For Frances
A Geography of Science?

Scientific knowledge is made in a lot of different places. Does it matter where? Can the location of scientific endeavor make any difference to the conduct of science? And even more important, can it affect the content of science? In my view the answer to these questions is yes.

The suggestion that science has a geography goes against the grain. We can readily understand that there is a philosophy of science and a history of science, even a sociology of science. But the idea of a geography of science runs counter to our intuition. Science, we have long been told, is an enterprise untouched by local conditions. It is a universal undertaking, not a provincial practice. Of all the human projects devoted to getting at the truth of how things are, that venture we call science has surely been among the most assiduous in its efforts to transcend the parochial. It has been extraordinarily diligent in deploying mechanisms to lay aside prejudices and presuppositions and to guarantee objectivity by leaving the local behind. Credible knowledge, we assume, does not bear the marks of the provincial, and science that is local has something wrong with it. As one observer has
put it, “It was the end for cold fusion when people decided that it only happened in Salt Lake City.” Genuine science, after all, is carried on in much the same way everywhere from Boston to Beijing; experimentalists replicate each other’s results in Moscow and Melbourne; conference delegates from Paris and Prague can engage in scientific conversation.

The places where science is conducted, then, seem to be of little or no consequence. Even geographers, despite their professional stake in matters of place and location, have been inclined to exempt science from the imperatives of spatial significance. To be sure, they have acknowledged from time to time that a geography of, say, astronomy could be written. But beyond such trivial circumstances as the fact that observatories are not erected in foggy valley floors or that the Pole Star is not visible in the Southern Hemisphere, there was really nothing more to say. To suggest that the methods of astronomy, or the theories astronomers devised, might be influenced by their spatial settings was little short of absurd. Of course geographers—like everyone else—readily conceded that the diffusion of scientific discoveries and technical innovations could be charted over space and time. The paths by which a new agricultural technique or medical serum spread from its point of origin, for example, could be presented in map form. But beyond such platitudinous concessions, geography seemed to have little bearing on science.

In adopting this hands-off attitude toward science, geographers have certainly not been alone. While sociologists—for long enough—were only too happy to socialize most everything from families and fiestas to rituals and religions, they drew back from looking at science in sociological terms. Whereas religion, for example, was supposed to reflect the character of the soil in which it had grown, science generated knowledge free from the imprint of the local. To be sure, certain aspects of science did seem open to sociological analysis. When scientists went off the methodological rails, allowed political prejudices to influence their research, fudged the data, read religious meaning into their findings, or came to erroneous conclusions, such “deviations” could be, and were, explained by reference to parochial factors. A sociologist of what we might call “pathological science” was permissible. Or again, national and international patterns of funding and levels of state support for research were acknowledged as influencing the direction of scientific progress. But beyond either the deviant or the fiscal, there was little to say about how local circumstances might bear on the scientific enterprise. It seemed that any more comprehensive effort to situate science in the places of its making would be taken as an assault on the integrity and authenticity of scientific knowing. Indeed, the modern invention of the laboratory can be interpreted as a conscious effort to create a “placeless” place to do science, a universal site where the influence of locality is eliminated. Securing credibility and achieving objectivity required “placelessness,” and the triumph of the laboratory as the site par excellence of scientific plausibility since the middle of the nineteenth century bears witness to this prevailing conviction.

This book questions such assumptions. While monumental efforts have gone into constructing “placeless places” for the pursuit of science, spaces that aspire to ubiquity, I believe there are questions of fundamental importance to be asked about all the spaces of scientific inquiry. What excites my interest, therefore, is the attempt to determine the significance for science of the sites where experiments are conducted, the places where knowledge is generated, the localities where investigation is carried out. The range of spatial questions we might pose is considerable. Does the space where scientific inquiry is engaged, for example, have any bearing on whether a claim is accepted or rejected? What weight is to be attached to the locations where scientific theories are encountered? In what ways has the circulation of ideas been dependent on the replication of instruments and the standardizing of methods? What strategies have been devised to acquire knowledge of things far away from direct observation? My suspicion is that along the spectrum of scales from particular sites through regional settings to national environments, the “where?” of scientific activity matters a good deal.

In anticipation of what is to follow, an illustration or two of how places matter in scientific enterprises will help to show why it is valu-
able to think geographically about science. During the first year of its existence in 1863, readers of Auckland’s *Southern Monthly Magazine* heard the praises of Darwin’s theory of evolution sung long and loud. Darwinism, they were assured, had shed new light on the settling of New Zealand by conclusively demonstrating how a “weak and ill-furnished race” inevitably had “to give way before one which is strong.” Here Darwinism was welcomed because it perfectly suited the needs of New Zealand imperialists. It enabled the Maori to be portrayed in the language of barbarism and thereby provided legitimacy for land-hungry colonists longing for their extinction. At the same time, things were dramatically different in the American South. Here Darwin’s theory was resisted by proponents of racial politics. Why? Because it threatened traditional beliefs about the separate creation of the different races and the idea that they had been endowed by the Creator with different capacities for cultural and intellectual excellence. For racial reasons, Darwin’s theory enjoyed markedly different fortunes in Auckland and Charleston. In these two places Darwinism meant something different. In one place it supported racial ideology; in another it imperiled it.

This case could be vastly extended, as we will later see. Darwinism meant different things in Russia and Canada; it meant different things in Belfast and Edinburgh; it meant different things in workingmen’s clubs and church halls. And much the same was true of Newton’s mechanical philosophy, of Humboldt’s global physics, and of Einstein’s theory of relativity. Their accounts were understood differently in different locations and were mobilized for different cultural and scientific purposes. Scientific theory evidently does not disperse evenly across the globe from its point of origin. As it moves it is modified; as it travels it is transformed. All this demonstrates that the meaning of scientific theories is not stable; rather, it is mobile and varies from place to place. And that meaning takes shape in response to spatial forces at every scale of analysis—from the macropolitical geography of national regions to the microsocial geography of local cultures.

Space and place can be scientifically important in other ways too.

Charles Elton’s theory of animal communities, for example, was born in a very specific place—on Bear Island in the Arctic during the early 1920s. And later his successor, Raymond Lindeman, developed Elton’s trophic scheme through his work at another particular location, Cedar Creek Bog, Minnesota. In both cases the natural places where biotic inquiries were conducted were fundamental to the scientific knowledge generated. They were isolated sites, and their natural features made it possible to restrict variables and to carry out comprehensive measuring. They required the development of a highly specific range of what have been aptly called “practices of place.” For these investigators, as for field scientists more generally, *place* was centrally implicated in everything they did. To such practitioners, the “where” of inquiry was fundamental to the practice of authentic science. Particular physical places shaped scientific theories of ecological succession, animal communities, and dune morphology.

In these ways and in many others, issues of space—location, place, site, migration, region—are at the heart of scientific endeavor. But before pursuing such cases in any further detail, it is important to reflect a little on the nature of “space” and on its role in social life more generally. Once we have grasped something of how central places are in the constitution of society, we will more easily begin to discern the inescapably spatial nature of science.

*Space Matters*

Human activities always take place somewhere. Where you live on the earth’s surface makes a difference to the life you lead. Your location, locally and globally, has much to do with the economic, social, and cultural circumstances you find yourself in. There is an uneven geographical distribution of resources, a discernible pattern of ways of life across the face of the earth, and a distinctive spatial arrangement of the planet’s physical features. Accordingly, it makes sense to speak of a regional economy, international geopolitics, a nation’s cultural landscape, the social morphology of a city, or the map of world
religions. These facets of human life have an obviously spatial dimension, and where an individual, a social group, a state, or a subcontinent is located in material space is therefore highly significant.

But we do not just inhabit material spaces. We also occupy a variety of abstract spaces, and we refer in spatial ways to the intellectual, social, and cultural arenas through which we move. People close together physically may be "miles apart" in terms of social distance or cultural space, living, as it were, in totally different worlds. So it is not surprising that we routinely resort to cartographic and other spatial metaphors: we hear of projects to map the human genome; some speak of theories as maps to enable us to find our way around; we are told that we each have our own mental map; we all try to chart our way through an argument or map out a course of action. In everyday speech it is common to find people wanting more personal space, feeling disoriented, or believing they are out of place. Both materially and metaphorically the spatial matters a great deal.

The social interactions we engage in from day to day are also crucially dependent on the shifting and overlapping spaces within which we transact the affairs of everyday life. Take the different arenas where we encounter other people. These include such diverse venues as the factory floor, the sports field, the dinner party, the dance floor, the office, the home—to name a very few. Each site provides repertoires of meaning that facilitate communication. The ways people behave and relate to each other in these various places can be radically different. Indeed, it has even been suggested that such conventional designations as the "normal" and the "bizarre" depend in important ways on setting: what passes as appropriate behavior in one place may be regarded as weird or grotesque in another.

