The Epistemology of the Suburbs: Knowledge, Production, and Corporate Laboratory Design

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For those in search of a whipping boy for the evils of modern capitalism, the corporate research laboratory seems like an easy choice. Seen from a passing car or a low-flying airplane (figs. 1–2), these buildings might appear to reinforce any number of clichés about the kind of people—and the kind of knowledge—created when profit reigns supreme. Their monolithic, repetitive architecture conjures images of the man in the gray flannel suit, stripped of individuality and creativity, rotting in New Jersey. Their huge lawns and manicured trees hint that these are closed, isolated fortresses that do not produce disinterested knowledge for the betterment of humanity but instrumental knowledge that serves only the logic of capital. After all, aren't these the places where nicotine is shown to be nonaddictive, where rabbits are tortured to make cosmetics, and where promising young researchers trade their scholarly ambitions for a generous paycheck? The chronology here is likewise suggestive. The first of these megafacilities was built in the late 1930s. Spurred by the triple intersection of big business, architectural modernism, and war—all of which have a pesky reputation for certain flavors of authoritarianism—over the course of the 1940s the typological principles of the corporate laboratory were adopted almost univer-

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FIGURE 1. The Esso Research Center in Linden, New Jersey. Were it not for the large corporate logo on the side of the building (seen on the left), this massive building might easily be mistaken for a socialist housing block. Designed by Voorhees, Walker, Foley, and Smith; opened in 1948. From Charles Haines, "Planning the Scientific Laboratory," *Architectural Record* 108 (July 1950): 107.

sally. By 1950, the same design ideas were applied not just to the sprawling sites of GE, GM, and IBM but to the more modest facilities of the American Can, Hercules Powder, and Pure Oil companies as well. Even academia and the government came to follow corporate precedent, and professional agreement about the qualities of a well-designed research space has remained remarkably stable in the decades since. One could hardly ask for a tidier tale of the corruptions of Mammon.

Corporate laboratories are indeed a crucial site for understanding the relationship between science and capitalism, but their importance is only obscured by this kind of politics of suspicion. Instead, this article approaches corporate laboratory design as an episode in the philosophy of

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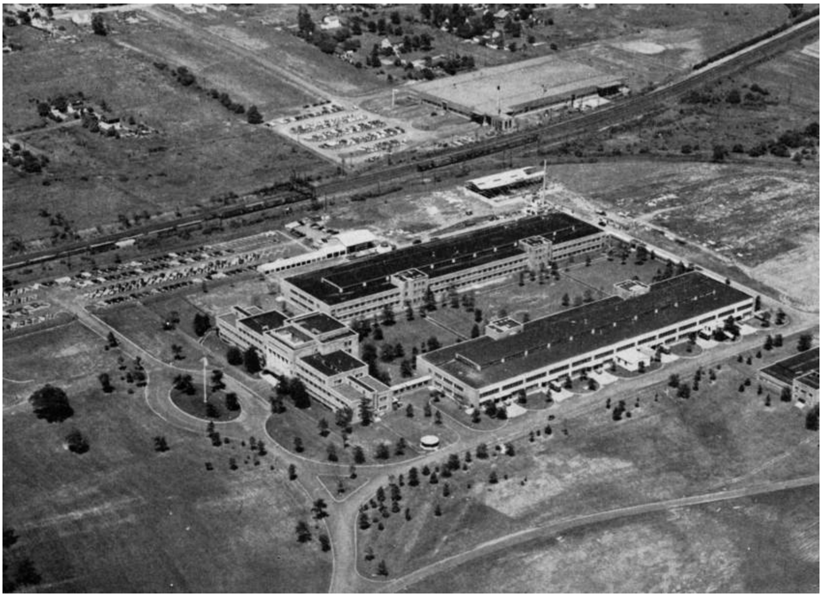


FIGURE 2. Aerial view of the Johns-Manville Research Center in Manville, New Jersey. Except for the full parking lot to the left of the buildings, most of this ninety-three acre site is grass and trees; the Raritan River runs nearby. Designed by Shreve, Lamb, and Harmon; opened 1949. From Clifford Rassweiler, "The Johns-Manville Research Center Six Years Later," *Architectural Record* 118 (Sept. 1955): 222.

knowledge; I want to analyze these buildings as an argument about knowledge and labor, one that challenges some common assumptions about the culture and priorities of the corporation. My starting point is the phrase *knowledge production*. Popularized in the early 1960s by the economist Fritz Machlup (only shortly after Peter Drucker's identification of the knowledge worker as the leader of the new knowledge-based economy), the phrase represents an important modification of earlier ideas of knowledge. Its immediate implication is that the creation of knowledge might be understood as a systematic process, something amenable to rationalization and organization. Yet when compared to *production of knowledge*, a phrase in use long before the 1960s, the adjunctive use of *knowledge* to modify *production* also suggests that there are significant differences between the production of knowledge and other kinds of production.[1] Both

1. See Fritz Machlup, *The Production and Distribution of Knowledge in the United States* (Princeton, N.J., 1962), and Peter Drucker, *Landmarks of Tomorrow* (New York, 1959). Searching for earlier uses of *knowledge production* brings up only classified ads that omit an intermedial *of* to save space.

of these ideas were potentially problematic, signaling not just the linking of two terms but the blurring of two previously distinct categories. In the mid-twentieth century, *knowledge* would almost inevitably have conjured up modifiers like *pure* and *fundamental* that would belie its alleged university provenance, while *production* (or *worker*) was traditionally a question of the kind of brute mechanical force found in the factory. The renegotiation of these terms is the major epistemological problem posed by knowledge production; it was also exactly the problem faced by mid-century laboratory planners.

The task of laboratory design was not simply one of constructing a building of adequate size that didn't leak; it was instead a kind of pragmatic social theory. Modernist laboratories involved an ongoing discussion among managers, scientists, and architects about the characteristics of the productive "research man" and the still-undefined nature of corporate—that is, organized—research. At the scale of both the researcher and the entire research division, the goal was not to establish control but to foster appropriate forms of creativity; in the ideal laboratory the interests of scientists and science managers would be the same. The result was an architecture that resisted the top-down imposition of order in favor of techniques of power that were positive instead of negative, constituting its inhabitants as agents and defining corporate research as something distinct from production, administration, or academic science. The relevant analytic model here is much less Michel Foucault's panopticon than it is his later work on governmentality; the laboratory was understood as an apparatus that would provide both freedom *and* control, but in a manner that did not set these two ideas in opposition.[2] The goal of management was enablement, and adequate autonomy could only be the product of adequate direction.

In a similar way, the corporate lab dissolved the idea that knowledge and production were ideal forms on opposite sides of a single axis, where more of one term implied less of the other. Even those managers who understood "pure" research as something distinct from "applied" development housed their staff in buildings that treated all forms of knowledge as essentially equivalent. The important distinction was not between more knowledge or more production but between different functional requirements. A laboratory for "basic science" would be designed using the same principles as one for process-development work. The same was true for

2. I am thinking specifically of Michel Foucault, "The Subject and Power," afterword to Hubert Dreyfus and Paul Rabinow, *Michel Foucault: Beyond Structuralism and Hermeneutics* (Chicago, 1982), pp. 208–26.

questions of size and specialization; whether large or small, biological or chemical, all modernist laboratories shared the same basic ideas about interior organization, site design, and geographic location. If anything, the more a company pushed for "pure research" in an "academic setting," the more it ended up problematizing purity and subverting academic precedents.

Methodologically, I want to make two claims for privileging laboratories as objects of theoretical interest. First, analysis of the practicalities of laboratory design allows a specificity about corporate research that is often difficult to find in purely textual sources. Although there is little ambiguity about the basic facts of corporate-style science—namely, the reorganization of research into multidisciplinary teams and the rejection of (academic) genius in favor of social conformity—there has, as my opening paragraph suggests, been long-standing debate about whether these changes represented a subversion of science (the manipulation of unwitting scientists by the military-industrial complex) or simply a new form of patronage and a new career path for those uninterested in the academic life. Analyzing laboratory design avoids the question of whether corporate managers' statements about the importance of openness were made in good faith, as the laboratories that were actually built suggest that laboratory planners did not see a dichotomy between conspiratorial coercion and unbridled freedom. The money-meets-mouth quality of multimillion-dollar buildings is what makes it possible for me to argue that the synthesis of knowledge and production did not involve compromise or mutual contamination but rather a genuine interest in creating a new social form, one that would ultimately be modeled neither on the factory nor on the university.

Second, this on-the-ground view allows historical clarity regarding the transition between monopoly capitalism and the flexible knowledge economy. Although the massive expansion of corporate research in the late 1940s and 1950s was certainly tied to World War II and the postwar military-economic boom, laboratory design suggests that much of the cultural content of this expansion had its roots in the earlier business-strategic importance of in-house corporate R&D. In other words, even though most of the published sources on corporate science date from after the war, looking at architecture makes it clear that the managerial and architectural models of the postwar were products of the corporate climate of the 1930s, not the military imperatives of the cold war. The link between the conceptual issues raised by Machlup or Drucker in the early 1960s and the architectural questions addressed twenty-five years earlier is thus direct and historical; my goal is to use architecture to unpack and situate these theoretical sources, not the other way around.

After a brief comparison of the basic problems of premodernist and modernist laboratory design, I address in turn the two major aspects of the modernist laboratory as arguments about the researcher, corporate research, and knowledge. The conclusion then returns to trace the larger trajectory of corporate knowledge space and the epistemology of capitalism.

The most prominent of the first wave of corporate laboratories was the unit of Bell Laboratories in Murray Hill, New Jersey designed in 1939 by the now-obscure New York firm of Voorhees, Walker, Foley, and Smith (VWFS) and opened in late 1941. Its salient features were the liberal use of moveable interior partitions and a spacious forested site; it was by far the largest of the new modernist labs and quickly became the standard against which later buildings would be judged.[3] With World War II proving the virtues of flexible space and geographic isolation, by the end of the decade the Bell Labs approach was "universally agreed upon" and had been codified in the architectural press, research-management trade journals, special laboratory design handbooks, and scores of built projects.[4] VWFS became the acknowledged source of laboratory design expertise, and even though later laboratories by more prominent modernists like Eero Saarinen or Skidmore, Owings, and Merrill received more exposure, they stayed remarkably close to the precedents set in the late 1930s.[5]

The methods used to design these laboratories were a radical departure from earlier ideas. From the late nineteenth century to the mid-1930s, publications on laboratory design very rarely included corporate space (corporate labs tended not to involve new construction) and were mostly a meditation on the disciplinary specificity then endemic to the academy. This disciplinarity presented design problems at two scales: those of the bench and the building. The bench was meant to accommodate the specialized services and equipment necessary for a particular type of research, and variations in bench design were potentially endless. Room design would follow the specificity of the bench, and rooms for chemistry, physics, or electricity would all be different. In turn, designing the building was a twofold problem, following Beaux Arts tradition. First was *distribution* in the French sense: to arrange the specially designed rooms into a unified

3. Bell Labs is ubiquitous in the laboratory design literature. See Scott G. Knowles and Stuart W. Leslie, "'Industrial Versailles': Eero Saarinen's Corporate Campuses for GM, IBM, and AT&T," *Isis* 92 (Mar. 2001): 21.

4. Roland A. Wank, introduction to *Laboratory Design,* ed. H. S. Coleman (New York, 1951), p. 3. For a complete list of VWFS's laboratory projects between 1942 and 1960, see Voorhees, Walker, Smith, Smith, and Haines, *Laboratories* (New York, 1961). The firm changed its name on a regular basis; I use VWFS throughout to avoid confusion.

