded by the givenness, the seeming inevitability of the plan that did in fact get built. Buildings structure social relations by making it difficult to conceive of other arrangements of architectural spaces – which are, at the same time, social relations. Biotechnology has become what the CBB was built to do, sealed up in a gleaming white skin.

The CBB conceals the contingencies of its design in two different ways, by acting on bodies and by acting on (or through) minds. In their physicality, buildings install routines in the movement of bodies, patterns of ingress/egress that quickly become implicit. The CBB was designed to shape access, to impose segregations, to exclude, to couple in co-presence – and its impervious walls and lockable doors (along with signifying codes of "decoration") accomplish these social ends by resisting bodies. What Blumer said of the "empirical world" in general applies especially well to buildings: "This resistance gives the empirical world an obdurate character that is the mark of reality."[92] Biotechnology has become more real with not-easily altered spaces designed and built to welcome visiting industrial scientists or technicians from biotech start-up firms. But the ebb and flow of undergraduate throngs, so obvious elsewhere on Cornell's campus at class-change time, is nowhere to be seen in the CBB. As diverse people enter the CBB or never go near it, they rarely conjure how it might have been otherwise (unmaterialized plans for biotechnology, and for a building, left on the design room floor). Buildings insist on the particular paths that our bodies move along every day, and the predictable convergence or divergence of these paths with those of others is (in a sense) what we mean by *structured* social relations. If buildings silently steer us into associations or away from them, we hardly notice how (or question the rightness of it all – what Merton has called the "normative force of the actual"). "Construction plays the role of the subconscious."[93] Put simply: buildings emplace sociations and practices.

Buildings also conceal their makings (and their purposes) through the discourses by which people customarily apprehend them. Three idioms are common in our post-occupancy interviews with scientists in the CBB. First, some said that buildings in general are irrelevant for the science that goes on inside (what matters is the people) and they evinced indifference about the design of this one in particular. A lab is a lab is a lab … no matter how designed, buildings are merely settings for assemblages of the people, ideas, and equipment that are the consequential stuff of science. One scientist told us that sometimes the best science comes out of the worst buildings,[94] and another told us that the CBB is "really very similar to quite a number of buildings with related functions." Second, if scientists did admit that the building mattered at all, they emphasized a personal functionality: it works fine for me and what I do. Not surprising. Judgments of efficiency are typically how we talk about a machine: it works, or it doesn't. "That's really the way I would have set it up. It is just fine to have lab benches like that. It's just quite well-known in terms of human mechanics how many feet you need to have [for] two people working back-to-back." Ergonomics has lost its politics. Broader reflection into questions such as "good for what – or whom?" are precluded by such immediate self-interested calculations. Third, scientists said that the beauty of the building made them feel good, mentioning its taut and fresh modernism or the abundance of windows. "This is a wonderful place…. It is just so nice to come to a building that is bright and airy. You just feel good working in this kind of environment." That aesthetic register also serves to mask the CBB that was never built.

Moment three: Post-hoc refigurings

Edifices endure, and they don't. Even in the first few years after its opening, the CBB did not stand pat. No building stabilizes social structure absolutely because no building is itself permanent and untouchable. Biotechnology now has a built-in fixity and normalcy at Cornell – a reality – but at the same time the CBB is altered in response to flaws in the social theory that steered its design. Itself an agent now in the stabilization of biotechnology, the CBB never really ceases to be an object of human agents eager to tinker with it. Design continues forever.

The need for reconfiguration may be thrust upon designers and users by something so innocuous as a sociologist's colloquium. I was invited back to Ithaca several years after conducting fieldwork there, and asked to give a report on my study of the Cornell Biotechnology Building. My presentation (i.e., a version of this article so far) woke up local audiences to the politics and interests that were now routinely concealed behind the fresh efficiency of a beautiful new space for research. After listening patiently to my account of the building and its congealed social structure, several of those present remade the artifact into something different altogether. The point is not that "I got it wrong," but that the building retains interpretative flexibility after construction and occupancy. On certain occasions and in a contingent manner, the place becomes once again what it must become to deflect possibly unflattering or threatening criticism.

The CBB was *complicated* during and especially after my colloquium at Cornell. Among those in the audience were biologists and campus architects who had been involved in the design, eager to hear what I would make of the finished product. My recovery of purposes and politics now hidden in the obvious functionality and beauty of the as-built CBB evoked immediate and firm response, which constructed the building all over again. On the day after my colloquium, a biologist with high administrative responsibilities (who was on the design team) and another scientist active in the Biotechnology Program (who arrived at Cornell after the building was opened) generously agreed to interviews – to set the record straight?