Clearly, the signs and symbols that are meant to give meaning to human actions are spatially linked. For this reason, making sense of even the simplest gestures and behaviors requires an understanding of the "imaginative universe" in which the occupants of any particular locality dwell. Familiarity with the "local customs" of the boardroom or the library or the building site or the church is fundamental to sorting out the coded messages within which communication is embedded. To figure these out requires unpacking the implications and inferences that are fixed in local structures. The task is to make particular sense of particular rules in particular places.

If these sentiments are in the right neighborhood, it is plain that space is far from a neutral "container" in which social life is transacted. Space is not (to change the metaphor) simply the stage on which the real action takes place. Rather, it is itself constitutive of systems of human interaction. At every scale from the international to the domestic, we inhabit locations that at once enable and constrain routine social relations. These sites dictate what we can say and do in particular social circumstances and—just as important—what we can't. Every social space has a range of possible, permissible, and intelligible utterances and actions: things that can be said, done, and understood. These spaces of discursive exchange are the consequences of social relations, and they are important because they are not simply about agreement; they also define what kinds of disagreements are pertinent and can be expressed.

Since the positions we speak from are crucial to what can be spoken, there are intimate connections between what we might call "location and locution." Of course, locutionary acts can no more be reduced to locational circumstance than geography can be reduced to geometry. Social spaces facilitate and condition discursive space. They do not determine it. This is to say that ideas are produced in, and shaped by, settings. They must resonate with their environments or they could not find expression, secure agreement, or mobilize followers. But ideas must also be sufficiently "disarticulated" from their social environments to permit them to reshape the very settings they emerged from. Spaces both enable and constrain discourse.

The spaces of everyday social life, moreover, are not insulated from the vicissitudes of international exchange. The very opposite is the case. All of us, in one way or another, are implicated in global transactions. As the Irish poet Seamus Heaney puts it, "We are no longer just parishioners of the local." The circulation of goods and commodities, information and data, means that the local is persistently shaped and reshaped by distant influences and agents. In everything
from fluctuations in the international money market to the gastronomic fantasia of almost any city where Chinese take-away, Italian pizza, and American doughnuts can all be eaten within a few square yards, the “nearby” is continuously transfigured by the “faraway.” Compared with past times, of course, the pace of these processes has dramatically quickened. With such modern technologies as the telephone, the Internet, and telecommunication systems more generally, contacts between “here” and “there” are virtually instantaneous. Space has been collapsed by time. The world has, as it were, shrunk from the time when the fastest mode of transportation was the horse-drawn carriage to the era of the passenger jet. The shifting tempo and changing rhythms of this “chronogeography” have dramatically changed our world, and they point to the immense significance of commodity flows, circuits of information, and the changing relations between the present and the absent. Spaces are therefore neither static nor stable; they are mobile and mutable.

But traffic in commerce and commodity is not the only way such transformations are effected. Economic sanctions, international conflicts, and military engagements are continually reshaping the world’s political map. And to that degree, at least, none of us is completely free from what has been called “the struggle over geography.” That struggle, moreover, is not simply to do with armies and ammunition; it also has to do with ideas and images. How we imagine distant people and places, and how we choose to represent them to ourselves and to others, is of immense moral and political significance. Imagined geographies have real consequences.

This has long been the case. Consider Europe’s rendezvous with the New World a half a millennium ago. The fabulous anthropology and mythic ecology of the Americas evoked in sixteenth-century European minds a space at once exotic and repulsive, alluring and threatening (fig. 1). The “new” realm’s peoples and lands were routinely cast in the language of inferiority and barbarity, and often in the categories of those “monstrous races” long resident in European travel accounts. As a result, the Columbian encounter between the Old World and the New was at once a moral, an economic, and a scientific event. Much of the early history of this transatlantic engagement depended on Europe’s geographical fantasies about the Western Hemisphere.

Nor were the Americas unique in this respect. The construction of the South Pacific as a coherent geographical entity in the eighteenth century and the designation “darkest Africa” during the Victorian era invite similar scrutiny. In both cases science and civilization
conspired to bring these regional labels into currency. In the former case, the voyages of men like James Cook brought that realm cartographically, anthropologically, botanically, zoologically, and geologically within the bounds of European science. In the latter, exploration and evangelism alike contributed to the flourishing of an iconography of lightness and darkness that darkened Africa’s image even as its explorers sought to flood the continent with light.

What is striking about these representations is the complicity of scientific endeavor in their propagation. The emergence of “the Orient” as a geographical region, and of the “Oriental” as a racial category, for example, was largely a product of science zealously persecuted during and after the European Enlightenment. Through the work of geologists, engineers, anthropologists, surveyors, cartographers, and many others, Europe sought to take the measure of these newly occupied spaces. The Orient was the outcome of a cultural as well as a military intrusion, a scientific as well as a religious crusade. It was a fact-fiction fusion that set off “the East” as the alter ego of “the West.” In turn, this imagined space became the locus of scholarly attention and found itself exhibited as Europe’s exotic “other.” On paper and canvas, in museums and exhibitions, through spectacles and snapshots, legendary geographies of the “Orient” were presented to the eyes of European witnesses (fig. 2).

All these endeavors reveal, to one degree or another, the power of place. At the world scale, the capacity to represent global regions—and thereby to construct them in human consciousness—has been fundamental to the practices of political supremacy. At the opposite end of the spectrum, very specific sites also exercise tremendous power over people. Take the hospital, the church, or the courtroom. In such spaces people are brought under the authority of medical, religious, and legal knowledge for different purposes. In these places people undergo medical diagnosis; they are told what is good and evil; they are sentenced or acquitted. In all three, they experience discipline, in one form or another, of body, mind, and spirit. For in all three there are intimate connections between the regimes of regulation that are practiced and the regimes of knowledge that govern them. To understand the history of medicine, or religion, or law, then, we must necessarily grasp the geography of medical, religious, and legal discourses. It is critically important to pay attention to those sites that have generated learning and then wielded it in different ways. At every scale, knowledge, space, and power are tightly interwoven.

Place is essential to the generation of knowledge. It is no less significant in its consumption. Ideas and images travel from place to place as they move from person to person, from culture to culture. But migration is not the same as replication. As ideas circulate, they undergo translation and transformation because people encounter representations differently in different circumstances. If theories must be un-
understood in the context of the period and place they emerge from, their reception must also be temporally and spatially situated. So if we are to appreciate something of how thoughts and theories, insights and imaginings, concepts and conjectures have changed the world, we need to be as attentive to how they are appropriated as to how they are made. And what is true of images and ideas in general is true of their scientific counterparts.

**Geographies of Science**

In what ways, then, does it make sense to speak of science as having a geography? Science is concerned with both ideas and institutions, with theories and practices, with principles and performances. All of these have spatial dimensions. Consider the laboratory as a critical site in the generation of experimental knowledge. Who manages this space? What are its boundaries? Who is allowed access? How do the findings of the laboratory’s specialist space find their way out into the public arena? Attending to the microgeography of the lab—and a host of other similar spaces such as the zoo, the botanical garden, or the museum—takes us a long way toward appreciating that matters of space are fundamentally involved at every stage in the acquisition of scientific knowledge. What is known, how knowledge is obtained, and the ways warrant is secured are all intimately bound up with the venues of science.

The geography of science also calls attention to the uneven distribution of scientific information. Not everyone has had access to the deliverances of science because there are diffusion tracks along which scientific ideas and their associated gadgetry migrate. The means and patterns of circulation, understandably, have changed dramatically over the past three hundred years or so. But the movement of science has had an impact of immense proportions. Then again, it surely makes sense to reflect on whether scientific cultures themselves display any discernible political or social topography. Can certain types of scientific inquiry be correlated with certain social classes, or with those of a particular religious persuasion, or with metropolitan or provincial cultures? To what degree was the science produced in colonies colored by the cultural politics of imperial powers? Has scientific work been used to sustain the ideology of particular groups and to promote their interests over those of others?