5. Designs like those of Frank Lloyd Wright at S. C. Johnson Wax, Louis Kahn at Penn, or Frank Gehry at MIT are exceptions that tend to prove the rule.

(usually symmetric, approximately square) ensemble while still placing each room in a location compatible with its specific requirements. Second was choosing an appropriate historical style that would, in the words of one architectural critic, balance the functional requirements of science with a desire for a "dignified architecture . . . to conform to the importance of the science."[6] Questions of location or programming were hardly questions at all, as they had ready disciplinary answers. Not only should chemistry buildings provide chemistry-specific services and be arranged in a way most suitable for chemistry, but each discipline should have its own building or floor, and subdisciplines should have their own floors or wings.[7]

For the modernist laboratories that would become ubiquitous after the war, disciplinary specificity was ignored both in method and in content. The design team was itself cross-disciplinary, as a new collaboration among architects, managers, and scientists replaced the earlier understanding that the scientist would design the bench and the architect—if employed at all—would be responsible only for overall arrangement and character. With the modernist laboratory, the architect was charged with "imaginative coordination" (not just decoration) and worked closely with managers, department heads, and even individual researchers to help design the most suitable facility; the best laboratory architects were known for "their grasp of the whole range of problems from site selection to the last shutoff valve."[8] The designed space of the laboratory likewise replaced disciplinary specificity with a new emphasis on universality; *flexibility* and *expansibility* were the new watchwords. Instead of designing at the scale of the bench and the building, the two design tasks were the "module," which

6. Albert Carman, "The Design of a Physical Laboratory," *The Brickbuilder* 20 (Dec. 1911): 257.

7. For more on premodernist laboratory planning, see Thomas Roger Smith, "New Science Laboratories at University College, London," *Journal of the Royal Institute of British Architects* 1 (1894): 281–308; T. H. Russell, *The Planning and Fitting-Up of Chemical and Physical Laboratories* (London, 1903); Alan E. Munby, *Laboratories: Their Planning and Fittings* (London, 1921); Jens Larson and Archie Palmer, *Architectural Planning of the American College* (New York, 1933), pp. 114–25, which recommends flexibility for small colleges but provides only discipline-specific examples; David Cahan, *An Institute for an Empire: The Physikalisch-Technische Reichsanstalt, 1871–1918* (Cambridge, 1989), pp. 94–102; and Sophie Forgan, "The Architecture of Science and the Idea of a University," *Studies in the History and Philosophy of Science* 20 (Dec. 1989): 405–34.

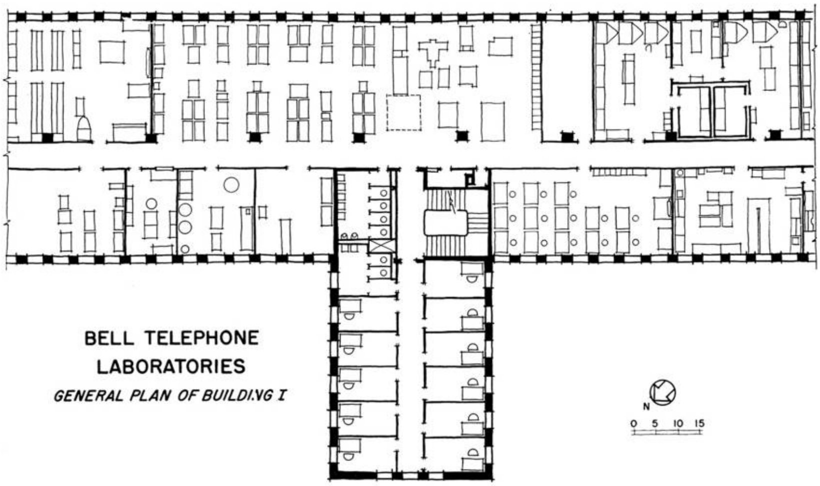
8. Wank, introduction to *Laboratory Design*, p. 3. For a slightly earlier expression of the same idea, see Lynn A. Watt, "Construction and Design of Research Laboratories," *Industrial and Engineering Chemistry* 39 (Apr. 1947): 440. These views stayed relatively constant; see Gerald M. McCue, "The Administration of Design and Construction of Research Facilities," *Research Management* 6 (Sept. 1963): 389–93, and James W. Beyvl, "Role of the Architect-Engineer in Planning and Building Research Facilities," *Research/Development* 15 (Mar. 1964): 28–31.

regulated the interior space of the laboratory, and the location and character of the (ideally suburban) site. The module was the guarantor of flexibility, and a well-designed site ensured expansibility. Technical requirements and adequate provision of laboratory services were still important, perhaps even more important than they had been previously, but postwar laboratory design pundits saw engineering problems as secondary to the organizational questions raised by these two central design problems.

The module and the site were likewise the two major devices through which laboratory planners addressed the problems of knowledge and its relation to production. The module acted on the scale of the individual researcher or small research team, while the location of the site (and its putatively "academic" character) shaped the qualities of the research division as a whole and the position of research within the larger corporation. The problem of knowledge production thus involved a double argument about the nature of the knowledge producer and the nature of the knowledge produced, and the corporate laboratory defined the corporate scientist at the same time that it defined corporate science. There was no necessary connection between a modular layout and a preference for a large suburban site (and laboratories were indeed built that used one without the other, especially before 1950), but they were motivated by similar goals and each reinforced the other. Both increased the legibility of the research process to management, both highlighted the social processes of research, and both replaced disciplinary specificity with functional specificity. In sum, both modules and a "campus-like" site were means by which laboratory planners sought to avoid any zero-sum tradeoff between the needs of science and the needs of the corporation.

The Module as a Human Being: Machinic Grids versus Psychological Sausages

As concerned the scientist, the module was the primary device of positive power deployed in the corporate laboratory. The module was a planning unit corresponding to the laboratory or office space needed by one researcher. The eventual plan of a building would often be nothing more than a multiplication of the module to accommodate all of a laboratory's staff, plus special areas for the cafeteria or library and outbuildings to accommodate wind tunnels, nuclear reactors, or bulk material storage. At Bell Labs, there were three kinds of modules: laboratory, office, and a combination laboratory/office space. These modules were arranged into a T, which was then repeated to generate the overall plan of the building (fig. 3). Other common arrangements had wings of only



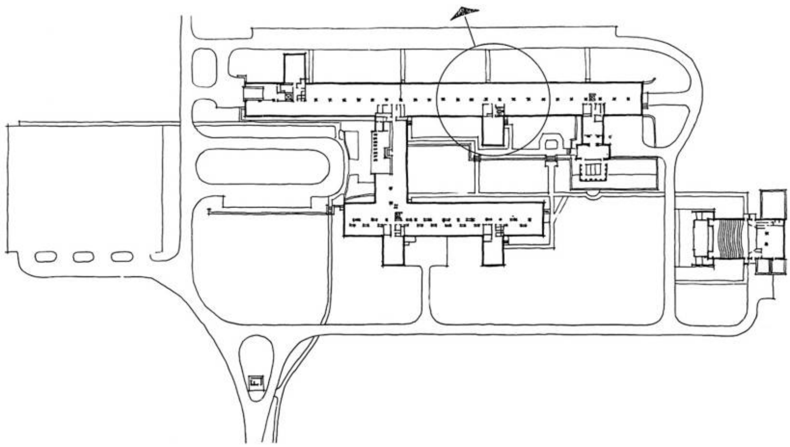


FIGURE 3. Module plans (top) and overall plan (bottom) of the first phase of Bell Laboratories in Murray Hill, New Jersey, designed 1939, opened 1941 (in 1949 a second building with a similar design would double the size of the laboratory). The top of the T shows sixteen laboratory modules, in the middle are twelve laboratory/office modules, and the bottom stem of the T contains eleven office modules. This T is then repeated (with rotation) six times to generate the typical floor plan. For clarity, this version is from Charles S. Haines, "Bell Telephone Laboratories," in *Laboratory Design,* ed. H. S. Coleman (New York, 1951), p. 339; drawings originally published in the early 1940s.

laboratory or office modules or different kinds of modules facing each other across a double-loaded corridor. Modules were almost always separated from each other by movable metal partitions or easily demountable clay-brick walls, and the laboratory for a research group might comprise several modules merged together. Since every module could handle any task, research groups were not tethered to specific parts of the building, and management could move or consolidate them as needed.

For the architects and managers who embraced the module as the organizing principle of the flexible laboratory, one word took precedence even over flexibility—*human*. They took pains to point out that the "human module" was about the "human needs" of researchers, since these researchers were the only justification for an expensive new laboratory. On a purely technical level, the module was thus seen to have more in common with an airplane cockpit than a typical room, with no clear boundary between furniture, services, or structure; the module was a kind of prosthetic, a set of tools lying in wait for inspiration to strike.[9] But this approach raised several important questions. First, what *were* the needs of the scientist? When the goal of research was to create novelty, trying to predict spatial requirements too closely would be grossly counterproductive. More importantly, however, where were the boundaries between engineering needs, intellectual needs, and psychological needs? Even the best engineering systems would be worthless without feelings of curiosity, excitement, and morale. In asking these questions, laboratory planners problematized the scientist as a new object of inquiry; as a result, the module also departed from much of the conventional wisdom of modern architecture. In both its managerial and its architectural uses, the module suggested that the creation of knowledge would not come from mastery of the corporate researcher, even though respecting his or her individuality provoked architectural solutions of a remarkably general flavor.

The first lesson of the module was that the apparently simple problem of providing the scientist adequate space, light, and services (while minimizing cost) required a new kind of knowledge about scientists' work habits. Managers and architects put themselves in the position of social scientists, treating research as an empirical problem that required studying the actual use of space by actual researchers. The design process for a new laboratory often included extensive study of other companies' modules or the construction of full-scale module mock-ups for studying finer adjustments, and debates on the scale of inches could be heated and protracted.[10]

9. As one senior researcher wrote, the laboratory "should be considered as forming part of [the scientist's] equipment" (J. Yule Bogue, "Some Aspects of Modern Laboratory Design," *Endeavour* 8 [Jan. 1949]: 38).

10. For mock-ups, see R. G. Hopkinson, "Research on the Design of Laboratories," in *The Design of Physics Research Laboratories*, ed. Institute of Physics (London, 1959), pp. 68–80. Full-scale module mock-ups were also built at the National Bureau of Standards (NBS) on their Washington, D.C. campus before the move to Gaithersburg. On the lengthy discussions, see A.V. Astin, interview transcript, 12 July 1983, p. 47, Oral History Files, Archives of the National Bureau of Standards Archives, Gaithersburg, Md. (NBS).

Responding to a long-standing desire for more systematic knowledge of research work, in the mid- and late 1950s the Nuffield Foundation, a British charitable trust, conducted extensive on-site analysis of working laboratories to study bench use, necessary light levels, and utilization of office versus laboratory space; its publications were widely reproduced in the management and architectural press. From the mass of data, two major conclusions emerged, both of which were largely seen as a codification of existing design principles. First, requirements for space and services were found to vary only between scientists and assistants, not between disciplines. At least in terms of architecture, the needs of chemistry, physics, and biology were more similar than different, and the real design question was one of providing space appropriate to the composition of the research team (scientists spent much more time reading and writing than assistants). Second was consciousness of what is now known as the long tail: the importance of the large deviations from normal found near the edges of a statistical distribution. Even though researchers spent the majority of their time using little or no bench space, or requiring only modest illumination, the largest needs for space or lighting would be formidable indeed. Similar to flood control engineers planning for a hundred-year storm, the Nuffield studies gave recommendations for amenities that would be used for only 1 percent of a researcher's tasks.[11] While the immediate goal of this approach was to make module design more systematic, it also advanced a working theory of the circumscribed autonomy of the corporate researcher. Simultaneously individuated and universalized, she or he was found to be unpredictably creative yet always operating within certain natural statistical limits.