The recently-arrived scientist took me downstairs to show what had become of the labs for visiting industrial scientists. One was still empty, but another was packed with the accoutrements of biological research – her own. Like the mock airstrips of the cargo cults, these labs had not succeeded in luring the planes. In the late 1980s, the bloom was off biotechnology, and corporations were paring down their research investments – especially initiatives as dicey as sending one of their own researchers to hang out with academics. I was also told, now, that the entire idea of space for visiting industrial scientists was ill-conceived. The gap between university and corporate cultures on issues such as accessibility, secrecy, agenda-setting, and credit was too wide to bridge. Moreover, there were functional alternatives to the hoped-for window on the cutting-edge – cheaper and less risky alternatives, such as colloquia or the timely circulation of preprints (among those with a stake in the Biotechnology Program). It is easier to acknowledge that the plan for visiting corporate scientists may have been ill-conceived now that the CBB is up and running. The theory had worked when it had to work, but the building was not strong enough in this instance to sustain anticipated links between pure and applied science. Some retrofitting was needed: a bench was removed from the standard module to accommodate her NMR machine.

No American university can afford to give off the impression that the education of undergraduates is only an incidental part of its mission. But exactly that impression, evidently, was given off by my discussion of the disappearance of teaching labs and lecture halls from the CBB –

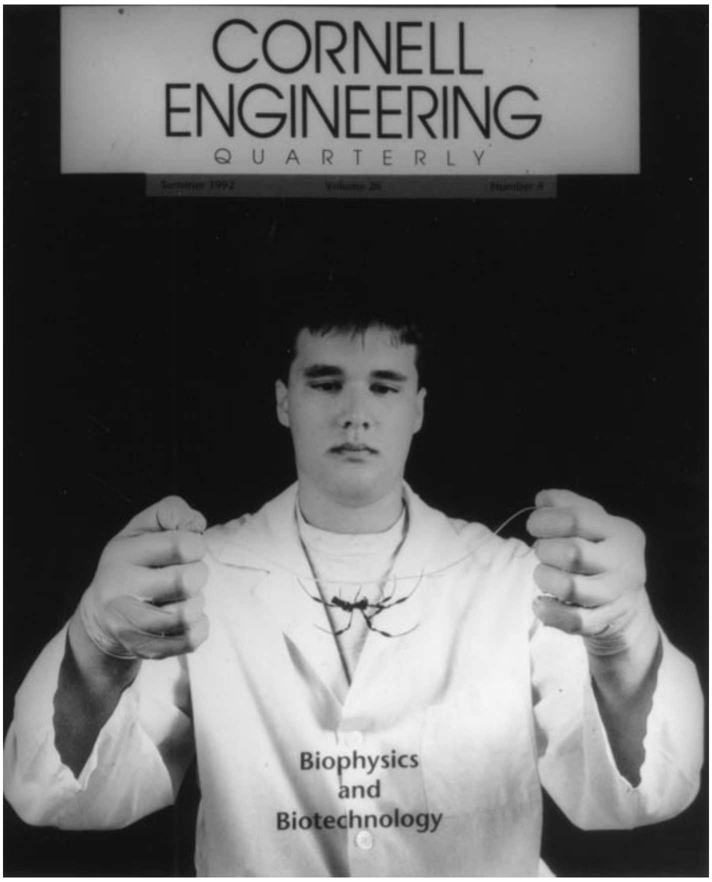

Figure 4. Undergrad and spider.

as it gradually but surely came to be constituted as a building for research (and, maybe, economic development). During my post-colloquium interviews, the CBB was reconstituted as a place where undergraduate education goes on all over – not by knocking down walls or even by building out previously unassigned "shell space," but instead by decoupling the process of teaching science from spaces dedicated to that end. I was told the story of a Cornell undergraduate engaged in research on spiders' thread – at the CBB. His faculty mentor went to the trouble (overnight, after my colloquium!) to make a slide of this student, pictured behind his huge spider, dressed in white lab coat, standing at a bench in the faculty mentor's lab module – an image that had appeared on the cover of one of Cornell's promotional magazines.

> it's a really good picture and I thought … you could put a different picture in place of your … empty slides. Your point is well taken … things were made specifically not to have classrooms but in a way, I would just hate to think somebody is going around the country … giving talks on Cornell not being really into the undergraduate research experience…. the kid still works, even during the year, one afternoon a week for me. You know, and this is just one example and it happens over and over and over…. It's what form does the teaching take. Does it take … a thousand seat auditorium where you pontificate or does it take teaching the kid how to pick up spiders and how to do controlled experiments and making him work all night?"

However incidental Cornell students might have been in scheming the CBB, the completed building is transformed by mere words and images into a cradle of undergraduate science education. I haven't lied, but neither has the faculty mentor, who artfully pried open the white black box to display the only permanence it has – interpretative flexibility.

Conclusion

Sociologists could take buildings more seriously, but maybe not too seriously. The play of agency and structure happens as we build: we mold buildings, they mold us, we mold them anew…. In buildings, and through them, sociologists can find social structures in the process of becoming. "Biotechnology" is negotiated at Cornell as designers imagine a building for it. Their choices get solidified first in floor plans, then in walls and doors that conceal the possibilities that never happened (and why). Interactive routines are built-in, and science gets done by denizens cheerful with their efficient and attractive new digs. But Cornell Biotechnology is not set in stone, despite its mass and the steep cost of undoing it now. Retrofitting begins almost immediately after the Dedication Ceremony, and every once in awhile, somebody is forced to reconsider (and justify) how the building came to be this way. Buildings evoke endless narratives, not always consonant with those heard earlier as people and powers were enlisted and aligned to move dreams toward reality.