Asking questions of this sort does not prejudge what the answers might look like, but it does suggest that our investigations will call attention to the local, regional, and national features of science. This means that science is not to be thought of as some transcendent entity that bears no trace of the parochial or contingent. It needs, rather, to be qualified by temporal and regional adjectives. At one scale of operations, science is always an ancient Chinese, a medieval Islamic, an early modern English, a Renaissance French, a Jeffersonian American, an Enlightenment Scottish thing—or some other modifying variant. While most of my discussion will rotate around science as we think of it in the West, that should not be taken to imply that these are the only practices that warrant the name science. We must work with a less fixed conception of what science is. What passes as science is contingent on time and place; it is persistently under negotiation. This becomes clear when we ask a question like, Were Plato and Aristotle engaged in the same sort of activity as, say, Newton and Boyle or Watson and Crick? To say that they were all “doing science” doesn’t help much, for the meanings of the very terms we use change from period to period and from place to place. Even seemingly standard designations like “atom,” “gene,” and “species” have undergone transformation. And the same is true for scientific movements like “Copernicanism,” “Newtonianism,” and “Darwinism.” Science is not some preordained entity fulfilling an a priori set of necessary and sufficient conditions for its existence. Rather, it is a human enterprise, situated in time and space.

Cultivating a geography of science will disclose how scientific knowledge bears the imprint of its location. Of course, there are constraints on what scientists can reasonably say about nature and—more important—what they can do with it. They can’t just decide what to believe about reality. Scientists make science, but they do not
emerges. These range widely from the laboratory to the zoological garden, from the field to the museum, from the hospital to the public house. In each case our concern will be to ascertain the significance of these locations in the shaping of their respective scientific inquiries. And we will visit some of those hidden spaces where science is practiced in secrecy, either from fear of public protest or in clandestine explorations. The human body as a site of scientific inquiry, not only for medical research but also as itself measuring device, will also engage our interest. Throughout, we will find scientific claims that sound universal but turn out to be situated, theories that seem transcendent but are profoundly embodied. At the same time, the plurality of scientific sites bears witness to the protean nature of science. Indeed, there is much justification for suspecting that the term “science” is an imaginary unity masking the disparate kinds of activity that trade under the label. It will be wiser, therefore, to work with the assumption that in different spaces different kinds of science are practiced.

Thereafter we turn to the larger regional scale. Here we will pursue some of the ways regional cultures, provincial politics, national styles, and such have conditioned the practices and products of scientific endeavors. There was a distinctly regional pattern to the rise of scientific Europe, and our task will be to determine why certain forms of scientific activity emerged in certain regions and at certain points in time. These reflections will confirm the salience of the geographical adjectives in “English science,” “French science,” and “Russian science”; they will also demonstrate why it makes good sense to think of “the Scientific Revolution” as having a geography as well as a history. By the same token the significance of more local scales, provincial and urban, will be underscored. Just why it makes sense to speak of, say, Manchester science during the Industrial Revolution or Charleston natural history in the mid-nineteenth century will become clear. The different ways novel concepts and practices have been received in various places will also attract our interest. Spaces of resistance and indifference tell us as much about the culture of science as spaces of acceptance and appropriation. By working at the regional scale, we can begin to get a sense of how local particular-
ities shape the ways scientific theories are encountered, mobilized, or discarded.

Finally, matters of circulation will assume center stage as we ponder the significance of the movement of specimens and instruments across space and time, as we reflect on the strategies devised to glean reliable information about far-off things, and as we consider how knowledge travels from place to place. Systems of establishing trust, standardizing measurement, and disciplining observers—all key features of attempts to obliterate the cognitive distance between “here” and “there”—will necessarily command our attention. In this connection we will reflect on the use of techniques like mapping and picturing as ways of overcoming doubts about the reliability of travelers’ reports and as methods of freezing time and fixing space. We will come to appreciate how what appeared to be detached findings were actually the outcome of judgment, negotiation, and regulation. The successful circulation of scientific knowledge was, as much as anything else, about settling upon strategies to stabilize knowing-at-a-distance.

I am fully aware that these items do not exhaust the scope of what I am calling the geographies of science. My arguments are built around historical examples drawn from the period between the sixteenth century and the early twentieth. Ancient and medieval science, as well as twenty-first-century science, have their own geographical narratives that need to be told. My aim is simply to provide a suite of illustrative cases, not a comprehensive survey, of how geography matters in scientific inquiry. And my hope is that these deliberations will catch the imagination of some readers who will be encouraged to venture into the terra incognitae of scientific culture and continue the task of surveying science’s hitherto unexplored spaces.

The range of sites within which science has been practiced, in which meaning has been made and remade, and from which scientific knowledge spreads is vast. We can begin to catch something of this diversity if we conjure up a mental picture of some of the disparate places where science is conducted. When we do we are impressed with the vastly different atmospheres they exude. The claustrophobic darkness of the alchemist’s workshop with its roaring furnace and smelly stills (fig. 3) stands in marked contrast to the clinical brightness and flickering screens of the modern medical technology laboratory. The wide-open, airy spaces of the field (fig. 4) contrast sharply with the stuffy alcoves of the archive and stuffed displays of the museum (fig. 5). The controlled exhibits of the botanical and zoological gardens are very different from the diagnostic spaces of the hospital or the asylum. Even to express things this way, of course, is to run the risk of caricature. Laboratories, gardens, museums, observatories, hospitals, and so on all come in a wide variety of shapes, sizes, and configurations. But these stereotypes do have sufficient imaginative currency to convey something of the range of sensory experiences that
such sites induce with their different sights, sounds, and smells. Each constitutes a different suite of optical, acoustic, and olfactory spaces. Scientific practice is influenced by these spatial settings in a number of ways. For a start, the disposition of equipment and other accoutrements regulates human behavior in one way or another. Frequently the site is constructed so as to restrain or promote certain interactions; in some cases entry is carefully controlled by formal or informal mechanisms of boundary maintenance. It is also within these spaces that students are socialized into their respective scientific communities. Here they learn the questions to be asked, the appropriate methods of tackling problems, and the accepted codes of interpretation. Here decisions are settled about what passes as scientific knowledge, how it should be acquired, and the means by which claims are warranted. In these venues practitioners absorb the core values, convictions, and conventions of their tradition of inquiry. To this extent, science is always local. Whether it is a John Dee conjuring angels in his domestic studio, an Isaac Newton conducting light experiments in a darkened room in Trinity College Cambridge, an Alfred Russel Wallace mapping plant and animal distributions in Borneo, or a Josef Mengele carrying out experiments in racial hygiene at Auschwitz, the site-specific conditions of knowledge making are immensely different. So too are the ways the knowledge accumulated moves out from its site of origin into the public sphere.

Various questions, then, plausibly arise from the obviously variegated geography of the spheres of science. How, for example, is the circuit of knowledge effected, from the domain of acquisition to common currency? How does knowledge move from the particularities of its site of production to communal exchange? If, as we might suspect, specific spaces of science were not homogeneous, then how were they internally structured? Just who was permitted access to those...
enterprise and that there are both physical and intellectual geographies of knowledge production to be uncovered.

The array of knowledge-producing sites is immense. We will thus approach them through a rather rudimentary taxonomy. This schema is only suggestive, and there are many cases of significant overlap. Our concern is simply to capture something of the forces animating scientific inquiry in these arenas.

Houses of Experiment

We have become accustomed to the idea that scientific endeavor takes place in specialized locations like the laboratory. In part this has to do with the equipment scientists need to carry out their activities. Telescopes, microscopes, pumps, retorts, test tubes, and precision instruments of all kinds need to be housed. But the placing of scientific inquiry in designated spaces cannot be reduced simply to the requirements of instrument management. There is a history here of far wider dimensions. And one way to begin thinking about the spaces of experiment is to briefly glance at the prehistory of the laboratory.

A long-standing tradition in the West was the idea that retiring from society was a precondition for securing knowledge that was of universal value. Prophets and seers withdrew into solitude and returned with insights devoid of parochial particulars. Ironically, to acquire knowledge that was true everywhere, the seer had to go somewhere to find wisdom that bore the marks of nowhere. Such sentiments arose from the conviction that to be authentic, the sage must stand outside the normal confines of society. It was precisely this kind of solitude that the monastic life sought to provide. But the monastery and the hermitage, not to mention the wilderness and mountain-top—all classical sites of medieval spiritual knowledge—were not suited to experimental pursuits. The ideal of solitude remained, but a new space had to be carved out to accommodate it. What, then, was the route from the monastery to the laboratory as a site of knowledge production?
To get some sense of how that new kind of space—laboratory space—began to be hewn out of existing spatial arrangements, it will be useful to pause for a moment at a house in Mortlake on the banks of the river Thames. It is the home of John Dee, Elizabethan England’s most celebrated natural philosopher. Despite initial impressions, this is no ordinary residence of the gentry. Strange sounds and foul smells emanate from certain regions of the dwelling. For in the Dee household we witness an early move in the relocation of knowledge generation into the domestic scene. Rooms were dedicated to various alchemical appliances and occult practices because the master of the house needed to slice a private workspace out of an otherwise public household. Securing such a hermetic retreat within the home, of course, cannot be understood in isolation from the more general social history of the house. The unpartitioned and rather public space of the large medieval dwelling had by now progressively given way to compartmentalization; private quarters provided retreat and solitude, especially for the merchant and “professional” classes. Among the domestic innovations of the sixteenth century were back stairs and basement rooms built to serve the needs of the household. Such arrangements provided conditions into which the spatial requirements of the natural philosopher could be inserted. Since the house is an architectural expression of social structure, the experimental workshop fashioned out of domestic quarters represents an important step in the segmentation of world and of self.