This duality of creative subject and manageable object was reinforced through considerations of a more psychological nature. Architects and managers liked to point out that in the design of a module there should be no conceptual distinction between the practical need for ventilation or pressurized argon and the psychological impact of a pleasant view of the countryside.[12] For Ralph Walker, the lead designer of VWFS who apparently introduced the idea of a module into laboratory planning with the

11. See Nuffield Foundation Division for Architectural Studies, *The Design of Research Laboratories* (London, 1961). More digestible notices were published in *The Design of Physics Research Laboratories,* and R. Llewelyn Davies, J. W. Nightingale, and Norman T. Bailey, "Laboratory Design: Survey of Space and Services Requirements in Two Agricultural Research Laboratories," *Nature,* 26 Nov. 1955, pp. 999–1001.

12. Douglas Beach of B. F. Goodrich, when evaluating windowless laboratories, cautions that having no view is "more serious than it sounds" (Douglas M. Beach, "A Large Industrial Research Laboratory," *Industrial and Engineering Chemistry* 39 [April 1947]: 452).

design of Bell Laboratories,[13] all these needs were in fact identical, as the only measure of a successful building was the well-being of its occupants. Walker opened a 1957 collection of his essays by writing that modern architecture needs more investigation of "*new techniques* concerning the understanding of human physiology and psychology, and fewer imitations based on a shallow acceptance of building techniques as the only guiding philosophy."[14] What was needed was not "the clever arrangement of queer unhuman modules" but "an architecture of human relations."[15] Judging from their ingroup conversation in books and trade journals, science managers were in complete agreement. Since the goal was to maximize a researcher's creativity over the course of an entire career, the human factors of emotional camaraderie and long-term conflict avoidance were much more important than maintaining day-to-day output, and managers tended to see the nurturing of morale as one of their most valuable skills. Good morale, in turn, was largely a question of creating the right environment. In addition to liberal policies for publication, benefits, and attendance at scientific conferences, research managers consistently cited the psychological benefits of a well-designed laboratory. Well-designed laboratories were credited with almost magical powers, able to increase productivity, health, and loyalty while decreasing turnover and internecine squabbles over resources.[16]

With the linking of morale and architecture, the module became a strategic asset in a larger managerial reconceptualization of freedom and control. As with the human relations management movement more generally, the idea that anonymous workers would be led by omniscient managers

13. Researcher-oriented spaces had been designed for earlier laboratories, and it seems that the standardized lab space at Bell Labs was requested by the management committee, but I have found no use of the term *module* or any similarly rigorous organizing principle before the publication of Bell Labs in the architectural press. See Walker's discussion of the "work unit principle" in Ralph Walker, *Ralph Walker, Architect, of Voorhees, Gmelin, and Walker; Voorhees, Walker, Foley, and Smith; Voorhees, Walker, Smith, and Smith* (New York, 1957), pp. 181–82. Compare Harry S. Coleman, "The Research Laboratories of Mellon Institute," *Industrial and Engineering Chemistry* 10 (Sept. 1938): 550–58. See also "The Murray Hill Unit of Bell Telephone Laboratories," *Pencil Points* 23 (Aug. 1942): 34–70, and Don Graf, *Convenience for Research* (New York, 1944). By 1947 the term was in common use among both managers and architects.

14. Walker, introduction to *The Fly in the Amber* (New York, 1957), p. 7.

15. Walker, "The Fly in the Amber," *The Fly in the Amber*, p. 19.

16. For a sampling, see Clifford Rassweiler, "The Johns-Manville Research Center Six Years Later," *Architectural Record* 118 (Sept. 1955): 222–24; Edwin Pike, "Purposes, Objectives, Principles," *Architectural Record* 118 (Sept. 1955): 205; Bell Labs's Harold Arnold, quoted in Lilian Hoddeson, "The Discovery of the Point-Contact Transistor," *Historical Studies in the Physical Sciences* 12 (1981): 51; and "Summary of Responses on the Move to Gaithersburg, from the Attitude Survey of NBS Scientific and Engineering Research Personnel of October 23, 1956," 11 Feb. 1957, p. 3, box 17, group 167.3.3, Archives II, National Archives and Record Administration, College Park, Md. (NARA).

had no place in the corporate laboratory.[17] For a prominent manager like Kenneth Mees, longtime research director at Eastman Kodak, the research director's job should not be to direct at all but "to protect the worker from those who would direct," especially auditors, accountants, and top management.[18] Good management required that strategies of top-down direction be replaced by those where organization and individual autonomy could become mutually supportive instead of antagonistic. As Mees and his colleague John Leermakers summed up this approach, "it is desirable to keep organization in a research laboratory as informal as possible, but this must not be carried to a point where the men are uncertain of their status and position."[19] Similarly, a survey of research managers by the Harvard Business School found that "the research worker wants and needs a considerable amount of freedom . . . [but] he does not desire an absence of supervision or planning."[20] The module was the spatial manifestation of this both/and strategy. As researchers, scientists were found to have similar spatial requirements and were given services to match; as emotional human beings, managers argued that scientists' feelings of self-worth and belonging would be strengthened by the egalitarian nature of the repetitive module. At the same time, this same repetitive logic also made the laboratory legible and adjustable by management. So, at least in theory, the more rigorous the system, the more scientists' individual creativity and satisfaction would be furthered, not stymied, by the involvement of management.

Considered only within the context of corporate psychology, it is tempting to see the module as but a clever tool of social control. When also seen as part of the history of architecture, however, this view becomes increasingly untenable. Though it continued many of the traditions of early twentieth-century design, the corporate laboratory module was a purposeful rejection of others, and the modular laboratory was an attempt to intervene in the much larger cultural discussion about the relationship between modern building and modern subjectivity. Indeed, the force and specificity of modular design is perhaps best understood in relation to the wider discourse of mid-century architectural modernism. Walker, although virtually unknown today and categorized by historians as a timid

17. For a good introduction to the methods and interwar origins of human relations, see Mauro F. Guillén, *Models of Management: Work, Authority, and Organization in a Comparative Perspective* (Chicago, 1994).

18. Kenneth Mees, quoted in N. A. Shepard, "The Research Director's Job," in *Research in Industry: Its Organization and Management,* ed. C. C. Furnas (New York, 1948), p. 60.

19. Mees and John A. Leermakers, *The Organization of Industrial Scientific Research* (New York, 1950), pp. 313–14.

20. Robert N. Anthony, *Management Controls in Industrial Research Organizations* (Cambridge, Mass., 1952), p. 53.

and second-rate modernist, was at the time a well-known and fiercely vocal critic of the dominant avant-gardes. He had no patience for their apparent complicity with the deindividualizing logic of the machine age and mass culture, and his module was a direct response to this machinic vision of modernity.[21]

Walker's module broke ranks with dominant ideas of modernism in two important ways. First, it represented a disavowal of the widespread interest in the separation of architectural systems. For architects allied with the arch-modernist Le Corbusier or the program of the Congrès International d'Architecture Moderne (CIAM), architecture was seen as a collection of independent tectonic parts, each obeying their own logic and hierarchically related to each other. Structure was primary, facades and interior walls were secondary, and mechanical services were tertiary. Thus columns should be pulled back from the facade, interior partitions should not necessarily align with the columns, and mechanical services were best left to mechanical engineers.[22] The antitectonic nature of the VWFS module is perhaps best seen by comparing two drawings of modernist laboratories from the late 1930s, alike in content but quite different in conception. Figure 4 shows the laboratory space of the Imperial Chemical Industries (ICI) labs outside of Manchester, designed by the Russian-born modernist Serge Chermayeff. Figure 5 is a drawing of the module system at Bell Labs. (Both projects were widely published in the 1940s, but ICI was almost never mentioned by later laboratory planners.) The ICI drawing seems to show a building in the process of being constructed; the windows have been installed, the hallway (and thus ventilation system) is half-

21. The American Association of Architectural Bibliographers included Walker among Mies van der Rohe, Walter Gropius, and Eero Saarinen as worthy of a bibliographic monograph. This publication described him as "remarkable": "It would be difficult to find in America many persons whose careers in architecture have been more distinguished than has that of Ralph Walker" (Joseph Bosserman, *Ralph Walker Bibliography* [Charlottesville, Va., 1960], p. [1]). He also held many leadership positions in the American Institute of Architects from the early 1930s through the late 1950s, including one two-year term as president. His reputation declined quickly; in 1982 Carol Willis criticized the "moderation of his modernism" (Carol Willis, "Ralph Walker," in *Macmillan Encyclopedia of Architects*, ed. Adolf K. Placzek, 4 vols. [New York, 1982], 4:363), and in 1996 John Pile labeled him "timid" (John Pile, "Ralph Walker," in *The Dictionary of Art*, ed. Jane Turner, 34 vols. [New York, 1996], 32:797).

22. On the separation of systems, see Reyner Banham, *The Architecture of the Well-Tempered Environment* (Chicago, 1969) and *A Concrete Atlantis: U.S. Industrial Building and European Modern Architecture* (Cambridge, Mass., 1986). For earlier ideas of separation and hierarchy, see Antoine Picon, "The Freestanding Column in Eighteenth-Century Religious Architecture," in *Things That Talk,* ed. Lorraine Daston (New York, 2004), pp. 67–99, and Robert Bruegmann, "Central Heating and Forced Ventilation: Origins and Effects on Architectural Design," *Journal of the Society of Architectural Historians* 37 (Oct. 1978): 143–60.

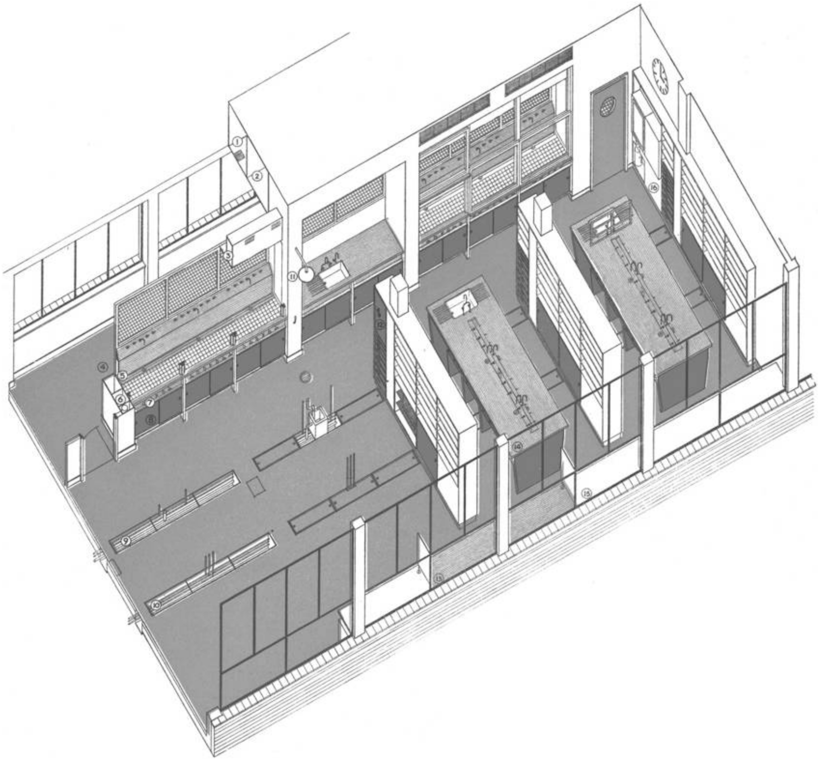


FIGURE 4. Drawing of the laboratory space for ICI laboratories outside of Manchester, designed by Serge Chermayeff and opened in 1938. The building is shown composed of additive systems, each complete in itself and independent from the others. From "Laboratories at Blackley, Manchester," *Architectural Review* 83 (Mar. 1938): 122.

complete, and the fitting out of the laboratory spaces is proceeding from right to left. The drawing implies an additive logic of distinct systems: the window system, the ventilation system, the piping system, the partition and bench system. In contrast, the Bell Labs drawing shows a finished building that has *subsequently* been cut to reveal its insides. Windows are cut off midmullion; structural columns are severed and shown embedded in their soffits. There is no visual hierarchy among structure, services, or partitions. The message is that everything is equally important and the project should be evaluated from the point of view of the occupant, not the builder.