Notes

1. Funding was provided by the Andrew W. Mellon Foundation. A short version was presented in a session on architecture and sociology at the 1999 meetings of the

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5. Stewart Brand, *How Buildings Learn* (New York: Viking, 1994).
6. Emile Durkheim, "Sociology and its Scientific Field," in Kurt Wolff, editor, *Essays on Sociology and Philosophy* (New York: Harper and Row, 1964), 362.
7. Geographers echo the idea that built places are key to structuration and reproduction: "Place is seen as a process whereby the reproduction of social and cultural forms, the formation of biographies and the transformation of nature ceaselessly become one another." Allan Pred, "Place as Historically Contingent Process: Structuration and the Time-Geography of Becoming Places," *Annals of the Association of American Geographers* 74 (1984): 279–297 at 279. "The space within a building … is formed by and formative of social relations." Jon Goss, "The Built Environment and Social Theory," *Professional Geographer* 40 (1988): 392–403 at 399. "Spatial structure is … a medium through which social relations are produced and reproduced." Derek Gregory and John Urry, editors, *Social Relations and Spatial Structures* (London: Macmillan, 1985), 2. "Spatiality is … a social product and an integral part of the material constitution and structuration of social life." Edward Soja, "The Spatiality of Social Life," ibid., 92.
8. Anthony Giddens, "Space, Time and Politics in Social Theory," *Environment and Planning D: Society and Space* 2 (1984): 123–132 at 126–127.
9. Pierre Bourdieu, "The Kabyle House or the World Reversed," in Bourdieu, *Algeria 1960* (Cambridge: Cambridge University Press, 1979). Originally published in 1963.
10. Nigel Thrift, "On the Determination of Social Action in Space and Time," *Environment and Planning D: Society and Space* 1 (1983): 23–57 at 38. For more recent discussions: Thrift, *Spatial Formations* (London: Sage, 1996); Nick Bingham and Nigel Thrift, "Some New Instructions for Travellers: The Geography of Bruno Latour and Michel Serres," in Mike Crang and Nigel Thrift, editors, *Thinking Space* (London: Routledge, 2000), 281–301.
11. Anthony Giddens, *The Constitution of Society* (Cambridge: Polity, 1994), 368, 118, xxv.
12. Ibid., 118.
13. Ibid., 118. My emphasis.
14. Anthony Giddens, *Central Problems in Social Theory* (Berkeley: University of California Press, 1979), 207.
15. Anthony Giddens, "Preface," in Benno Werlen, *Society, Action and Space* (London: Routledge, 1993), xv. Werlen himself seems equally reluctant to attribute agency to material objects, such as buildings. After noting the "constraining character" of

material artifacts ("to a large extent producers [of artifacts] control the interpretations of users, even when they themselves are no longer present and their artifacts have taken their place"), Werlen writes that such objects are "always and only constituted and reconstituted through subjective agency." Ibid., 199.

16. Anthony Giddens, *Modernity and Self-Identity* (Stanford: Stanford University Press, 1991), 18, 146.
17. M. Hannah and U. Strohmayer, "Ornamentalism: Geography and the Labor of Language in Structuration Theory," *Environment and Planning D: Society and Space* 9 (1991): 309-327 at 321.
18. M. Storper, "The Spatial and Temporal Constitution of Social Action," *Environment and Planning D: Society and Space* 3 (1985): 407–424 at 414, 409.
19. Edward W. Soja, *Postmodern Geographies* (London: Verso, 1989), 144.
20. William Sewell, Jr., "A Theory of Structure: Duality, Agency and Transformation," *American Journal of Sociology* 98 (1992): 1-29 at 19, 13.
21. Soja, *Postmodern Geographies*, 6; cf. 121–122. Bourdieu captures the idea that buildings *disguise* rather than announce: "social space translates into physical space, but the translation is always more or less blurred," and comes "in a form that is more or less distorted and, above all, disguised by the naturalization effect produced by the long-term inscription of social realities in the natural [material?] world." Pierre Bourdieu et al., *The Weight of the World: Social Suffering in Contemporary Society* (Stanford: Stanford University Press, 1999), 124. Originally published in 1993. My query.
22. Pierre Bourdieu, "Men and Machines," in Karin Knorr-Cetina and Aaron Cicourel, editors, *Advances in Social Theory and Methodology* (London: Routledge, 1981), 305–306.
23. Bourdieu, "Kabyle House"; cf. Pierre Bourdieu, *Outline of a Theory of Practice*. (Cambridge: Cambridge University Press, 1977), 163.
24. Bourdieu, "Kabyle House," 133.
25. Pierre Bourdieu, *In Other Words* (Stanford: Stanford University Press, 1990), 24.
26. Pierre Bourdieu, *The Logic of Practice* (Stanford: Stanford University Press, 1990), 71; cf. 76.
27. Ibid., 10.
28. Ibid., 9. Levi-Strauss identifies this possibly stillborn French Structuralist tradition: "It has been Durkheim and Mauss's great merit to call attention for the first time to the variable properties of space which should be considered in order to understand properly the structure of several primitive societies.... There have been practically no attempts to correlate the spatial configurations with the formal properties of the other aspects of social life." Claude Lévi-Strauss, *Structural Anthropology* (New York: Basic, 1963), 290–291. The allusion is to Emile Durkheim and Marcel Mauss, *Primitive Classifications* (Chicago: University of Chicago Press, 1963), originally published in 1902–1903.
29. Nicholas Garnham, "Bourdieu, the Cultural Arbitrary and Television," in Craig Calhoun et al., editors, *Bourdieu: Critical Perspectives* (Chicago: University of Chicago Press, 1993), 178-192 at 179.
30. Anthony King, "Thinking With Bourdieu Against Bourdieu: A "Practical" Critique of the Habitus," *Sociological Theory* 18 (2000): 417–433 at 431.
31. Bourdieu, "Kabyle House," 134, n. 3.
32. Sewell, "Theory of Structure," 15.
33. Bourdieu, "Kabyle House," 153.
34. Bourdieu, *Logic of Practice*, 130. Even Bourdieu's most recent theoretical consid-