Getting hold of a piece of space for alchemical experiment in his own home was a tricky business for John Dee. For one thing, it created tensions between him and his wife, Jane, at a time when the domestic roles of husband and wife were in transition. Simply put, John’s experimental life got in the way of Jane’s management of the household. And then the costs of distilling equipment, for example, put a strain on the family purse. Besides all this, the large number of servants in the dwelling, together with the various assistants Dee employed over the years, made finding any privacy difficult. And solitude was understood, as we have seen, to be an essential prerequisite for intellectual projects. So here, right on the cusp of the emergence of what has been called “laboratory life,” Dee was embroiled in a series of negotiations between the call of the private and the demands of various publics, family and otherwise. Even Jane was forbidden to enter the room where John engaged in his astral conversations; that was a sanctuary where angelic forces transacted the business of natural philosophy with her husband. Finding himself stranded between the library and the laboratory, Dee represents a key moment in the early construction of experimental space.

But it was not just the seemingly furtive crafts of the occult sciences—frequently closeted in basements—that were secreted within inner chambers. A host of key players in the emergence of English science in the mid- to late seventeenth century had laboratories either in their own homes or in the homes of gentleman patrons. Think of the circumstances at Robert Boyle’s home in Pall Mall in London, where he spent the last twenty or more years of his life in the home of his sister Katherine, Lady Ranelagh. Here, it seems, the laboratory was again in the basement; but it did have its own direct access from the street. These arrangements were significant, because while solitude was important to Boyle, he and his associates at the Royal Society insisted that scientific knowledge was in some fundamental sense a public matter. So while Boyle lamented over disturbances, he still needed to accommodate the new science’s strictures on the public attestation of natural knowledge. In order to achieve the status of “knowledge,” claims had to be produced in the right place and had to be validated by the right public. Where science was conducted—in what physical and social space—was thus a crucial ingredient in establishing whether an assertion was warranted. So Boyle’s experimental quarters had to be both private and public space at the same time.

Of course the new experimental arenas that surfaced in the period, not only in Boyle’s home but at the Royal Society and elsewhere, were far from public in today’s sense. To be sure, “gentlemen” were permitted access, according to the social norms of the day. But most important was what has been called “the experimental public”—those whose presence was essential to the confirmation of empirical
findings. Occupying the laboratory’s physical space was one thing; occupying its discursive space was quite another. This means that the laboratory’s social space was differentiated in a number of ways. It had, so to speak, its own cultural topography. On the one hand, there was a gulf between figures like Boyle, who had the authority to deliver knowledge, and the numerous attendants who worked the equipment and operated the instruments. The latter had craft competence, but they lacked the social standing to make scientific knowledge. Here was what we might call an epistemological chasm dividing the scholar from the mechanic. They occupied different social spaces. And in so doing they gave spatial expression to a suite of dualisms running the length and breadth of English society in the seventeenth and eighteenth centuries—philosopher and artisan, head and hand, mind and brain, soul and body. On the other hand, casual callers inhabited a different knowledge space from those socially and cognitively sanctioned to ensure experimental reliability. Here were boundaries that, though unmarked in physical space, were prominently displayed in the laboratory’s mental cartography.

The whole issue of the public warranting of knowledge raises yet another matter of spatial significance for science. Because an experiment “worked” in the private recesses of the scientist’s workplace was not sufficient to establish its claims as genuine knowledge. To secure that level of cognitive standing, it had to receive the approval of the relevant experimental public. A gulf thus opens up between what has been called the “trying” of an experiment and the “showing” of an experiment. Only when the journey from private to public space had been successfully concluded could a scientific claim enjoy the privilege of knowledge status. Through public demonstration, private speculation achieved open confirmation. The shift from “trying” to “showing,” from delving to demonstrating, we might say, is a spatial manifestation of the move from the context of scientific discovery to the context of justification.

Stabilizing experimental claims, however, was often not just a matter of disclosing them; it was frequently necessary to dramatize them. This was as true of the spectacles that Michael Faraday put on for his Victorian audiences at the Royal Institution as it continues to be of the nuclear power industry. As for the former, Faraday’s famous Friday evening performances during the 1830s and 1840s, in the presence of a highly controlled guest list, were presented in such a “natural” manner that any sense of artistry was erased. His hard work behind the scenes was as effective in the way he presented “nature” as were the elocution lessons he had taken to improve the way he presented himself. In the latter, the demonstrations are so effective precisely because the smooth public performance obscures the untidiness behind the scenes; the vagaries of nature are caged, as one observer puts it, “in thick walls of faultless display.” Here the theatrical dimensions of experimental space are clearly exposed.

Demonstrations, however, have long trailed their own clouds of cynicism. Public experimentation could easily be charged with using illusory techniques to deceive the eye. So during the eighteenth century, natural philosophers felt the need to find ways of putting distance between themselves and those plebian “mechanicals” more intent on dramatic entertainment. The carefully constructed experimental arena, requiring sophisticated instrumental choreography, could too easily resemble the trickery of the mountebank. All this meant that experimental display inhabited a space poised between conjuring tricks and scholarly authority, between the theater and the academy. Nevertheless, what experimental demonstration succeeded in establishing, certainly over the long haul, was a way of knowing that required hands-on experience irreducible to conventional numerical or linguistic signs. That this outcome was the product of long-drawn-out negotiations is nicely disclosed in the origins of the modern university physical laboratory, where space had to be appropriated to provide instruction and demonstration to students, on the one hand, and research facilities for teachers, on the other.

The founding of the Cavendish Laboratory in Cambridge in the 1870s, and of its Scottish predecessor, William Thomson’s experimental lab in Glasgow a decade and more earlier, nicely illustrate such maneuvers. The founding of the Cavendish required the acquisition of a species of intellectual and material space hitherto alien to
the university's academic ethos, for mid-Victorian Cambridge was the stronghold of Anglicanism and mathematics. The workshop was terra incognita to the university establishment. With its savor of the merely technical, moreover, it threatened the moral fabric of the old order by transgressing lines of social demarcation. Such was the environment into which proposals for a new physical laboratory were launched as a key feature of the move to bring experimental physics into the English academy. Territorial acquisition, it seems, is as fundamental to educational crusades as it always has been to military campaigns. To grasp the factors involved in this reconfiguration of the geography of Cambridge science, it is illuminating to glance at the apologia for the new space made by James Clerk Maxwell, the nineteenth-century Scottish physicist and student of electromagnetism.

Maxwell knew only too well that the values of the factory workshop were alien to the dominant university ethos of his time, and that he needed to find some way of domesticating the world of the laboratory to the prevailing culture of scholarship. In fact, as a Scotsman he was particularly well suited to the project of mediating between the scientific reformists pushing for an electromagnetic and thermodynamic laboratory and defenders of the traditional mathematics curriculum. For, as was typical of late Enlightenment Scottish intellectuals, he retained a strongly metaphysical cast of mind, and he applied it to the disputed connections between algebra and geometry. This enabled him to urge that providing facilities to ensure precise computational standards was analogous to the Anglican God's work of calculation and measurement. Thereby he could forge a strategic alliance between God and mammon, between philosophy and the factory. Not surprisingly, displayed over the Gothic entrance to the Cavendish, suitably decorated with the family coat of arms, were words from the book of Psalms. The new physical laboratory was a spatial and symbolic incursion into the university's scholarly domain. The chapel and the study now had to make room for the laboratory. Work carried out here on electrical technologies would transform the social polity. Even as the physics laboratory recast the academy, the telegraph remade global geography.

Maxwell’s laboratory labors, however, were not without precedent. Entirely appropriately for a Scotsman, he had looked for inspiration to William Thomson—Lord Kelvin—in Glasgow. For here Thomson had cemented the very links that Maxwell yearned for between the culture of the classroom and the craft of the foundry. Glasgow College—one of Scotland’s five medieval university colleges—was particularly well positioned to move beyond what has been called the “monkish” values of Oxbridge. After all, among its celebrated achievements the city boasted James Watt’s steam engine and Adam Smith’s political economy, both symbolic of its progressivist inclinations. As Thomson himself remarked, Glasgow was especially well served with suppliers of the apparatus of the new industrial order. Add to these the visual drama that attended his spectacular demonstrations in electricity and magnetism, and we find the ingredients that enabled Thomson to wrest the intellectual initiative from those wedded to the old regime long enshrined in the college’s hallowed halls. And so in Glasgow, as later in Cambridge, the physical laboratory emerged as the spatial articulation of a new cultural order (fig. 6).