Second, and not unrelated, the very notion of *module* employed by VWFS and later laboratory planners was significantly different from the more common understanding of the term by other architects. To the casual reader of the architectural press in the 1950s, the natural context of any

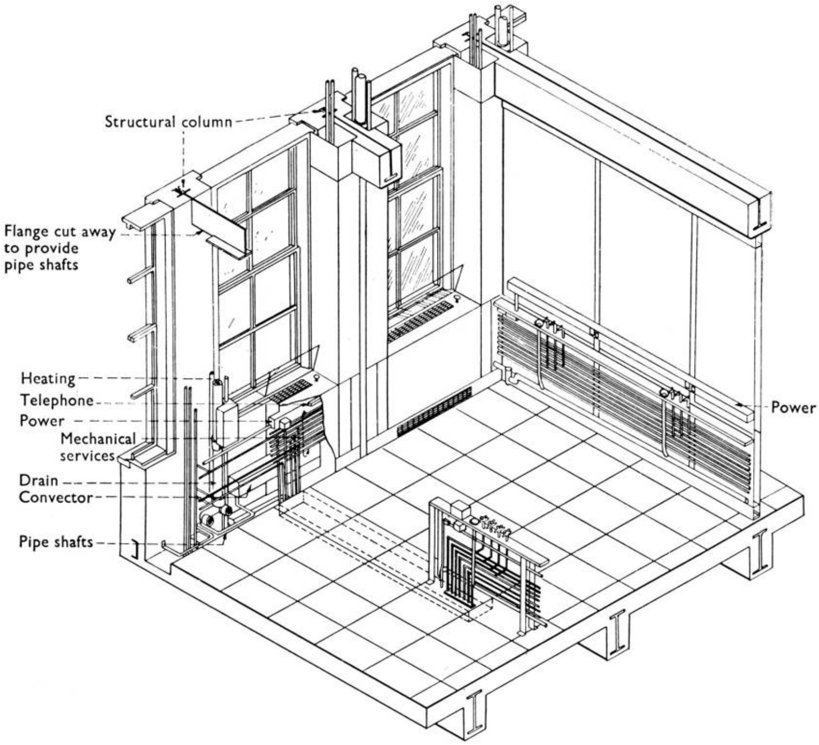


FIGURE 5. Drawing of modules at Bell Labs, showing a complete system with very little hierarchy, as it might be evaluated by an actual researcher. "Structural Column," "Heating," and "Telephone" are all called out on equal terms. For clarity, this version from Nuffield Foundation, *The Design of Research Laboratories* (London, 1961), p. 21; drawing originally published in the early 1940s.

mention of modularity would have been standardized construction, and the word *module* would have referred to a standardized dimensional unit. This constructional module was fundamentally a one-dimensional concept, similar to the centuries-old use of *module* or *modulus* to refer to the width of the base of a classical column. As a one-dimensional unit, this kind of module was used to provide a framework for locating the dimensions of a building. Modular coordination, as this technique was called, was part of architects' efforts since at least the First World War to rationalize the construction industry and make housing amenable to mass-production techniques. (For example, if the building-component industry could agree to cut lumber only in multiples of four inches, and architects designed using the same lengths, there would be no need for builders to custom-cut every board on site.)[23] By the 1940s, enthusiasm for constructional modules was widespread amongst builders, professional architects, and standardizers of all stripes. The French standards association (AFNOR) issued the first "*modulation*" standard in September 1942; the American Standards Association followed suit in 1945, and, by the time of a 1961 UN report on modular coordination, agreements on standardized units were in effect in thirty countries in Europe and the Americas.[24]

Despite these eminently practical ends, this kind of module was thoroughly abstract in conception. When used by working architects, the construction module would be manifest as a grid on the drafter's page, spaced in intervals of (usually) four scaled inches or ten centimeters. When drawing large-scale construction details, the drafter would simply ensure that the most important joints would line up with the lines on the paper: "the gridlines make everything fit" was the slogan of the modular detail. But the promoters of modularity stressed that the grid was not just a drafting tool; it was an invisible principle of order, permeating all space, and its orthogonal logic should be kept in mind even when drawing at small scales.[25] Even in the most practical of pamphlets and articles, the module was depicted as an all-encompassing Cartesian abstraction, relatively indifferent to scale or orientation. In figure 6, from a publication of the European Productivity Agency, the module and the grid reference only themselves; whether the module be ten centimeters, four inches, or five miles, the system is the same.

In contrast to the space of the infinite grid, conceptually empty and subdivided into constructional quanta, the space of the laboratory module is full, complete, and additive. Walker described his module as "dimensional only through its use factors"; that is, it was not standardized based on the needs of efficient construction—or even dimensionality at all—but

23. The most prominent interwar proposal was the "modular measure" introduced by Albert Farwell Bemis in 1921; see Albert Farwell Bemis and John Burchard, *The Evolving House* . . . , 3 vols. (Cambridge, Mass., 1933–36). After his death in 1936 the Bemis Foundation created the Modular Service Association to promulgate his ideas. See also the page from *L'Almanach d'architecture moderne* (1925) reproduced in Mary McLeod, "'Architecture or Revolution': Taylorism, Technocracy, and Social Change," *Art Journal* 43 (Summer 1983): 140.

24. See Alvaro Ortega, *Modular Coordination in Low Cost Housing* (San Salvador, 1961), pp. 34–35. For more examples, see the projects presented in *Progressive Architecture* 38 (Nov. 1957), and Richard Roth, "High-Rise Down to Earth," *Progressive Architecture* 38 (June 1957): 196–200. Modularity was also used extensively for furniture and schools; see Stanley Abercrombie, "Office Supplies: Evolving Furniture for the Evolving Workplace," in *On the Job: Design and the American Office,* ed. Donald Albrecht and Chrysanthe B. Broikos (New York, 2000), pp. 81–97, and Andrew Saint, *Towards a Social Architecture: The Role of School-Building in Post-War England* (New Haven, Conn., 1987).

25. See William Demarest, "Modular Measure: The Working Tool for Modular Assembly," *Progressive Architecture* 38 (Nov. 1957): 168.

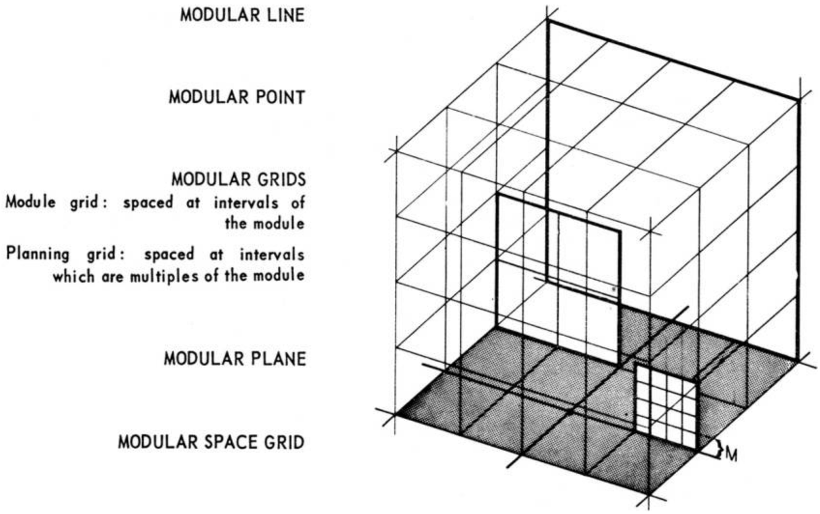


FIGURE 6. The infinitely extensive, subdividing logic of the construction module. The grid became a primary feature of space, existing as a matrix into which the building would fit. From European Productivity Agency (of the EEC), *Modular Co-ordination in Building* (Paris, 1957), p. 29.

rather around the "human needs" of the scientist.[26] As such, it was a fundamentally three-dimensional concept, a "unit of space" that Charles Haines, a later partner of Walker's, argued "must be complete in its repetition."[27] There is no such thing as a module without its full array of services, and a 12'×18' module cannot simply be resized to 8'×12' without becoming useless. The use of this kind of modularity—ubiquitous in laboratory design, but sometimes found in the planning of schools, offices, and hospitals as well—meant that, like a children's set of wooden blocks, a building would be essentially nothing but a collection of modules stacked together. Each additional module would represent an extension of a system rather than the filling-in of a preexisting system. Instead of being grid-based, the buildings that would commonly result are known by architects as "sausages": a horizontal extrusion of a basic cross-section that, like a sausage, can be cut off at any point to make a building.[28]

26. Walker, *Ralph Walker, Architect*, p. 183.

27. Charles S. Haines, "Bell Telephone Laboratories," in *Laboratory Design,* p. 336. For further articulation and evolution of the concept, see Haines, "Planning the Scientific Laboratory," *Architectural Record* 108 (July 1950): 107–23 and "Recent Trends in the Design of American Industrial Research Facilities," in *The Design of Physics Research Laboratories*, pp. 42–51.

28. *Sausage* is the popular term today; for historical use of this idea, see Walker's reference to "wienies" (Walker, "Is Modern Art Human?" *The Fly in the Amber*, p. 57). Though many of

These architectural differences reveal two different attitudes about the type of human subject that would occupy modern architecture. In the intellectual history of modernism, the abstract dimensional module is mostly remembered as part of the postwar attempts of architects like Ernst Neufert, Le Corbusier, or Ezra Ehrenkrantz to couple the benefits of standardized construction with universal dimensional systems derived from the timeless proportions of the golden section or the Fibonacci series.[29] These systems—Le Corbusier's 1948 *Modulor* and Ehrenkrantz's 1956 *Modular Number Pattern* were the best known in the United States— often made reference to human dimensions but took as their subject an idealized, unitary man (and, rarely, a woman) of exactly average height and proportions; Neufert's man was always 175 centimeters tall, Le Corbusier's was 6 feet. The use of this modern-day *homme moyen* reduced human considerations to purely physical questions of clearances and ergonomics. Architectural historian Reinhold Martin has recently argued that this attitude was tantamount to treating humans as yet another kind of modular unit; for Martin, it suggests that the postwar dimensional module was at the vanguard of a much broader human-relations-inspired false consciousness of the "individual" and his or her consumer "choice" (scare-quotes his)—the creation of a hollowed-out modular subject "always already a product of the [corporate] machine."[30] Yet the corporate laboratory module, with its architectural deemphasis of rationalization in favor of researcher-centric flexibility and researcher-scaled spatial units, suggests that the kind of subject actually posited by corporations was expressly *not* this alienated automaton. The very fact that mid-century capitalism came increasingly to rely on novelty for its survival meant that emptying out the individual's agentive core was exactly what corporate managers wanted to avoid. The architectural approach of studying and then accommodating this idiosyncratic individual in his or her fullest range, not averaging to create a standard, indicates that for the corporation

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his buildings are sausages, he uses the term here to critique the modernist megalomania of mile-long buildings.