erations of buildings do not fully avoid the limitations of his studies of the Kabyle house. The brief essay on "Site Effects" is familiar Bourdieu all over again. "Part of the inertia of the structures of social space results from the fact that they are inscribed in physical space and cannot be modified except by a work of transplantation, a moving of things and a uprooting or deporting of people, which itself presupposes an extremely difficult and costly social transformation." Bourdieu, *Weight of the World*, 3. I suspect that the reinscription of new meanings or values into extant buildings is a little easier and happens far more often than the idea of "transplantation" would suggest.

35. Bourdieu calls this "praxeology" or "constructivist structuralism" in Bourdieu and Loïc Wacquant, *An Invitation to Reflexive Sociology* (Chicago: University of Chicago Press, 1992), 11; Bourdieu, "Social Space and Symbolic Power," *Sociological Theory* 7 (1989) 14–15. Cf. Frédéric Vandenberghe, "'The Real is Relational': An Epistemological Analysis of Pierre Bourdieu's Generative Structuralism," *Sociological Theory* 17 (1999): 32–67. I am sympathetic to the position staked out by Emirbayer and Mische in their idea of a "double constitution of agency and structure." "The challenge here is to analyze the variable nature of the interplay between structure and agency, rather than to understand these as either standing in insurmountable opposition, or, as in currently influential theorizations, being 'mutually constitutive' in a direct and stable way." To anticipate my argument through the lens provided by Emirbayer and Mische: while designing a building is certainly a specimen of "projective agency" ("capacity to imagine alternative possibilities"), the finished place inevitably (but not absolutely) serves to "decrease [actors] capacity for invention, choice and transformative impact." Mustafa Emirbayer and Ann Mische, "What is Agency?" *American Journal of Sociology* 103 (1998), 962–1023 at 1002, 962, 1003.
36. Giddens, *Constitution of Society*, 288; Giddens, "Space, Time and Politics," 128–129.
37. David Brain exploits a similar theoretical perspective to analyze American public housing within the modernist project: "Cultural Production as 'Society in the Making': Architecture as an Exemplar of the Social Construction of Cultural Artifacts," in Diana Crane, editor, *The Sociology of Culture* (Oxford: Blackwell, 1994), 191–220.
38. Since my purpose in going into this literature on technology is to come out with concepts that will inform the empirical understanding of structuration and reproduction in the design and use of a science building, I have intentionally overlooked palpable differences among those here lumped together as "constructivists" (and including devotees of actor network theory and the social worlds perspective). For a review, cf. Wiebe Bijker, "Sociohistorical Technology Studies," in Sheila Jasanoff et al., editors, *Handbook of Science and Technology Studies* (Thousand Oaks, Cal.: Sage, 1995), 229–256. For a review that connects Giddens to the literature on social construction of technology, cf. Werner Rammert, "New Rules of Sociological Method: Rethinking Technology Studies," *British Journal of Sociology* 48 (1997), 171–191. Criticisms of constructivist studies of technology draw special attention to the sometimes overlooked question of *who* has the power to shape technology: Hughie Mackay and Gareth Gillespie, "Extending the Social Shaping of Technology Approach: Ideology and Appropriation," *Social Studies of Science* 22 (1992): 685–716; Langdon Winner, "Upon Opening the Black Box and Finding it Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology and Human Values* 18 (1993): 362–378; Maria Lohan, "Constructive

Tensions in Feminist Technology Studies," *Social Studies of Science* 30 (2000): 895-916.