Having looked in on a set of rather different “houses of experiment,” it is clear that we have witnessed a variety of laboratory microgeographies. Concurrently we have seen that laboratory space has conveyed a range of meanings. There have been occasions when it assumed the role of theater; as knowledge moved from its point of origin to public disclosure it frequently had to be dramatized in order to be stabilized. The space of experiment was also theatrical in that this is where various stagings of nature took place; in the micro-world of the lab, aspects of the world were manipulated, controlled, and reconstructed courtesy of the available technology and the local experimenter’s know-how. Indeed, it was only by operating material apparatus in the laboratory that such invisible entities as lines of magnetic force could be made manifest. At the same time the laboratory’s very construction was routinely seen as a decisive cognitive move in the campaign to establish new ways of knowing. The laboratory was thus an emblematic space replete with cultural meaning, though as a site of knowledge it could function only in the presence of the geo-
graphically privileged who were permitted to cross the threshold. Their role was critical. For only if they enjoyed the trust of those outside could they warrant the credibility of the claims made inside the laboratory's walls. They were the vehicle by which experimental knowledge was "disembedded"—extracted from its place of origin—and transferred to a wider public.

**Cabinets of Accumulation**

The experimental laboratory, of course, is not the only site where scientific endeavor has taken place. Running alongside, and indeed predating, the laboratory were spaces of accumulation such as the museum and the archive, where specimens and samples were collected and organized according to the prevailing norms. In these chambers the aim—at least in part—was less to manipulate the natural world by experiment than to arrange it through classification. Whereas the drama of the laboratory lay in staging demonstrations, the museum's theatricality is expressed by amassing, ordering, categorizing, and displaying exhibits of all kinds.

The origins of museum culture can be traced back to what were known as "cabinets of curiosities"—early collectors' closets into which gentlemen of the sixteenth century packed curios of all kinds. The more rare in occurrence or exotic in appearance or distant in origin an object happened to be, the more likely it would end up in a "world of wonders" housed in some secluded antechamber. This habit of collecting, frequently nurtured as a noble pastime, was actively cultivated as the insignia of a civilized household and, it has been said, provides "a window into a private psyche" by disclosing the whims of the collection's proprietor. As instances of conspicuous consumption, collectible objects served to confirm social standing.

At the same time, the acquisitive impulse delivered, in the form of the museum, a key site for pursuing a different kind of scientific knowing. The dazzling variety of the natural order, with its profusion of particularity, which the museum accumulated, classified, and
re-presented, did much to feed the nascent scientific craving for facts, more facts, and yet more facts. In contrast to Albertus Magnus, the medieval Scholastic philosopher who had insisted in the mid-thirteenth century that “there can be no philosophy of particulars,” the English essayist, statesman, and philosopher Francis Bacon, in his 
*Novum Organum* of 1620, called for “particular natural history” and the accumulation of “Singular Instances.” For Bacon these very things were crucial to overthrowing a priori thinking, impromptu generalization, and the syllogistic reasoning so beloved of contemporary natural philosophy. To be sure, wonder might be nothing but open-mouthed gawking or vain admiration, pernicious astonishment or reverential awe, but when harnessed to curiosity it could do scientific work. Thereby collecting became established as a valuable and valid way of knowing. Concurrently, the idea of wonder came to reside both in material objects and in the human response to artifacts excited. All this meant that a seventeenth-century collection might exhibit, side by side, dwarf species, chameleons, wampum belts, mathematical instruments, Turkish knives, Oriental footwear, stuffed dodos, and medals of famous men. Such seemingly bizarre juxtapositions were cataloged according to the conditions of their acquisition, their philological associations, and their historical circumstances. In this way the museum, as a site of accumulation, played a vital role in the mushrooming of those sciences concerned with ordering and arranging the specimens of natural and civic history.

Originating in the *studio*, by the end of the seventeenth century the museum had become a *galleria*. And this shifting internal geography had important ramifications for the kind of place it turned out to be. As a setting for scientific inquiry and human interaction, the museum was—both socially and acoustically—a synthetic space. It mediated between private and public domains, yet it was, as one scholar puts it, “located between silence and sound.” In its early days, as the stillness of the study yielded to the murmur of the gallery, the museum provided a setting for courtly—and almost always manly—civility in which the virtues of scholarly conversation could be engaged (fig. 7). As it renegotiated the relationships between intimacy and sociability, the domestic and the public, museum space at once socialized privacy and cloistered civility. Indeed, some felt that when the Ashmolean Museum at Oxford allowed access to the public, including women, in the late 1680s, the polite boundaries of the community of learning had been grossly breached.

Because the gallery was no longer a static site of contemplation but had become a mobile space through which patrons passed, it signaled a move away from contemplation toward the active life as the road to genuine knowledge. Bodily movement, intellectual exchange, and ordered display were all integral parts of a domain whose very existence was dependent on a never-ending ebb and flow of commodities, information, and conversation. But as articles streamed in from near and far, they were reassembled, positioned, and displayed

7. The late sixteenth-century museum of Ferrante Imperato, in the family palace. *In contrast to the solitariness of the study, this illustration reveals the museum as a space of male conversation as well as a site of natural curiosities.*
in the way the curator believed was most appropriate. So even while museums exhibited real-world objects, they refashioned reality through classification, location, and genealogy. Museums have thus always been sites of interpretative practice in which the spatial allocation of items fundamentally reconfigures the world of nature.

At no time, perhaps, was the obsession with amassing and arranging global data more feverishly nurtured than at the height of Victorian Britain’s overseas imperial adventure. From institutions like the Royal Geographical Society, the Royal Asiatic Society, the Royal Society, and most particularly the British Museum, the acquisitive tentacles of empire snaked their way around the globe. Yet the fact-fascination that characterized such spaces ultimately reduced universal geography to the cabinet-sized exhibit and file-sized archive. In turn these became the way administrators, bureaucrats, and the general public encountered the “collective improvisation” that was the British Empire. By accumulating, reorganizing, and reproducing information from the remotest corners of the earth, the Victorian archive played its part in shaping worldwide geopolitical relations. In one way or another, the data-hungry museum did much to fulfill the surveillance needs of colonial management.

Because it is a vehicle for expressing knowledge claims, the museum’s spatiality has often been an arena of struggle. In Charles Willson Peale’s museum in Philadelphia, which first opened its doors to the public in 1786, tensions arose over classifying North American specimens according to Carolus Linnaeus’s fundamentally European system. The new republic and the Old World were locked in cultural combat over the relative excellence of the two continents’ floral and faunal specimens. Yet Peale felt constrained to adopt the Linnaean system even while expressing a preference for native American nomenclature. His museum thus further advanced the domain over which the European taxonomists held sway. By the same token, Peale’s remarkable undertaking did much to constitute the museum as a vital educational tool in the life of the new democracy. Ordinary people like farmers and merchants, he was sure, could benefit from the commercial possibilities of natural history.

Again, when Alpheus Hyatt was hired as the permanent curator of the public museum in Boston in 1870, he immediately set about using the collection to illustrate the development of species. Thence the dramatically departed from the creationism of his teacher, Louis Agassiz, who once observed that the “great object of our museums should be to exhibit the whole animal kingdom as a manifestation of the Supreme Intellect.” Hyatt, by contrast, regrouped exhibits into a set of categories that revealed the development of species—mineralogy, botany, paleontology, zoology, geography, and anthropology. Such moves were far from inconsequential, because the museum had by now become a significant teaching venue within American colleges. Agassiz’s own Museum of Comparative Zoology at Harvard, for instance, superseded the classroom as his key site of instruction. And later in the 1930s, at the American Museum of Natural History in New York, the differing views of William King Gregory and Henry Fairfield Osborn on the evolution of primates found expression in their respective exhibition halls. Gregory’s “Hall of the Natural History of Man” stressed the evolutionary continuity between the different human races, whereas Osborn’s “Hall of the Age of Man” sought to undermine the theory of ape ancestry, to stress parallel development, and to portray the different human races as discrete “species.” The displays mounted on the second and fourth floors of the museum thus articulated the different social, political, and religious convictions of the two scientists. In ways like this, the museum voiced the values of its curators and disclosed their mental geographies.