29. See Ernst Neufert, *Bauentwurfslehre* (Berlin, 1936) and *Bauordnungslehre* (Berlin, 1961). The latter was only translated into English in 1970, the former is still untranslated. See also Le Corbusier, *The Modulor,* trans. Peter de Francia and Anna Bostock (1948; Cambridge, Mass., 1954), and Ezra D. Ehrenkrantz and John D. Kay, "Flexibility through Standardization—Part 2: The Modular Number Pattern," *Progressive Architecture* 38 (July 1957): 112–15.

30. Reinhold Martin, *The Organizational Complex: Architecture, Media, and Corporate Space* (Cambridge, Mass., 2003), pp. 5, 121. Note that Martin does not discuss architects' different attitudes towards modularity; no doubt this empirical distinction informs our respective analytic conclusions.

the needs and personality of the human at the center of the laboratory module were a priori unmasterable.[31]

These different attitudes about the human subject went hand in hand with different attitudes about efficiency and flexibility. In its alliance with rationalized building, the dimensional module represented a continuation of a long-standing interest among many architects in the social project of Taylorism. Before World War II, several prominent architects—Hannes Meyer, Grete Lihotzky, and Le Corbusier foremost among them—had argued that, just as Taylor's minute analysis of workers hauling pig-iron had led to his perfection of that process, architects should examine the processes of everyday life in order to design the scientifically optimum envelope for living or working.[32] Lihotzky's Frankfurt kitchen, for example, was designed to be the perfect architectural match for the work process of the typical German housewife, a kind of human-architectural machine ensemble. While similar to the corporate laboratory module in some respects, the mass-produced Frankfurt kitchen suggested that there was only one ideal solution to the problem of women's work, and actual housewives found it almost comically inflexible.[33] If there was flexibility in rationalized building, it tended to be what Ehrenkrantz called "flexibility through standardization": achieving the greater good of rational interchangeability through some suppression of the autonomy of both the designer and the occupant.[34] Walker, however, reserved his fiercest vitriol for exactly this

31. Note that constructional and human modularity could often be conjoined in built projects (especially those of SOM or Saarinen), but specialists in laboratory planning only wrote about modularity in human terms. The gridlike organization and industrial standardization of some labs—some even using Le Corbusier's Modulor—received little notice, and design guides recommended sausages.

32. See CIAM, *Die Wohnung für das Existenzminimum* (Stuttgart, 1933) for perhaps the best expression of this ideal. See also K. Michael Hays, "Diagramming the New World, or Hannes Meyer's 'Scientization' of Architecture," in *The Architecture of Science,* ed. Peter Galison and Emily Thompson (Cambridge, Mass., 1990), pp. 233–52, and McLeod, "'Architecture or Revolution.'" For larger cultural alliances, see Galison, "Aufbau / Bauhaus: Logical Positivism and Architectural Modernism," *Critical Inquiry* 16 (Summer 1990): 709–52 and "Constructing Modernism: The Cultural Location of *Aufbau*," in *Origins of Logical Empiricism,* ed. Ronald N. Giere and Alan W. Richardson (Minneapolis, 1996), pp. 17–44; Hays, *Modernism and the Posthumanist Subject: The Architecture of Hannes Meyer and Ludwig Hilberseimer* (Cambridge, Mass., 1992); and James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven, Conn., 1998), pp. 103–46.

33. See Leif Jerram, "Kitchen Sink Dramas: Women, Modernity, and Space in Weimar Germany," *Cultural Geographies* 13 (Oct. 2006): 538–56.

34. See, for example, the emphasis on "discipline" in "Office Buildings: Fenestration," *Architectural Record* 177 (Apr. 1955): 198–216, and the "designer's social task" in Nordic Committee on Building Regulation, *Scandinavian Modular Coordination in Building* (Copenhagen, 1960), p. 9.

kind of thinking. He was especially harsh on the "huckster" Le Corbusier,[35] who "exalt[ed] the machine over humanity" and considered individuals only in the abstract, not "in their own expressed opinions."[36] For Walker, approaching social problems through constructional efficiency could only lead to the worker being "a tenant in the servile mass," dwelling in "insect hives."[37] Corporate architecture has often been critiqued for its alleged abdication of the social ambitions of high modernism, but, as Walker and his clients made clear, the corporation did not lack a social consciousness; it simply saw radical technocracy as a stifling and self-defeating strategy.

Looking at the hundreds of nearly identical floor plans of corporate labs built in the 1950s and 1960s, there seems to be a paradox at the heart of laboratory design, one concerning precisely this relationship between flexibility and the human subject. Planning for an uncertain future and attending to the researcher's needs produced buildings that can seem quite inhuman in their use of monotonous, repetitive modules. Conversely, Taylorist-inspired design seems attuned to local specificity, as the lesson of modernism for many architects was to match a building to its contents in an organic, symmetric relationship. But the actual relationship between human and building is the opposite. For Le Corbusier and Ehrenkrantz, the problem of modern architecture was finding the socially optimal balance between individual autonomy and the rational (repressive) logic of the machine age. As Le Corbusier argued from the 1920s through the end of his life, the architect's role was that of an enforcer: "We must create the mass-production spirit. The spirit of constructing mass-production houses. The spirit of living in mass-production houses."[38] For Walker and his corporate colleagues, the problem was entirely different. Instead of seeing architecture as a coercive force, they understood it as a tool for moderating morale and provoking creativity. The rationality of the laboratory module was not about immediate constructional efficiency but long-term human efficacy. Consider the somewhat arbitrary examples in figures 7 and 8, a spring factory and an industrial laboratory published side by side in *Architectural Record* and praised equally for their flexibility. Whatever their immediate visual impact, the gridlike spring factory ultimately argues that the manufacturing process, including its human aspects, can be fully understood and mapped directly onto a floor plan (the

35. Walker, "L'Unite: The Housing of Man," *The Fly in the Amber*, p. 81.

36. Walker, "Is There a Future?" *The Fly in the Amber*, pp. 34, 78.

37. Ibid., pp. 59, 41.

38. This quote is best known from his *Vers une architecture* (Paris, 1923); trans. Frederick Etchells under the title *Towards a New Architecture* (New York, 1927), p. 6. But the same text had appeared a few years earlier in Le Corbusier's revue, *L'Ésprit Nouveau*.

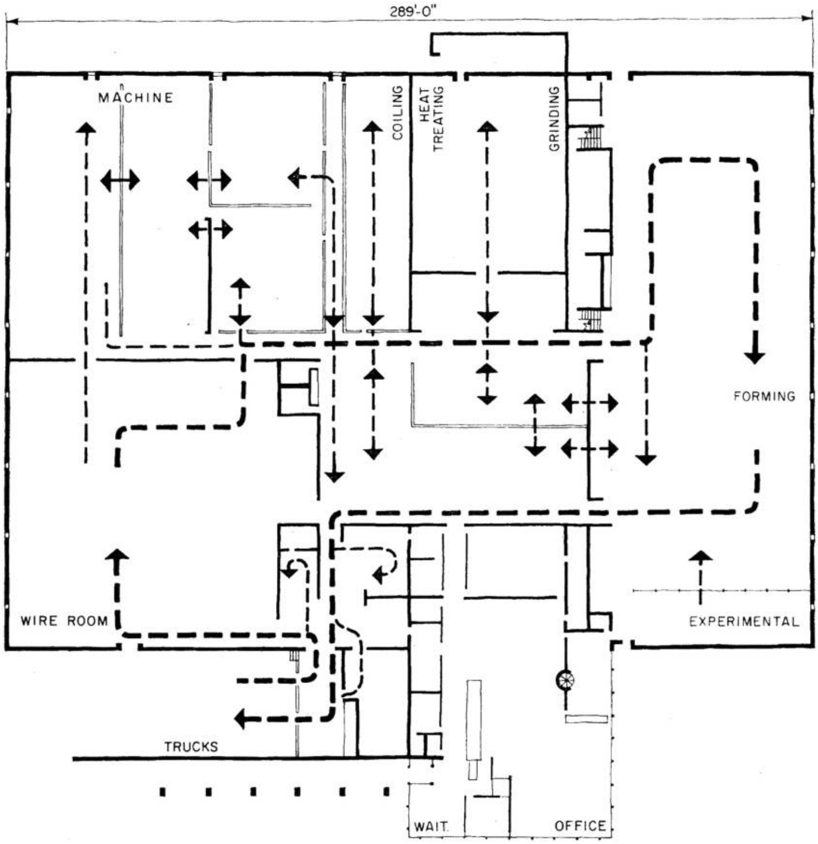

FIGURE 7. Plan of Connecticut Spring Corporation in Farmington, Connecticut, designed by Walter Green. The process of spring manufacture is inscribed into the plan, as the flow of material from the loading dock in the lower left, through the building, and back to the loading dock, is shown with dashed arrows. This is a design for a building-sized machine. From William B. Foxhall, "Industrial Buildings," *Architectural Record* 130 (Nov. 1961): 181.

arrows show the flow of material through the plant), while the sausagelike laboratory suggests that the process of research can never be fully understood and that the best that architecture can offer is an adaptable infrastructure, a series of well-equipped boxes.

The Site as a Definition: Management, Geography, and a "Campus" for Industry

Postwar corporate laboratories were almost always located outside the city and removed from both the company's headquarters and its production facilities. In addition to pragmatic decisions about avoiding urban