39. John Staudenmaier, S.J., *Technology's Storytellers* (Cambridge: M.I.T. Press, 1985), 194. Cf. Kathryn Henderson, *On Line and On Paper* (Cambridge: M.I.T. Press, 1999).
40. Bruno Latour, "Where are the Missing Masses? The Sociology of a Few Mundane Artifacts," in Wiebe Bijker and John Law, editors, *Shaping Technology/Building Society* (Cambridge: M.I.T. Press, 1992), 225-258 at 247. Latour would say that even *ontological* distinctions between natural and cultural entities should be suspended as a matter of analytic principle: *We Have Never Been Modern* (Cambridge: Harvard University Press, 1993), 10ff; *Aramis, or the Love of Technology* (Cambridge: Harvard University Press, 1996); *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge: Harvard University Press, 1999), 174ff. Evens suggests that such an ontological move might rescue Bourdieu from the flaws identified earlier in this article: T. M. S. Evens, "Bourdieu and the Logic of Practice," *Sociological Theory* 17 (1999): 3-31. Incidentally, Latour considers the agency/structure problem a "cliché, or, as we say in French, … the *pont aux ânes* of social theory." He suggests that social processes are made up neither of agency nor structure, but of entities (material, natural, human, whatever) that endlessly *circulate* without ever settling into an agent or a structure – a "trajectory, a movement," not an opposition. Bruno Latour, "On Recalling ANT," in John Law and John Hassard, editors, *Actor Network Theory, And After* (Oxford: Blackwell, 1999), 15-25 at 16-7. For a gentle critique of actor network theory, cf. Scott Frickel, "Engineering Heterogeneous Accounts: The Case of Submarine Thermal Reactor Mark-1," *Science, Technology and Human Values* 21(1996): 28-53.
41. Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge: M.I.T. Press, 1990), 86.
42. John Law and Michel Callon, "Engineering and Sociology in a Military Aircraft Project," *Social Problems* 35 (1988): 284-297 at 290.
43. Andrew Pickering, *The Mangle of Practice: Time Agency and Science* (Chicago: University of Chicago Press, 1995).
44. Steve Woolgar, "Configuring the User," in John Law, editor, *A Sociology of Monsters: Essays on Power, Technology and Domination* (London: Routledge, 1991), 57-99. On the general idea, cf. Monica Dianne Mulcahy, "Designing the User/Using the Design," *Social Studies of Science* 28 (1998): 5-37. An interesting case is suggested by the possibility that cockpits in aircraft may or may not be accommodated to fit women pilots. Rachel N. Weber, "Manufacturing Gender in Commercial and Military Cockpit Design," *Science, Technology and Human Values* 22 (1997): 235–253.
45. Langdon Winner, *The Whale and the Reactor* (Chicago: University of Chicago Press, 1986), 54.
46. Madeleine Akrich, "The De-Scription of Technical Objects," in Bijker and Law, editors, *Shaping Technology,* 205–224 at 208. Cf. Marianne de Laet and Annemarie Mol, "The Zimbabwe Bush Pump: Mechanics of a Fluid Technology," *Social Studies of Science* 30 (2000): 225–263; Michel Callon, "Society in the Making: The Study of Technology as a Tool for Sociological Analysis," in Wiebe Bijker, Thomas Hughes, and Trevor Pinch, editors, *The Social Construction of Technological Systems* (Cambridge: M.I.T. Press, 1987), 83–103.
47. An attempt to see closure from the perspective of Bourdieu's "habitus" is provided by Mikael Hård, "Technology as Practice: Local and Global Closure Processes in Diesel-Engine Design," *Social Studies of Science* 24 (1994): 549–585.