The museum, then, can be considered a map of its curators’ claims to knowledge. Richard Owen, the celebrated English comparative anatomist and first director of the Natural History Museum in London, expressly couched his tale of the genesis of the building in the language of organic progression. The structure itself, he assured his hearers in 1881, displayed developmental advances in morphology, and the arrangement of its specimens reflected his own conception of natural history. The same was true of the Museum of Practical Geology in London’s Jermyn Street, where the geological displays in the early Victorian period were arranged so as to establish and stabi-
lize the version of stratigraphy championed by Sir Roderick Murchison. Precisely because items were allocated to their "proper places," the layout of the galleries was itself a map of geological knowledge.

Much the same was true of anthropology. The regulation of museum space in late nineteenth-century America conjugated the differences between the anthropology of Franz Boas and of Otis T. Mason and his mentor John Wesley Powell. Whereas the latter two employed an evolutionary narrative to account for—and to display—certain ethnographic inventions, Boas urged the virtues of exhibition by tribal group. To Mason and Powell the very purpose of the museum was to reveal progress—of anthropology, of science, of human culture. For Boas, ever impatient with taxonomic systems, schemes of unidirectional evolution, and what we might call "object fetishism," the goal was to confirm the relativity and diversity of human civilization. How space was managed declared differences between evolutionary and ethnic modes of anthropological understanding, between temporal and territorial ways of thinking. The profound contrast between anthropological leaders on the very nature of their projects was literally laid out in the layout of the exhibits. The microgeography of museum pathways disclosed different ways of telling the story of the human species.

Such stories, moreover, could have wider ideological implications. In his museum of anthropology in Victorian Oxford, Augustus Pitt-Rivers used his displays—whether of weapons, tools, pottery, or religious paraphernalia—to emphasize the gradual development of human societies and cultures. The idea of progress from the simple to the complex, from the elementary to the sophisticated, was crucial to Pitt-Rivers's anthropological credo. And where supporting evidence was in short supply, he had no hesitation about engaging in conjectural cartography. Gradual improvement was no less central to his political thinking. Because he was convinced that institutional development was slow and steady, he recoiled at the thought of radical social change. It was by incremental evolution that the state, the family, and language had developed. And he hoped that in a period of chronic political unrest in Britain during the final quarter of the nineteenth century, his museum would convey to the public a salutary caution against insurrection. Nature exhibited no jumps—and neither should society. The Pitt-Rivers museum was thus a tract for the times on the benefits of moderation and the value of education. Gradual development was the order of the day in natural history, human institutions, and technological arts; and, he insisted, "this knowledge can be taught by museums, provided they are arranged in such a manner that those who run may read."

One of the most conspicuous expressions of how its exhibits were structured according to the museum's internal geography was the remarkable "sociological laboratory" spearheaded by Patrick Geddes in 1892 at his Outlook Tower in Edinburgh (fig. 8). This construction was intended to be a novel type of museum in which the study of civics and regional survey was encouraged through a synthetic integration of landscape, history, and sociology. Essential to this "temple of geography," as one of his peers called it, was the orchestration of its internal spatiality. The various stories were organized in a hierarchy. On top was the "prospect," housing a camera obscura through which the city of Edinburgh could be observed. Below this level was the Edinburgh Room, accommodating a scale model of the city with accompanying plans, maps, and engravings of its architectural heritage. The bottom two stories dealt with Europe and the world, respectively.

This interior geography was designed to lead the visitor from the local via the regional to the global. It was a dramatic spatial articulation of Geddes's entire philosophy of knowledge. Committed to social reform and global humanitarianism, Geddes persistently sought to equip people to engage in political transformation by fostering regional awareness. The Outlook Tower thus exuded its architect's sense of global holism, his commitment to educational innovation, his conviction that direct experience of the world should replace bibilolatry, and his assurance that regional particularity was the outcome of global evolutionary forces. It also imposed a hierarchical taxonomy on its exhibits and conveyed the impression that the world was composed of a nested set of interregional relations. The Outlook Tower,
which Geddes envisioned as an *encyclopaedia graphica*, thus constructed the world he hoped to reform.

It would be mistaken, though, to think that museums were just passive reflectors of their curators’ preferences. Museums were not simply cartographic texts. They were often sites of struggle between curators, academics, sponsors, and the general public, all of whom had different aspirations for the institution. Moreover, the very materiality of the museum’s physical space could “bite back.” Its transformative influence was clearly felt on late nineteenth- and early twentieth-century anthropology in Berlin, where the study of the subject was conducted outside the university sector in the Royal Museum of Ethnology. German anthropology had been dominated by a craving to accumulate cultural artifacts, and this appetite was gratified through global networks of commodity acquisition. Such cupidity was theoretically justified by the belief that single items were nothing more than mere curiosities and that any particular article acquired anthropological value only when placed in a complete series. Collectors engaged in unlimited hoarding of specimens on the conviction that anthropology was best pursued through a comprehensive overview of humanity’s material culture. Such thinking resulted in uncontrolled stockpiling in the Berlin museum. But the confines of the museum meant that the collection soon descended into chaos, lacking any order. The very ethnological overview that the museum was intended to supply was subverted by the volume of objects amassed. In due course, with disquiet being expressed by the public and alternative conceptions of anthropology developing elsewhere, curators eventually adopted new methods of handling artifacts. Intellectual change and spatial constraint went hand in hand. Ironically, the very site that had cradled the developing discipline provided the structural foundation for discarding the approach to the subject that it was originally established to advance.

If a museum’s internal geography could condition the cognitive shape of the science produced, its external iconography could speak to the society in which it found itself. Museum architecture is not simply a set of structural answers to practical problems. It is itself a symbolic
writing of space. The very buildings where scientific inquiry was housed were often pronouncements in the language of stone, site, and plan about the place science should occupy in the wider culture. We might allude, for example, to the ways museum architecture echoed ecclesiastical forms. Alfred Waterhouse’s Natural History Museum in South Kensington was often referred to as “nature’s cathedral.” Opened to the public in 1881, this Gothic Revival “temple of science” was the world’s most remarkable structure of its kind (fig. 9). Such celebratory ascriptions were entirely in keeping with the efforts of certain elements in late Victorian society to wrest social authority from the clergy and deliver it into the hands of a new scientific elite, even if the design itself was reflective of its director Richard Owen’s personal enthusiasm for natural theology. After all, the scientific fraternity that congregated around T. H. Huxley, who saw himself as a “bishop” of the “new ecclesiology,” sang “hymns to creation,” preached “lay sermons,” joined the “church scientific,” and was ordained to the “scientific priesthood.” In such circumstances architectural symbolism could well become one more weapon in the arsenal of cultural conflict.

While its architecture was intervening in the cultural struggles of late Victorian society, the museum as an institution did much to promote what has been called an “object-based” approach to knowing in the decades around 1900, not least in the United States. In a period when Chicago’s Field Museum, the American Museum of Natural History, Harvard University’s Peabody, and a host of similar institutions came into existence, the idea that knowledge could reside in material objects as much as in texts gripped the imagination of American intellectuals. Appropriately, apologists for museology urged that what distinguished their efforts from those of their antebellum predecessors was precisely that in the new museum specimens were viewed as objects of scientific scrutiny, not simply as spectacle. By thereby domesticating the dazzling, the fundamental order of nature could be unveiled by rational inquiry. The Philadelphia paleontologist Edward Drinker Cope sought to capture the spirit of the moment: “[As] the middle ages were the period of cathedrals, so the present age is one of colossal museums, and of an extensive development of knowledge of the sensible creation.” By giving such priority to objects and their value, the American museum fit remarkably well into a culture of acquisitiveness and, for a short time at any rate, was in the vanguard of the new century’s cultural economy of science.
This triumph was short-lived. The modern research university soon acquired the cognitive authority that had resided in the museum. At the same time, the realization that the meaning of artifacts is unstable and shifts depending on how objects are arranged, tended to downgrade their scientific significance. For all that, the late nineteenth-century museum constituted a remarkable experiment in visual encyclopedism.

The museum, it is clear, has performed a variety of roles in the historical unfolding of scientific inquiry. Occupying a distinctive niche in the ecology of science, it constitutes a space where items have been accumulated and allotted their “proper place” on the stage of history. In this way museum culture played an important part in the history of “viewing.” In the museum people learned how to look at the world, how to value the past, and how to visualize relations between specimens. Yet no matter how extraordinary the exhibit or how dramatic the diorama, the museum was not the world itself. The museum was no mirror of nature. To view that required moving outside the confined spaces of the collectors’ cabinets and into the open spaces of the field—another site of scientific endeavor.