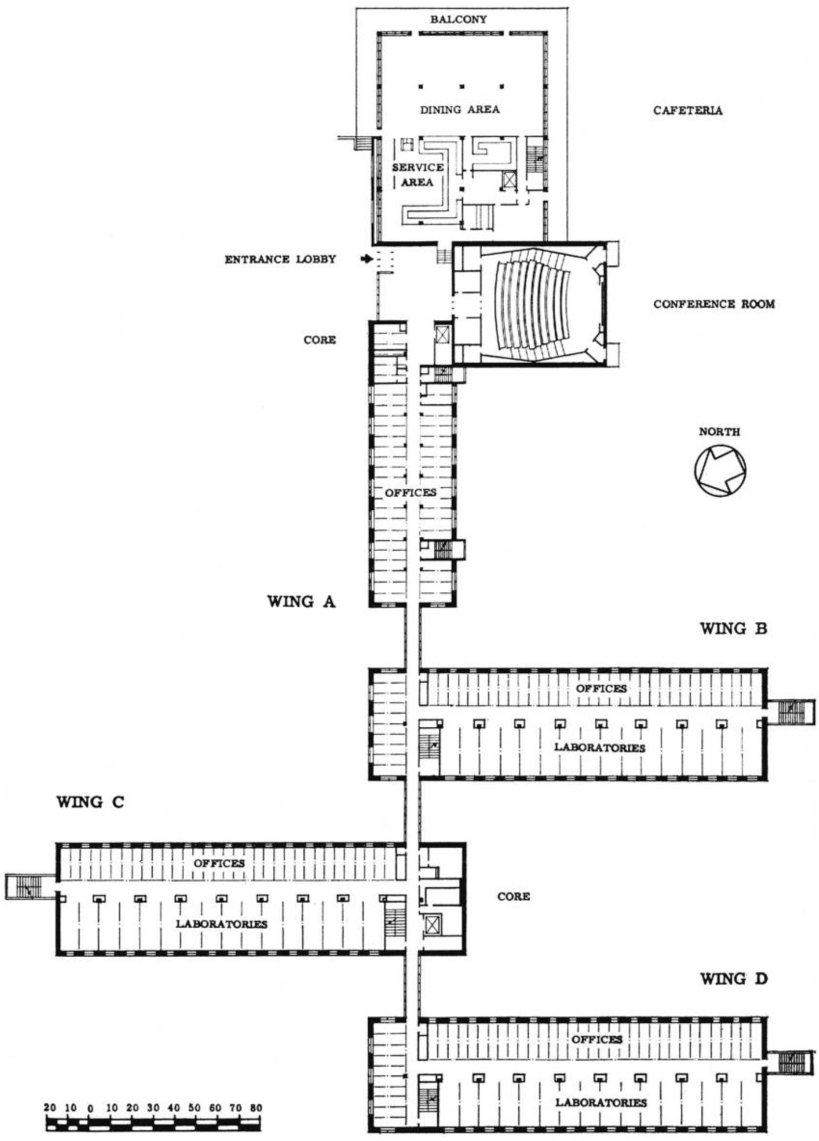

FIGURE 8. Koppers Company Research Center in Monroeville, Pennsylvania, designed by Voorhees, Walker, Smith, Smith, and Haines (successor to VWFS). Wings of office and laboratory modules seem almost maniacally repetitive, but note that the lines between modules are dashed, showing a flexible system instead of any predefined arrangement; not even doors are indicated. Just as the spring factory is a diagram of a machine process, this plan is a diagram of an organizational system for negotiating between the individual and the collective. From Foxhall, "Industrial Buildings," p. 179.

noise, vibrations, or electromagnetic interference, freedom from the city and from other divisions of the company was also important for establishing the kind of environment necessary for recruiting new researchers and keeping morale, and research productivity, high.[39] But the geographic location and general character of a laboratory site was at the same time a proposition about the identity of corporate research itself. The problem of the site was inherently a question of definition: defining corporate research both negatively against what it was not and positively in line with what it should be. This was in part a question of location alone, as the laboratory had to be put *somewhere,* and its inevitable emplacement would be an argument about its character. Was corporate research more aligned with production than administration, or should it be equally removed from both? Just as inevitably, the design of the corporate research site would also have to grapple with design precedents in industry and academia. Scientists and managers had strong preferences for emulating an academic atmosphere, but the academic of the corporation turned out not to be the same as the academic of the academy, neither in terms of spatial form nor social organization. And even though the corporate version of "academic" inverted many of the defining characteristics of academic planning, it was ultimately seen as better suited to the pursuit of knowledge. These two questions—location and character—drove discussion of the site and together reinforced the positive project of the module. Just as the module's focus on the researcher as an ever-shifting empirical problem replaced a dichotomy of freedom and control with a psychological emphasis on morale, the corporate campus problematized the duality of university and factory by creating a fully suburban typology.

Research managers were explicit in counseling that the choice of a site should not just be a question of cost, serviceability, and comfort; it could

39. Isolation could be used to protect the research apparatus from interference, to protect neighbors from accidents, or to provide a safe place in case of nuclear war (many government labs received relocation funding as part of Truman's urban dispersion program). Several economic factors were also important, as managers would try to balance the cost of land with the cost of development (usually inversely related), and proximity to suburban knowledge workers' homes with the difficulties of providing transport for the mostly urban clerical and service staff. See, for example, F. M. Lea, "Buildings: What Is Required," *The Builder,* 5 Oct. 1956, p. 589; "Medical Research Building," *Architectural Forum* (June 1950): 106; Walker, "Location and General Design Features," in *Laboratory Design*, pp. 139–48; Beyvl, "Role of the Architect-Engineer"; Haines, "The Technique of Organizing for Planning and Construction," in *Laboratory Planning for Chemistry and Chemical Engineering,* ed. Harry F. Lewis (New York, 1962), pp. 2–12; and W. R. Ferguson, *Practical Laboratory Planning* (New York, 1973), pp. 4–6. Archival sources from NBS suggest that these ideas routinely influenced decision making; a map was used to locate NBS personnel in preparation for the move; see "Summary of Responses," NBS.

also be a powerful management tool for inflecting the goals of research. In an influential 1948 volume on corporate research, research managers from B. F. Goodrich argued that "the prime factor in choosing a site for an industrial research laboratory is the place of the research division on the organizational chart"; the degree to which research was treated as an autonomous activity would dictate its geographic distance from other divisions.[40] In multiple surveys of research directors published in the 1940s and 1950s, however, there was almost no consensus about the ideal location for research, either organizationally or geographically. Even within the same industry, some companies would have all their research done at factory sites, while others would have their laboratory so isolated as to require an overnight trip to meet with other divisions.[41] Disagreements about isolation were essentially disagreements about whether management could ever protect researchers from the distractions and pressing problems of ongoing factory work (and whether distractions were in fact distracting). Managers who favored isolation felt it was the surest method of ensuring that the researcher's "independence of spirit" would be maintained ("L," p. 311). Detractors, however, cautioned that "geographic isolation is a poor substitute for strength and independence of research management," especially since close proximity to the rest of the company could also be a source of healthy motivation.[42] (As one chemist at the Pure Oil Company put it, "creativity is cultured by seeing needs as they develop.")[43] All managers agreed that location was an organizational question, but the complexity of the problem left most managers with only rules of thumb: a common survey response was simply that research should be located "away, but not too far away" from the rest of the company ("L," p. 313).

Several managers argued for a simple formula relating the isolation required of research to its concern with pioneering or fundamental inquiry. Should a manager feel that research and development are qualitatively similar pursuits, the laboratory and the factory should be located near each other, perhaps even sharing space. But when research is seen as a distinct activity, with different methods and aims (for the B. F. Goodrich managers, "complete freedom from the demands of the present"), it

40. Howard E. Fritz and Beach, "The Location, Design, and Construction of a Modern Research Laboratory," in *Research in Industry*, p. 309; hereafter abbreviated "L."

41. See Thomas Midgley, Jr., "The Chemist's View," *Chemical and Engineering News* 22 (Oct. 1944): 1757–58.

42. R. W. Cairns, "Selection of Laboratory Location," *Industrial and Engineering Chemistry* 39 (Apr. 1947): 440. See also Mees and Leermakers, *The Organization of Industrial Scientific Research*, p. 353.

43. Quoted in Hugh Hemmingway, "Creativity and the Physical Environment," *Research/Development* 15 (Mar. 1964): 52.

should be located away from production "in fact as well as on paper" ("L," p. 310). Further distinctions could be made between process-development research and (often scare-quoted) "pure" or "academic" research; the more pure the research, the more proximity to the white-collar environments of administrative headquarters and universities might also be advantageous. (A nearby university could be fruitful both for recruitment and for continuing "stimulation and aid" to the research staff.)[44] According to this logic, a research manager need only place research on a spectrum from pure to applied and then find a geographic relationship between the laboratory, the headquarters, and cultural facilities to match.

These various solutions, however, are perhaps less important than the problem itself. The fact that the siting of the laboratory was not obvious meant that the relationship between knowledge creation and business goals was, and would remain, up for grabs. Knowledge had no inherent logic that had to be respected; even though there was relative consensus that "fundamental" research was an inherently suburban undertaking, the overriding idea was that a manager might be able to craft the knowledge to suit the organization rather than vice versa. Moreover, research was never seen as the conceptual opposite of production but always as just one node in a multidimensional field of marketing, administration, production, universities, libraries, suburbs, and cities.

In contrast, the discussion about internal site layout and landscape design did seem to be much simpler—the nearly universal view was that a successful research complex should be campus-like or university-like in ambiance—but this apparent simplicity masks a knowledge/production negotiation quite similar to the geographical one. The campus-like admonition applied not just to the Nobel Prize-winning facilities of Bell Labs or GE but also to government research labs like the National Bureau of Standards (NBS) and the building-component manufacturer Johns-Manville, whose vice president wanted even its process-development labs to "resemble a modern college campus."[45] Details about how exactly a research site should evoke a college campus were often left vague, however. The most explicit manager might only express a preference for "slightly rolling contours" and "generous grassed areas and landscaping";[46] architects could be even more opaque, calling simply for a "generous" or "park-like" setting.[47]

44. David Bendel Hertz, *The Theory and Practice of Industrial Research* (New York, 1950), p. 295. This view is also expressed in Cairns, "Selection of Laboratory Location."

45. Rassweiler, "The Johns-Manville Research Center Six Years Later," p. 224.

46. R. C. de Wahl, "Selection of the Site," in *Laboratory Planning for Chemistry and Chemical Engineering,* p. 14.

47. Walker, "Location and General Design Features," p. 148.

Given how many hundreds of pages laboratory planners could devote to the intricacies of fume hoods and light levels, this near-silence on a topic seen as central to the success of a research site is particularly alarming. If nothing else, it suggests that the insistence on an "academic" environment should not be taken at face value but should be broken down into several related questions about the relations between industry and academia.

First, it seems clear that researchers in corporate and governmental labs did not envy the facilities of their university counterparts, and there is no sign that corporate science was anxious about competing with the academy for top talent. Although Johns-Manville was quite proud of its "campus-like" facilities, one of its research administrators was simultaneously disdainful of corporations whose designs followed "traditional collegiate patterns."[48] Likewise, even though one of the most common of scientists' suggestions for the new NBS facilities in Gaithersburg, Maryland, was that they exude "a university atmosphere" or "a campus-like arrangement,"[49] when a 1956 federal government survey asked NBS employees to rank their facilities against those of industry and academia, 42 percent felt that industry's were better, while only 12 percent thought facilities were better in the universities. A similar survey from the same year found that NBS employees looked to industry—not academia—for standards of facility security and safety.[50] By the time that corporations began building "academic" laboratories, there is little evidence that industry regarded the universities as anything but training grounds for industrial scientists. In the 1950s, when more than half of American scientists worked in industry, a company with an insufficiently enticing environment would probably not lose its staff to academic positions but to other companies that promoted a more "collegiate" atmosphere. (And in earlier decades, when many scientists did have to be convinced of the benefits of an industry job, corporate research facilities were usually housed in converted factories or farm buildings.)[51] Many managers' attitudes toward the academy resembled pity more than jealousy, and some even expressed concern that

48. Edward M. Jenkins, "Johns-Manville Research Center," in *Laboratory Design,* p. 344.

49. "Summary of Responses," p. 3, NBS.

50. See James Collins, "The Decision to Move the National Bureau of Standards: An Account and Evaluation of Management's Role in Responding to Employee Dissatisfaction," master's thesis, 1967, p. 7, box 5, group 167.3.3, NARA.