48. Mukerji continues: "we live in built environments, and we make sense of ourselves and others not just by what we say and write but also by our actions in the material world." Chandra Mukerji, *Territorial Ambitions and the Gardens of Versailles* (Cambridge: Cambridge University Press, 1997), 36.
49. Bruno Latour, *Science in Action* (Cambridge: Harvard University Press, 1987), 132. Latour's example is germane for understanding the origins of a new biotechnology research building at Cornell. In the late nineteenth century, French pig farmers lost much livestock to anthrax. A remedy was elusive until Pasteur demonstrated the effectiveness of his vaccine during inoculation trials. A new obligatory passage point was thus engineered: Pasteur's Parisian laboratory itself became the indispensable gate between dying pigs and happy farmers. But healthy swine came at a high price: laboratories must be nurtured by substantial government financing. A new network of social relationships among farmers, scientists, and government officials, with rearranged flows of authority and material resources, is stabilized in and around the scientific laboratory. *Its* requirements force the realignment of organizations and individual behavior patterns, these days routinized in institutions like the National Institutes of Health. Bruno Latour, *The Pasteurization of France* (Cambridge: Harvard University Press, 1988).
50. Winner, *Whale and the Reactor*, 5; cf. Winner, "Political Ergonomics," in Richard Buchanan and Victor Margolin, editors, *Discovering Design* (Chicago: University of Chicago Press, 1995), 146–170. As Winner tells the familiar tale, most people who drove their cars on New York area parkways designed by Robert Moses from the twenties through the seventies passed under innumerable bridges without a thought – or, upon reflection, saw them only as means to facilitate a quicker trip to Long Island beaches by segregating cross-traffic. But the bridges were built too low to permit 12 foot high buses from passing underneath, thus preventing easy access to Jones Beach by those who relied on public transportation (racial minorities and low income groups). Moses' "social class bias and racial prejudices" became invisible but demonstrably efficacious when they were black boxed in an artifact routinely seen only in terms of its workability as defined by the immediate needs of users. The bridges prevented buses from reaching the beaches, but also preempted an awareness and scrutiny of *why* beach goers happened to be overwhelmingly white and middle class. Apocryphal? Cf. Bernward Joerges, "Do Politics Have Artifacts?" *Social Studies of Science* 29 (1999): 411–431.
51. MacKenzie, *Inventing Accuracy*, 26; Michel Callon and Bruno Latour, "Unscrewing the Big Leviathan: How Actors Macro-Structure Reality and How Sociologists Help Them To Do So," in Karin Knorr-Cetina and Aaron Cicourel, editors, *Advances in Social Theory and Methodology* (Boston: Routledge and Kegan Paul, 1981), 277–303 at 285.
52. Latour, *Aramis*.
53. Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore: The Johns Hopkins University Press, 1983), 140ff.
54. John Law and Michel Callon, "The Life and Death of an Aircraft: A Network Analysis of Technical Change," in Bijker and Law, editors, *Shaping Technology,* 21-52; Wiebe Bijker, "The Social Construction of Fluorescent Lighting, Or How an Artifact Was Invented in Its Diffusion Stage," in Bijker and Law, editors, *Shaping Technology*, 75-102; Trevor Pinch and Wiebe Bijker, "The Social Construction of Facts and Artifacts," in Bijker et al., editors, *Social Construction of Technological Systems*, 17–50; Wiebe Bijker, "The Social Construction of Bakelite," in Bijker et al., editors, *Social Construction of Technological Systems*, 159–187; Sherry Turkle,

The Second Self: Computers and the Human Spirit (New York: Simon and Schuster, 1984); Stephen R. Barley, "The Social Construction of a Machine: Ritual, Superstition, Magical Thinking and Other Pragmatic Responses to Running a CT Scanner," in M. Lock and D. R. Gordon, editors, *Biomedicine Reexamined* (Boston: Riedel, 1988), 497–539; Stephen R. Barley, "Technology as an Occasion for Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments," *Administrative Science Quarterly* 31 (1986): 78–108; Stuart S. Blume, "The Rhetoric and Counter-Rhetoric of a "Bionic" Technology," *Science, Technology and Human Values* 22 (1997): 31–56; Lisa Jean Moore, "'It's Like You Use Pots and Pans to Cook. It's the Tool': The Technologies of Safer Sex," *Science, Technology and Human Values* 22 (1997), 434–471.

55. Exactly the fate of a personal rapid-transit system designed for Paris: Latour, *Aramis*. Sometimes the material re-making is unexpected and not of human origin, as with the 1995 Kobe earthquake: Takashi Harada, "Space, Materials, and the 'Social': In the Aftermath of a Disaster," *Environment and Planning D: Society and Space* 18 (2000): 205–212.
56. Akrich, "De-Scription of Technical Objects," 209-11.
57. Callon and Latour, "Unscrewing the Big Leviathan," 284.
58. Robert K. Merton, *Social Theory and Social Structure* (New York: Free Press, 1968), 39ff.
59. Scott G. Knowles and Stuart W. Leslie, "'Industrial Versailles:' Eero Saarinen's Corporate Campuses for GM, IBM and AT&T," *Isis* 92 (2001): 1-33; Peter Galison and Emily Thompson, editors, *The Architecture of Science* (Cambridge: M.I.T. Press, 1999); Crosbie Smith and Jon Agar, editors, *Making Space for Science* (New York: St. Martin's, 1998); Jan Golinski, *Making Natural Knowledge* (Cambridge: Cambridge University Press, 1998), ch. 3: "The Place of Production."
60. Adi Ophir and Steven Shapin, "The Place of Knowledge: A Methodological Survey," *Science in Context* 4 (1991): 3–21 at 3; Steven Shapin, "Placing the View from Nowhere," *Transactions of the Institute of British Geographers* (New Series) 23 (1998): 5–12.
61. Emile Durkheim, *Selected Writings*, ed. Anthony Giddens (Cambridge: Cambridge University Press, 1972), original published in 1899; cf. Thomas F. Gieryn, "Durkheim's Sociology of Scientific Knowledge," *Journal of the History of the Behavioral Sciences* 18 (1982): 107–129.
62. The shift was precipitated by the first two "lab ethnographies:" Karin Knorr-Cetina, *The Manufacture of Knowledge* (Oxford: Pergamon, 1981); Bruno Latour and Steve Woolgar, *Laboratory Life* (Princeton: Princeton University Press, 1986, 2nd edition), originally published in 1979.
63. Thomas J. Allen, *Managing the Flow of Technology* (Cambridge: M.I.T. Press, 1977), 236ff; cf. Bill Hillier and Alan Penn,"Visible Colleges: Structure and Randomness in the Place of Discovery," *Science in Context* 4 (1991): 23–49; L. McCracken and T. Samuels,"Lab Support Areas Help Employees Boost Productivity" *Research and Development* 26 (1984): 82–85.
64. Emile Durkheim and Marcel Mauss, *Primitive Classifications* (Chicago: University of Chicago Press, 1963), originally published 1901–1902, 60; Peter Galison, *Image and Logic* (Chicago: University of Chicago Press, 1997), 785.
65. Lawrence Aronovitch, "The Spirit of Investigation: Physics at Harvard University, 1870-1910," in Frank A. J. L. James, editor, *The Development of the Laboratory* (London: Macmillan, 1989), 83–103 at 100.
66. Robert E. Kohler, *From Medical Chemistry to Biochemistry: The Making of a*