Field Operations

The idea that the world should be its own laboratory, and that the best way to study some part of nature is to go there and experience it firsthand, is anything but the obvious claim it appears to be. When the French comparative anatomist Georges Cuvier commented on the scientific travels of Alexander von Humboldt in the early nineteenth century, he sharply contrasted the styles of scientific travelers and “sedentary naturalists.” Because the former quickly traversed territory and viewed many things in sequence, Cuvier insisted, they could “only give a few instants of time to each of them.” The observations of the fieldworker were “broken and fleeting.” By contrast, the bench-tied student of nature had the time to spread out samples, to collate and analyze them, and thereby to come to reliable conclusions. The laboratory naturalist occupied a kind of hyperspace: because creation in all its dazzling diversity passed across the workbench, it afforded the opportunity to rearrange the natural order and grasp it as a whole. By patient comparison and correlation, the armchair naturalist could easily triumph over the fragmentary and precarious claims of the fieldworker. For Cuvier the most wonderful voyages of discovery never weighed anchor and pushed out to sea: they never left the workshop. Only in the study could one rove the cosmos.

Whatever the merits of Cuvier’s partisan analysis, his interventions call attention to the markedly differing cognitive styles that characterized open-space and closed-space naturalists. For the former, as one commentator puts it, “mastery over and comprehension of nature” derives from “passage over terrain”; for the latter, “the steady and immobile gaze” is accorded cognitive privilege. Cuvier’s conviction was deeply ironic. The very thing that secured the reliability of the sedentary naturalist was what advocates of field science strenuously repudiated—absence from wild nature. To fieldworkers it was presence, not absence, closeness, not distance, that underwrote their claims to authenticity. Their immediate experience of moving through space, often heroically, with all the bodily exertion and rigors that entailed, provided warrant (as we shall see in chapter 4) for the scientific stories they had to tell. Dissecting specimens and displaying exhibits were all well and good, but it was only in the field that nature could be encountered in the raw. The workshop bench could deliver only a virtual world—valuable enough, but no substitute for the real thing.

Nor was Cuvier’s dispute with Humboldt a unique episode. To the mid-nineteenth century Edinburgh student of Alpine glaciers, James David Forbes, it was only “protracted residence among the icy Solitudes” that warranted genuine scientific knowledge of glacial matters. It was only presence in the ice fields that could replace rumor with reason. The Cambridge mathematical theorist William Hopkins, however, didn’t see things the same way at all. To him the nature of glacial motion could be deduced from the laws of physics and their operation in laboratory-based experiments on force, solids, and fluids.
What was going on here, fundamentally, was a dispute about appropriate modes of scientific knowing. And that debate was not without its fair share of name-calling. Field men like Forbes, and indeed the Irish physicist John Tyndall (whose views on glacial motion differed from Forbes’s but who shared his manly enthusiasm for heroic rigor in remote places), did not hesitate to dismiss their opponents as mere armchair theorists. The rhetoric of adventure dominated the culture of field science: adventurousness conveyed its own authority. Laboratory opponents, by contrast, felt that high adventure in an uncontrolled wilderness delivered nothing like the precision good science demanded. Fun was one thing, physics something else.

As these two debates reveal, enthusiasts for field science regularly appealed to location as a key component in justifying their knowledge claims. To them, where science was practiced constituted an important strand in their arguments about why they should be believed. Credibility was, to a considerable degree, a matter of locality. And yet just exactly what “the field” means has never been clear-cut: it is shot through with ambiguity and inconstancy. As an open space it is less easily defined, bounded, and policed than its intramural counterparts like the laboratory or the museum. For this very reason the field is inhabited differently from these other scientific spaces. For a start, the investigator here is likely to be the visitor rather than the resident—precisely the converse of the laboratory world. The settled inhabitants of the field site are not the scientific experts engaged in research. And there are likely to be other transient sojourners such as tourists, campers, foragers, artists, and hunters, to name but a few. The variegated nature of the field’s dynamic human geography makes for an unstable network of social relations. The field thus discloses precisely the kind of sociology that the laboratory seeks to escape, with its formal and informal disciplines geared to maintaining stability.

In these and other ways, the field is a space where the structures of social life are at once reproduced and destabilized. The ambiguities of presence and absence are also significant here. Take, for instance, the involvement of amateurs in field sciences. Although they are fundamental to everything from archaeological digs to botanical surveys, their presence has been regarded as cognitively compromising by those promoting the supposed rigor of laboratory standards. And indeed, while the boundary between the professional and the amateur is much less clear-cut in the field than elsewhere, it is true that “amateur knowledge” often has passed as genuine science only when warranted by the credentialed professional.

A similarly equivocal position has been occupied by women in the field. On the one hand, the field has often been promoted as a manly site of intrepid heroics, with its narratives cast in an epic form that celebrates the virtues of stoicism, resilience, pragmatism, and inventiveness. Indeed, the impression has sometimes been given that these practices make their own contribution to justifying claims to knowledge. Often, too, fieldwork has been venerated as a rite of passage that the fledgling scientist must struggle through, both metaphorically and literally, to achieve mastery over nature. These values have not always been attractive to women. And since the field was foundational to such Victorian sciences as geology and physical geography, it may well have colluded in their exclusion from these groves of the academy. On the other hand, the foreign field has sometimes afforded women the opportunity to escape from the rigid regimens of the homeland. Their personal experiences far away, moreover, occasioned domestic equivocation. When Mary Kingsley (whose Travels in West Africa appeared in 1897) returned to England from her second journey to the “dark continent” in 1895, she was welcomed by the press as a marvel, a novelty, a wonder—“a lonely English lady” who had “manfully” borne the trials and tribulations of the foreign field. Plainly, her conduct abroad transgressed the virtues of her comportment at home. She might be a heroine, but she was also an anomaly.

Women also energetically participated in the domestic field club movement in Victorian England, which did much to foster amateur science at the time. At least in part a manifestation of a romantic sensibility toward the natural order, groups like the Berwickshire Naturalists’ Club, formed in Scotland in 1831, opened membership to both men and women. Such societies were as much experiments in innovative social relations as places where the cult of the naturalist was ac-
tively nurtured. By the same token, middle-class women who did
infringe the conventions of gender relations by going on such field
outings did so—emphatically—as amateur "botanophiles," not as
professional botanists. Indeed the amateur/professional polarity
could itself operate as a means of excluding women from serious
scientific visibility and underscore the presumption that, for women,
natural history was nothing more than a genteel hobby.

Ambivalence also attended the remarkably successful field ven-
tures of Alfred Russel Wallace (the codiscoverer of evolution by
natural selection) in the Malay Archipelago during the nineteenth
century. However transforming a personal experience it was, and
however much his ventures were presented in the language of the
rugged explorer, Wallace's time in the East depended on an existing
colonial network of merchants, government officials, medical practi-
tioners, and clergy into which he easily fitted. To be sure, in its trans-
plantation to the colonies, the structures of British society had endured
change. Relations between the middle and upper classes were less
fixed than at home, for example, and Wallace used this social fluidity
to good effect. Nevertheless, like Humboldt in South America, Wal-
lace was able to rely on the entangled systems of socioeconomic inter-
change that European colonists had woven. Intrepid his excursions
may have been; isolated they certainly were not. For in order to over-
come the distrust of the local peoples he moved among, he had to de-
pend on the friendship, loyalty, and trustworthiness of a variety of
associates to procure the information he sought. Here the idiom of the
heroic individual is all wrong. Wallace's field science was an inescap-
ably social affair. And the knowledge he acquired was the compound
product of personal observation, trusted testimony, and colonial in-
fragrate.

At once restrictive and liberating, by virtue of its social flexibility
fieldwork offered greater space for renegotiating personal and voca-
tional identity. The field allowed scientists scope to engage in re-
sourcing the self. Whether breaking down gender roles, encouraging
the transgression of social conventions, blurring the line between am-
ateur and professional, or furthering the mythology of hardy hero-
ism, the field regularly exhibited a borderland sociology and a fron-
tier mentality. While these arose in some measure from the human
geography of the field's occupants, its physical geography has also played
its part. The field is an inherently unstable scientific site, and for that
very reason practical rationality and functional imagination are at a
premium there. Local conditions pose local problems needing local
solutions. In such circumstances science is an inescapably local prac-
tice. Here the good scientist is the skilled hand, the resourceful
artisan. Not that such aptitudes are irrelevant in the laboratory. But in
the field, replication is not so easily effected, the environment is less
readily controlled, and impromptu ingenuity is in correspondingly
greater demand. And yet however innovative in situ practices may
be, the crafts deployed in the field are nonetheless typically acquired
at home. Encounters with the unexpected are routinely construed in
customary ways, for field scientists—it has tellingly been said—
"travel with their domestic habits of mind and behavior." And this is
not only the case for acquiring field knowledge; it is no less important
to communicating findings. The singular experiences of the field can
be expressed only by using a common lexicon and drawing on shared
cultural resources. To that extent the homeland is always present
with the scientific traveler (fig. 10).