51. On prewar buildings, see Mees and Leermakers, *The Organization of Industrial Scientific Research*, p. 352. On prewar recruitment, see George Wise, *Willis R. Whitney, General Electric, and the Origins of U.S. Industrial Research* (New York, 1985), and David A. Hounshell, "The Evolution of Industrial Research in the United States," in *Engines of Innovation: U.S. Industrial Research at the End of an Era,* ed. Richard S. Rosenbloom and William J. Spencer (Boston, 1996), pp. 13–85.

the desirability of corporate jobs would leave no qualified teachers to train the next generation.[52]

Second, neither managers nor architects looked to the academy for design ideas, and the actual layout of a corporate research "campus" almost never followed established principles of college campus design. From the beginning of the twentieth century until the postwar university boom, almost all universities were organized either around the intersecting monumental axes of the Beaux Arts tradition or around a neo-Oxbridge quadrangle. (UC Berkeley is perhaps the best-known example of the former, Princeton of the latter.) And with the notable exception of MIT, all university campuses were composed of separate buildings, individually designed for specific disciplines.[53] Corporate campuses, however, were designed for functional, rather than intellectual, separation. The research labs were almost always housed in one huge building placed centrally on the site, surrounded by support buildings, hazardous facilities, and parking. In the cases where one building was thought to be too large to be practical, a central research area would be treated in the same way, unbroken by quadrangles or axes.[54] Corporate campuses thus effectively reversed the traditional figure/ground relationship of academic campus planning. University campuses tended to look in on themselves, and their collection of buildings defined and gave primacy to an outdoor space crisscrossed by walkways (indeed, the word *campus* originally referred to only this enclosed green space). Corporate sites, in contrast, emphasized the lab itself as a figure in a neutral field, which then looked out onto the world. The landscape was the source of a pleasant view, but researchers spent their day inside, in the designed spaces of the laboratories, conference rooms, or cafeteria. So even though corporate and academic planners shared certain Olmstedian ideas about the moral uplift of picturesque landscape design, their social understanding of inside and outside were exactly opposite. At

52. For this view, see Midgley, "The Chemist's View"; Clyde Adams, "University or College Laboratory," *Industrial and Engineering Chemistry* 39 (Apr. 1947): 457–61; and Machlup, "Can There Be Too Much Research?" *Science*, 28 Nov. 1958, pp. 1320–25. For a more comprehensive view of industry/academy relations, see Steven Shapin, "Who Is the Industrial Scientist?" in *The Science-Industry Nexus: History, Policy, Implications,* ed. Karl Grandin, Nina Wormbs, and Sven Widmalm (Sagamore Beach, Mass., 2004) and *The Scientific Life: A Moral History of a Late Modern Vocation* (Chicago, 2008).

53. See Paul Venable Turner, *Campus: An American Planning Tradition* (Cambridge, Mass., 1984). On the peculiarities of MIT, see Mark Jarzombek, *Designing MIT: Bosworth's New Tech* (Boston, 2004).

54. The truly campus-like layouts of the GM Technical Center and the Johns-Manville research station, both from the late 1940s, are the only real exceptions I have found. For a helpful but ahistorical classification of corporate campus typologies, see Peter G. Rowe, *Making a Middle Landscape* (Cambridge, Mass., 1991), pp. 149–83.

the university, the quad was the social space that connected disparate disciplines; in the corporation, professional and social spaces overlapped in one continuous indoor space.

Laboratory planners were hardly blind to this difference and often considered the question of centralized management and centralized building as two aspects of the same problem. Flexibility was again key; the architect Perry Smith (of VWFS) advised bluntly that "the maximum facility for change and growth exists where both organization and building are consolidated." Even when a research unit was organized into separate departments, a single building had many advantages, not just for economy and flexibility but because "contiguity of groups can be multiple, horizontal, and vertical."[55] The main concern of managers was explicitly to combat one of the distinguishing features of the university: the feeling of intellectual seclusion that came from departmental "ownership" of space. The research director of Bell Labs cited this as one of the main advantages of the Murray Hill project, and the NBS planning committee used a similar logic when deliberating between separate or connected structures.[56] Indeed, the design of the new NBS labs show just how conscious this radical rejection of academic planning was, since the bureau moved to its centralized modernist campus in suburban Gaithersburg from a much more typically academic campus arrangement in Washington, D.C. Their old site was dotted by over one hundred separate structures and included several quad-like spaces, but the twelve NBS divisions were spread throughout too many buildings, fragmenting research teams. The Gaithersburg design consolidated the divisions, provided them identical accommodations in flexible modular labs, and connected them to the cafeteria, library, and administrative offices with enclosed walkways. The resulting outdoor spaces enclosed by the separate wings were not even immediately accessible (compare figs. 9 and 10). But, despite this drastic change in their architectural/managerial environment (that also included the introduction of a new antidisciplinary layer of management structure), a postmove study concluded that both scientists and managers were very satisfied with the new facilities.[57]

This raises a third question: if managers and scientists universally

55. Perry Coke Smith, "Design of Facilities for Research," *Industrial and Engineering Chemistry* 39 (Apr. 1947): 445–46.

56. See Mees and Leermakers, *The Organization of Industrial Scientific Research*, p. 243; Knowles and Leslie, "'Industrial Versailles,'" p. 19; and "First Report of Laboratory Planning Committee," 6 Sept. 1957, pp. 1–2, folder 1957, box 5, group 167.3.3, NARA.

57. Collins, "The Decision to Move the National Bureau of Standards," reported very little scientist dissatisfaction, despite premove reservation on the part of many senior researchers. For interdisciplinary management, see James Schooley, *Responding to National Needs: The*

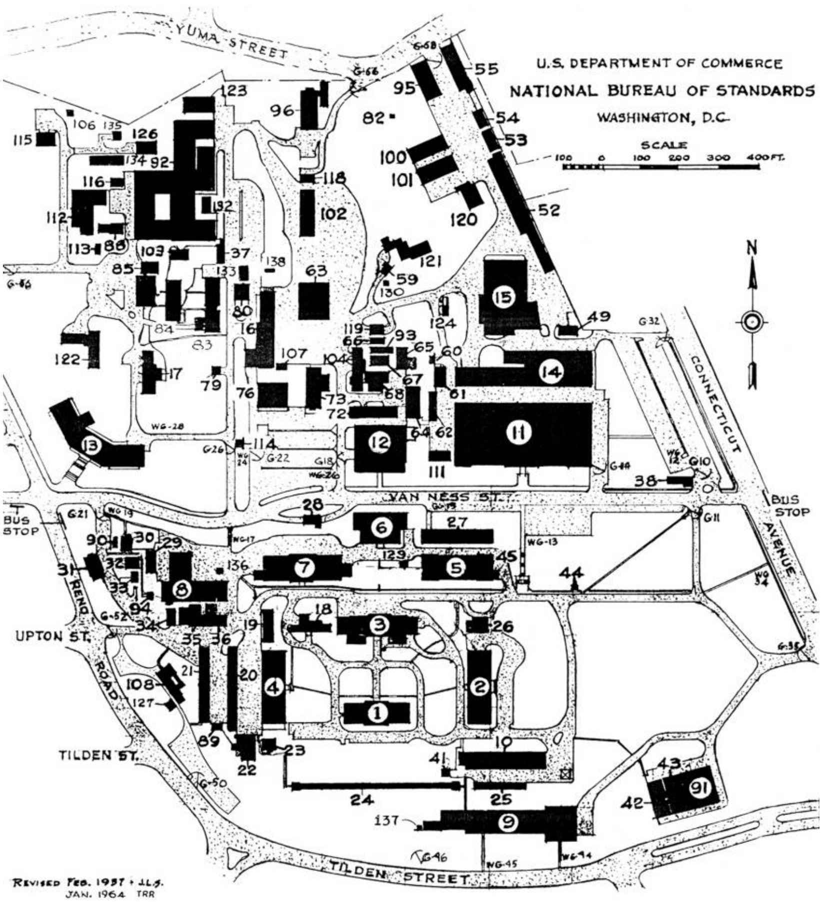

FIGURE 9. Site plan of the National Bureau of Standards facilities in Washington, D.C., just before the move to suburban Maryland. Although not ideal for the rational organization of the Bureau's twelve divisions, the site was quite collegiate in character; a large number of buildings unified by shared open spaces, historical styles, and trees throughout. From "Gaithersburg Relocation" folder, Jan. 1964, NBS.

wanted campus-like facilities but designed—and were satisfied with—nonacademic forms, what did they mean by *academic*? Some pundits simply made light of the emphasis on comfort over scholarship, suggesting that *campus-like* was simply a synonym for *park-like*, even *country club*, surroundings. One commentator writing in 1962 suggested, tongue in

National Bureau of Standards Becomes the National Institute of Standards and Technology, 1969–1993 (Gaithersburg, Md., 2000), pp. 51–52.

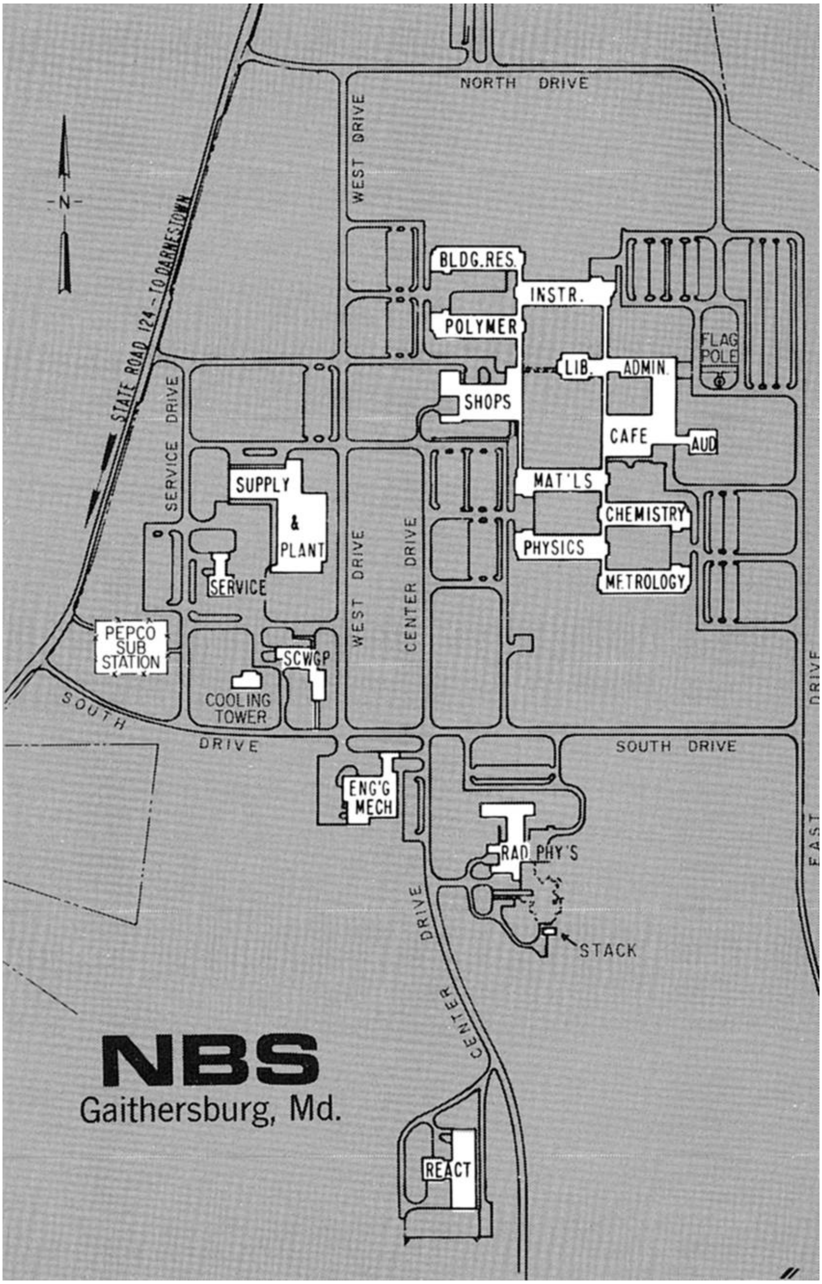

FIGURE 10. Site plan of the NBS facilities in Gaithersburg, Maryland, Voorhees, Walker, Smith, Smith, and Haines; design begun 1956, opened 1966. The large continuous structure in the upper right is the main laboratory complex (three-story labs and a twelve-story administration tower, all connected with walkways); the other buildings are support buildings and a nuclear reactor. The lab complex dominates the open site, looking out onto the parking lots and trees beyond instead of creating enclosed outdoor spaces. From *Technical News Bulletin of the National Bureau of Standards* 50 (Nov. 1966): 203.