Biomedical Discipline (Cambridge: Cambridge University Press, 1982), 232, 252. O'Donnell suggests that creation of the "esoteric" experimental laboratory was the "vital center" of American psychologists' efforts (at the start of this century) to detach themselves from moral philosophy and metaphysical speculation, and to constitute themselves as a *scientific* discipline. John M. O'Donnell, *The Origins of Behaviorism: American Psychology, 1870–1920* (New York: New York University Press, 1985), 7; cf. Maarten Derksen, "Are We Not Experimenting Then?: The Rhetorical Demarcation of Psychology and Common Sense," *Theory and Psychology* 7 (1997): 435–456.

67. Galison, *Image and Logic*, 787; Sharon Traweek, *Beamtimes and Lifetimes: The World of High Energy Physicists* (Cambridge: Harvard University Press, 1988), 33.
68. Bill Hillier and Julienne Hanson, *The Social Logic of Space* (Cambridge: Cambridge University Press, 1984), 8.
69. Owen Hanaway, "Laboratory Design and the Aim of Science," *Isis* 77 (1986): 585–610 at 587.
70. Several critics have argued that it is easy for analysts to read too much into laboratory floor plans, and so come away with undeservedly robust conclusions about what they "mean" for science. Shackelford challenges Hanaway's account by suggesting that although Tycho's laboratory was isolated and, with its fences to keep the public out, seemingly designed for privacy and secrecy, a variety of other evidence – volumes of theories and findings published by Tycho – suggest that he actively sought to make his findings public knowledge. Jole Shackelford, "Tycho Brahe, Laboratory and the Aim of Science," *Isis* 84 (1993): 211–230 at 225; cf. William R. Newman, "Alchemical Symbolism and Concealment: The Chemical House of Libavius," in Galison and Thompson, *Architecture of Science*, 59–77. The ethnomethodologist Michael Lynch agrees that walls and floors are not irrelevant for the science they ensconce, but analysts should treat them "as surface features of the phenomenal fields investigated by the scientists inhabiting such a 'place.'" That is, the place of laboratory work is "constituted by the actions that *dwell* grammatically within it" (p. 53), not by the lines and spaces one sees on a blueprint. Michael Lynch, "Laboratory Space and the Technological Complex: An Investigation of Topical Contextures," *Science in Context* 4 (1991): 51–78 at 53.
71. Sophie Forgan, "The Architecture of Science and the Idea of a University," *Studies in the History and Philosophy of Science* 20 (1989): 405–434 at 423; for the American context, cf. John Servos, *Physical Chemistry from Ostwald to Pauling* (Princeton: Princeton University Press, 1990), 179-180. Nobody, of course, has done more to connect the seemingly innocuous designs of buildings to the "microphysics of power" than Michel Foucault, *Discipline and Punish* (New York: Random House, 1979); cf. Markus, *Buildings and Power*; Chris Philo, "Foucault's Geography," in Crang and Thrift, *Thinking Space*, 205–238.
72. Thomas F. Gieryn, "Two Faces on Science: Building Identities for Molecular Biology and Biotechnology," in Galison and Thompson, *Architecture of Science*, 423–455.
73. Sophie Forgan, "Context, Image and Function: A Preliminary Enquiry into the Architecture of Scientific Societies," *British Journal of the History of Science* 19 (1986): 89–113 at 91. On the diversity of *cultural* spaces for science, cf. Thomas F. Gieryn, *Cultural Boundaries of Science* (Chicago: University of Chicago Press, 1999).
74. Ophir and Shapin, "Place of Knowledge."
75. Steven Shapin, "The House of Experiment in Seventeenth Century England," *Isis* 79 (1988): 3730–404 at 378, 397.