cheek, that the corporate campus should emulate "not an old crowded campus, like Harvard or MIT, but a grassy, new campus, like Florida State or Miami."[58] But more common was a description of the campus through lists of pleasant adjectives and desirable social values. A 1958 memo by an NBS administrator titled "Meaning of 'Campus-Like'" tried to give a comprehensive definition in ten bullet points:

> 1. Notion of purposeful though leisurely dedication of structures to learning, growth, and training.
> 2. Attitude of convenience without pure functionalism.
> 3. Buildings that blend with each other—not necessarily with the landscape.
> 4. Place where learning and study are encouraged for their own sake.
> 5. Notion of complete freedom for visitors.
> 6. Place of eminent people and institutional prestige.
> 7. Attractive open spaces around the buildings or building which may be used for the leisurely exchange of information.
> 8. Structures which have some heritage from ancient institutions of learning.
> 9. Non-factory like.
> 10. Library an important part.[59]

Note that this list does not necessarily describe a university campus; complete freedom for visitors and harmony of architectural style are hardly typical in academic settings, and only a very few universities are known for their eminence and prestige. Instead of seeing this list as a misreading of the academy, however, or even as a fanciful description of an ideal university, it is perhaps better understood as an argument about the kind of environment that would best facilitate high-quality science. On the whole, it is a place of freedom and convenience that seems more dedicated to study than even the largest research universities. The "academic" of the corporate laboratory was thus nothing more (and nothing less) than an argument about the primacy of knowledge creation over all else.

The polysemy of the corporate "academic" ideal has gone largely unnoticed by those analysts of corporate science who have critiqued mid-century industrial research for its implicit embrace of the so-called linear model of "pure" science (or "basic research") leading to "applied" devel-

58. David Allison, "Places for Research," *International Science and Technology* 1 (Sept. 1962): 28.

59. Henry Birnbaum, "Meaning of 'Campus-Like,'" 5 Aug 1958, folder "1958," box 5, group 167.3.3, NARA.

opment. To these critics, the linear model reinforces the (demonstrably false) idea that knowledge is only created in the university, and many lament the fact that corporate science was apparently in the conceptual thrall of the academy. Analyzing both the rhetoric and the spatial form of corporate research, however, gives a different impression. True, the more a company separated research from development, the more likely it was to treat research as something that should be conducted in isolation, removed from the day-to-day cares of the world, and best conducted in an "academic" atmosphere. But it is also true that a greater focus on this kind of research meant that a company was more likely to house their staff in a large modular building dominating its generous site.[60] In other words, the companies that most embraced the "pure research" model were also the ones that most subverted the actual spatial organization of university campuses in favor of labs that were designed to balance the (modular) needs of the individual researcher with a management preference for centralization. So even though many—though certainly not all—research managers expressed allegiance to a linear model of innovation, their laboratories reveal that their model of pure research was more collaborative and management-intensive—that is, less "pure"—than might be suggested solely by the insistence on "academic" surroundings.

How, then, did the laboratory define corporate research? Here I would suggest that the suburbanism of the campus be taken quite seriously as a marker for corporate science as a whole. Consider the homology between the various artifacts of suburbia. The laboratory module, the single-family house, and the automobile all renegotiated the relationship between the individual and the collective, giving individual choice an important structural position that was not simply the antithesis of social control. The agency of the corporate researcher is remarkably similar to the agency of the consumer; it is simply its productive counterpart. And like the relationship between the detached house or the car and the earlier city/country duality, the strategy of the corporate lab was not to find any ideal balance between opposites—autonomy and restraint, isolation and proximity, knowledge and production, university and factory—but to introduce new categories that would override these terms: morale, interaction, knowledge production, research campus. In short, the suburbanization of science was not simply a move of science to the suburbs but involved the creation of new subject-positions and a fundamental recentering of

60. A 1952 survey of research directors found that those research departments situated "some distance" from the rest of the company tended to be "giant" both in size and in number of personnel (Anthony, *Management Controls in Industrial Research Organizations*, pp. 86, 88).

knowledge from a discourse of truth to one of production and consumption. Just as the module and the geographic location and internal organization of the site posited research as but one part of larger organizational structures, science itself was made to be just one node in a larger economy of creativity, where research, marketing, and consumer demand each influenced the others, with no clear hierarchy. This economy was horizontal in content as well; the psychology of the module and the sleight of hand of the academic label were no less (or more) genuine than the consumer psychology of ever-expansible needs or the commodification of personal identity.

The Generalization of the Corporate Ideal

Understanding the corporate laboratory has importance beyond recapturing the goals of mid-century scientists, managers, and architects, as the epistemology of knowledge production posited by the laboratory has become the general template for both knowledge and production. I mean this is two senses. First, the design principles of the corporate laboratory have been adopted so universally that nearly all lab space is built to the corporate ideal, a flexible container for an inherently social activity, where change is rapid and disciplinary boundaries respected only in their crossing. Second, and more profoundly, the arguments that the corporate lab made—about the knowledge worker as knowable but not controllable and about the productivity of a tense relationship among research, production, and administration—no longer seem controversial. Even though the corporate laboratory might easily be seen as the greatest monument to the linear model of pure research leading to applied development, it was also one of the first indications that this opposition would soon be rendered obsolete.

The transfer of flexible, modular planning to university and government contexts was almost simultaneous with the opening of Bell Labs. Even during World War II, academic physicists in the Manhattan Project expressed annoyance at their inadequate university facilities and looked to Bell Labs as a model. In late 1941 the Columbia University physicist Harold Urey tried to convince James Conant to commandeer the new Murray Hill building as a centralized laboratory for bomb work; when that failed, he suggested hiring Bell Labs's head laboratory planner to oversee planning at the secret Oak Ridge site.[61] Prominent universities' war-research facilities were also built with modular principles; VWFS was employed to renovate

61. See Harold Urey, letter to James Conant, 27 Dec. 1941; Jewett, letter to Urey, 31 Dec. 1941; Jewett, letter to Vannevar Bush, 31 Dec. 1941; and Urey, letter to Conant, 16 Oct. 1942, entries 209, 229, roll 12, Bush-Conant file, NARA microfilm.

buildings at Columbia for atomic research, and the modular Rad Lab building at MIT was designed for flexible postwar conversion. After the war, academics writing in laboratory planning books consistently looked to industry. One chemistry professor acting as a laboratory consultant praised "the high [design] standards expected and demanded by industry" on several occasions and found almost all the academic facilities he visited "wholly inadequate."[62] By the mid-1950s, not only were leading industry architects being universally hired by the academy and by government (notably SOM), but nearly all university laboratories designed by staff architects used a modular approach. The most prominent academic scientists tended to be even more forceful in their rejection of academic precedents, with physicists like Luis Alvarez or Charles Stark Draper embracing exactly the factory-like structures that corporate scientists saw as insufficiently academic.[63]

Although the academy, in contrast to the pattern in the corporate world, tended to adopt the module before any new ideas of site planning, by the 1960s new academic laboratories had begun to compromise universities' Beaux Arts or neomedieval master plans as well. The influential 1963 book *Campus Planning*—a three-hundred-page manifesto for a "new approach" in academic design—advocated the use of a remarkably corporate, humancentric "planning module" for making even the largest-scale planning decisions.[64] Two years later, a prominent English campus architect summed up the change, writing that "there is now some general agreement that, in considering the science areas of universities, we are no longer considering separate buildings but a general principle or system of layout in which individual departments and faculties form part of a larger concept."[65] This "larger concept" tended to produce the kind of centralized multidisciplinary buildings favored by industrial labs, both in Britain and the United States.[66] So not only was the academic atmosphere sought by industry not really academic, the academy was quickly becoming altogether unacademic as well.

These material changes, however, were only the outward signs of the larger reorganization of knowledge into knowledge production in the

62. Adams, "University or College Laboratory," p. 457. See also Adams, "Interior Arrangements," in *Laboratory Design*, pp. 80–88.

63. For Alvarez, see Galison and Jones, "Factory, Laboratory, Studio: Dispersing Sites of Production," in *The Architecture of Science*, pp. 497–540, and Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago, 1997), pp. 239–311. For Draper, see Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York, 1993), pp. 90–100.

64. Richard P. Dober, *Campus Planning* (New York, 1963), p. 61.

65. Leslie Martin, quoted in Jonathan Barnett, "Laboratory Buildings: The Architecture of the Unpredictable," *Architectural Record* 139 (Nov. 1965): 175.

66. See the buildings in *Architectural Record* (Nov. 1965), and James Mellow, "The Multidiscipline Laboratory," *Industrial Design* 13 (Mar. 1966): 40–43.

years after Machlup and Drucker's books. The fact that the familiar clichés about the volatile flows of the information economy, the perpetual becoming-obsolete of today's knowledge workers (and we are all knowledge workers), or the rise of a consumer model of education are in fact clichés should only underscore how naturalized the link between knowledge and production has become. If the category error of the early twentieth century was the linking of knowledge and production—the radicality of which was preserved in the idea that research was nevertheless applied to development—the category error now is exactly this idea of application. Today seeing technology as applied science (or anything as the application of anything else) is not simply unfashionable; it is semantically incorrect.

The larger lesson of the corporate laboratory concerns exactly this question of the place of knowledge in twentieth-century capitalism. For many observers of the cultural impact of the modern corporation—from cultural pessimists like William Whyte or Reinhold Martin to such neo-Marxists as Harry Braverman or David Noble—the logic of capital is a repressive juggernaut, the inevitable deskilling and will-to-control of the rational factory writ large. But even monopoly capitalism relied on relatively autonomous subjects to produce novelty, and the creativity and intellectual freedom of these subjects was the explicit goal of management, not a hard-won compromise between power-hungry capitalists and disgruntled scientists. However one might critique knowledge capitalism, it is difficult to characterize it as dominating through the imposition of control on otherwise free subjects, at least without resorting to unhelpful ideas of widespread false consciousness or conspiracies without identifiable agents. Instead, the laboratory's push for a win-win relationship between research workers and managers (or between the research division and the exigencies of production) suggests that knowledge capitalism is not based around these kinds of dichotomies at all. The strategies used to organize corporate research, both architecturally and managerially, did not coopt a more natural form of science; they were the very means by which scientific research was understood and made legible to scientists and managers alike.[67]

In other words, knowledge and capitalism are not unchanging categories that came together only imperfectly; rather, the epistemology of corporate research realized by the modernist laboratory—where knowledge is a product, but one produced in an entirely different way from manufactured goods—requires a reconsideration of both the nature of knowledge and the nature of the corporation.

67. Compare corporate science management to the organizational changes in the academy during and after World War II, in Galison, *Image and Logic.* See also Shapin, *The Scientific Life.*