76. Peter Galison, "Buildings and the Subject of Science," in Galison and Thompson, *Architecture of Science*, 1–25 at 4–5.
77. Karin Knorr-Cetina, "The Couch, the Cathedral, and the Laboratory: On the Relationship between Experiment and Laboratory in Science," in Andrew Pickering, editor, *Science as Practice and Culture* (Chicago: University of Chicago Press, 1992), 113–138 at 113, 116. She puts the general point this way: "this is why the study of *knowledge settings* becomes the goal in the attempts to understand not only science and expertise but also the type of society that runs on knowledge and expertise." Karin Knorr-Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge: Harvard University Press, 1999), 8. My emphasis.
78. Robert Bud, *The Uses of Life: A History of Biotechnology* (Cambridge: Cambridge University Press, 1993). On the Human Genome Initiative: Daniel J. Kevles and Leroy Hood, editors, *The Code of Codes* (Cambridge: Harvard University Press, 1992).
79. On the politics and economics of biotechnology: Jack Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology, 1492–2000* (Cambridge: Cambridge University Press, 1988); Lawrence Busch et al., *Plants, Power and Profit: Social, Economic and Ethical Consequences of the New Biotechnologies* (Cambridge: Blackwell, 1991); Martin Kenney, *Biotechnology: The University-Industrial Complex* (New Haven: Yale University Press, 1986); Gina Bari Kolata, *Clone: The Road to Dolly, and the Path Ahead* (New York: William Morrow, 1999); Sheldon Krimsky, *Biotechnics and Society: The Rise of Industrial Genetics* (New York: Praeger, 1991); Edward Yoxen, *The Gene Business: Who Should Control Biotechnology?* (New York: Oxford University Press, 1983).
80. On "speed-up" in biotechnology: Michael Fortun, "The Human Genome Project and the Acceleration of Biotechnology," in Arnold Thackray, editor, *Private Science: Biotechnology and the Rise of the Molecular Sciences* (Philadelphia: University of Pennsylvania Press, 1998), 182–201.
81. Kloppenberg, *First the Seed*; Christopher Henke, "Making a Place for Science: The Field Trial," *Social Studies of Science* 30 (2000), 1–29.
82. Kenney, *Biotechnology*, 116ff, 131.
83. Ibid, 31.
84. This research is a product of the Project on Laboratory Design in Biotechnology, which is housed at the Department of Sociology, Indiana University, Bloomington. The primary materials used in the following analysis are available for scholarly examination with permission of the author. Interviews were conducted in 1990 and 1992, with the assistance of Project assistants Mitch Berbrier and Rob Bienvenu. Interview respondents have not been identified by name to protect their anonymity. All design documents were photocopied with permission from files in the office of the Executive Director of the Biotechnology Program at Cornell.
85. Latour, *Pasteurization of France*, 200–201.
86. Processes of standardization have become an important theme in the literature on the social construction of technology, e.g., Ken Alder, "Making Things the Same," *Social Studies of Science* 28 (1998), 499–545; Geoffrey C. Bowker and Susan Leigh Star, *Sorting Things Out: Classification and Its Consequences* (Cambridge: M.I.T. Press, 1999).
87. Thomas F. Gieryn, "Biotechnology's Private Parts (and Some Public Ones)," in Smith and Agar, editors, *Making Space for Science*, 281–312 at 300 [reproduced in Thackray, *Private Science*, 219–253]. This article offers additional empirical analysis of the Cornell Biotechnology Building, centering on issues of private vs. public spaces and on competition among scientists for their "own" workplaces.

88. During the design process, there were frequent debates over the need for space that would allow environmental biologists to process the raw materials they gathered in the field. Very little such space ended up in the final plans, which further emphasized through architecture that this branch of biology was not the obvious occupant of the CBB. I should add, however, that since the opening of the building, the environmental implications of biotechnology have become more pronounced, and so has the presence of scientists doing research on such subjects at labs inside the CBB.
89. Peter Galison, *Image and Logic*, 803ff. Georg Simmel brilliantly anticipates the general point: "The significance of fixed spatiality [i.e., a building] as a pivotal point for social relationships emerges whenever the contact or union of otherwise independent elements can occur only at one particular place." "Sociology of Space," 147.
90. An extension of the concept of "reference group" developed by Robert K. Merton, *Social Theory and Social Structure* (New York: Free Press, 1968), ch. 11.
91. Gieryn, "Two Faces on Science," 446–448. A University administrator suggested to us that the need to solidify connections between biotechnology at Cornell and economic development in New York State may have made it difficult to fit classrooms into the picture: "We never had any intent to have teaching labs or classrooms.... We were going to the State and saying 'this is a research building, and it's organized around graduate study, corporate-supported research, federally-supported research....'"
92. Herbert Blumer, *Symbolic Interactionism* (Berkeley: University of California Press, 1969), 22.
93. Merton has developed this concept only in lectures. The line about "subconscious" comes from Sigfried Giedion, *Bauen in Frankreich* (Leipzig, 1928), 3; quoted in Walter Benjamin, *The Arcades Project* (Cambridge: Harvard University Press, 1999), 4.
94. "I was at NIH ... half of the lab was out in the hall. But work got done.... How do you want to measure success: number of publications, number of invited talks, whatever. NIH is successful ... and [it] was terribly crowded. And then I went to Bell Labs.... They put a modern face on what we called a penal institution.... Everything was extremely jumbled. But if you look at success, I mean, Bell Labs and all the Nobel Prizes that come out of there.... I guess what I'm trying to argue you into is that maybe horrible buildings are successful!"