That science is a cultural practice, then, is exemplified with par-
ticular clarity in the field. For here hands-on experience, routine im-
provisation, and performative rationality are highly valued. The
caliber of the science produced is a direct reflection of the quality of
practical reasoning and proficiency at manipulation. This reminds us
that rationality is not independent of the customs and practices that
constitute a tradition of inquiry. To the contrary, it is embedded in
them. Theory and practice need to be thought of in reciprocal rather
than oppositional terms. It is in practices as much as in theories that
traditions of inquiry articulate themselves, and they do so in activities
that are not reducible to formal rules of inference. There is no sci-
cific rationality that is independent of a tradition's procedures, cus-
toms, and performances—that is, of the practical conditions of
knowledge making. For this very reason what we might call "ap-
prenticeship” is essential in the field sciences, where one can learn how to deal with the exigencies of the contingent only by working under the authority of an accomplished practitioner.

In some measure at least, the centrality of practice and the premium put on the craft competencies of the fieldworker arise from the open space and deeply uncontrollable character of the field. But it would be a mistake to think that the field is simply a site that just “is there” and can be taken for granted. Rather, it is constituted “as the field” by the activities of scientific investigators. Because of the power the academy has to define the field and thereby, in many cases, to justify its own “field of inquiry,” the field site is always politically negotiated. In some academic disciplines, notably anthropology, fieldwork has been a kind of fetish that has normalized the domain’s practices, empowered certain styles of knowledge while impeding others, and sanctioned certain objects of study. In anthropology it was Bronislaw Malinowski who installed fieldwork as central to the institutionalization of the discipline. Thereby he effected a move away from the worldview of Victorian gentlemen-scholars who considered going into the field rather beneath their dignity. Courtesy of his organizational skills, the field methods Malinowski had deployed in the Trobriand Islands rapidly became the legitimating insignia of the profession. By valorizing the field, the new professionals were able to subvert the authority of the old gentlemen-naturalists. From then on, fieldwork became “the central ritual of the tribe.”

In important ways, then, the field is constituted by academic projects and narratives. Its existence as a scientific site depends on the stories scientists tell about it. While this is the case with all field sites, it is in the social sciences that we may most clearly catch a glimpse of how this is so, for here the relationships between the researcher and the researched dramatically surface. The investigator has the power to group individuals into some abstract collective and then label them as slum dwellers, domestic servants, middle-class fundamentalists, migrant workers, or some such. This is because the social scientist delineates the boundaries and defines just who is in and who is out of the subject circle. The politics of fieldwork thereby surface as part and
parcel of the politics of representation. The knowledge claims arising from fieldwork in the social sciences are thus intensely local. And they are local in two senses. First, the information collected is about circumstances in some particular locality; second, the entities that social theories seek to explain are constituted by the analytical categories the field investigator imposes on local data.

In other ways too, fieldwork gives voice to the political commitments of the researcher. Late nineteenth-century urban fieldwork, for example, often had the aim of rendering service to the dwellers of disadvantaged areas. More recently inner city "expeditions" have been mounted by radical social scientists to advance what might be called an emancipatory geography that is designed to empower the marginalized and enable them to escape from the grip of oppression and the spiral of poverty. Fieldwork in such scenarios is a prelude to political liberation and a chapter in its history. Frequently in these cases relationships are further complicated because the conventional distinction between "home" and "field" does not apply as "insiders" and "outsiders" are elided. In this sense the field is a space that is at once familiar and foreign.

The field, then, turns out to be anything but the obvious scientific site it might initially seem to be. Characterized by ambiguity and constituted by academic projects, fieldwork has nonetheless been installed as an operational answer to questions about appropriate ways of knowing for certain traditions of scientific inquiry. Absence from home and presence in the field, as the necessary precondition of bona fide knowledge, was the outcome of historical negotiations that gave the field sciences their distinctive place in the scientific division of labor. Here cognitive warrant was built on the foundations of spatial practices, for fieldwork literally grounded the claims of the scientist.

Gardens of Display

Between the archive and the field, the world of the museum and the world of nature, stands the garden. A site of botanical and zoological inquiry, the garden has a complex spatial history in which different purposes and practices have intermingled. It is a multilayered space whose meaning has undergone manifold transformations, each trailing clouds of earlier associations. Enclosed yet expansive, open yet delimited, natural yet managed, the garden occupies a place between the great outdoors and the cloistered cabinet. It was always so. Wasn't God the first gardener when he planted the Garden of Eden? It was a spiritual site in which its human inhabitants walked with their Creator. But once sin entered their lives they were expelled from its pleasures and perfections. Since then, in the Christian tradition at least, every gardener's battle against the encroachments of the wilderness has been an attempt to reflect, if not retrieve, primordial paradise (fig. 11). From earliest times, the garden has been seen as a place of retreat and renewal, an outdoor temple of contemplation and meditation in which spiritual well-being could be maintained. Further, the garden's very existence has depended on its capacity to represent order over against chaos, cultivation in opposition to wilderness, art as opposed to nature. The boundary of the garden thus marked out a line between the rational and the irrational. As a space of display, the garden was meant to present the orderliness of creation by recovering Eden's pristine harmony. Not surprisingly, the garden long remained a fertile repository of ecclesiastical metaphor and spiritual allegory. It was a "type" of heaven, with trees an emblem of Christ, branches a symbol of the saints.

With scientific pursuits these meanings began to be reshaped. Whereas early gardeners yearned for the recovery of ancient wisdom, often in the hope of retrieving the lost powers of Adam, scientific travelers lusted for new knowledge. In the wake of the European voyages of reconnaissance, the conception of the garden as a hallowed refuge from the world began to be supplemented by a vision of the garden as a living encyclopedia. As plants arrived from across the globe, they were identified, named, and allotted their proper places in the garden's spatial taxonomy. The early botanical garden was both a re-creation of paradise and a key moment in the genesis of modern science. Even as the encounter with the New World challenged the
classification schemes of the ancients, it no less inspired the hope that, for the first time since the fall from grace, the plenitude of Eden could be restored. The seventeenth-century author Abraham Cowley, for example, insisted that America had brought back into view lost elements of the creation and that Eden could be re-created by reassembling in one location the scattered pieces of the globe’s plant jigsaw puzzle. The first modern botanical gardens, established in Padua and Pisa in the early 1540s and, for the English-speaking world, at Oxford in 1621, thus served the interests of both theology and science.¹

This was clearly so in the collection of the mid-seventeenth-century gardener John Tradescant, which housed a rich variety of items. Widely known as “the Ark,” it reinforced connections between the biblical Noah and natural history. This association was intentionally optimistic. It was in Noah’s ark that God had restored human dominion over the creation, and it was thought that its replication could recover optimal conditions for acquiring reliable knowledge. The ark, after all, was God’s museum laid out according to divine specifications. Gardeners like Tradescant were latter-day Noahs engaging in a task of spiritual and scientific retrieval and reversing the global effects of negligence and depravity. The ark, like such other biblical sites as the Garden of Eden and Solomon’s temple, provided the seventeenth century with images of ideal knowledge spaces. The temple, for example, provided inspiration for the restoration of a godly society in which cooperation and diligence would yield true understanding. Here the cognitive effects of Adam’s fall could begin to be reversed. Clearly, the site of knowledge acquisition was crucial to establishing the integrity of the knowledge procured.

Understandably, the garden’s internal geography began to be rethought in consequence of its rapidly growing range of specimens. The layout was meant to map onto the globe in some discernible way.

¹ Other early botanical gardens include Zürich, established in 1561, Lyons in 1564, Rome in 1566, Bologna in 1567, Leipzīg in 1579, Leyden in 1587, Montpellier in 1592, Heidelberg in 1593, Giessen in 1605, and the Jardin des Plantes in Paris in 1635.
The four continents were each allocated their literal "quarters" in the
garden. John Hill, for example, specified—in his *Idea of a Botanical
Garden in England*, which appeared in 1758—that the sections should
be "appropriated to the four great regions of the earth, and defined
for the reception separately of European, African, American, and
Asiatic plants." In eighteenth-century France, the landscaping of
botanical gardens was carried out to provide what one historian has
recently called "simulacra of different climatic and topographical
conditions." By geographical planting, as it was called, the garden
was intended to display the elegance and symmetry of global botany.
Not that it always did so with identical design arrangements. Some
used circles, some squares, some circles enclosed in squares, or a
dozen other variations (fig. 12). Either way, the prodigality of the na-
tural order was systematically tamed by symmetrical reconfiguration,
its blithe randomness brought under the reign of enlightened rati-
nality. The garden also reduced the global macrososm to a micro-
cosm, to what Francis Bacon called "a model of the universal nature
made private."

What remained dominant was a fascination with geometric pre-
cision and proportional symmetry. And this, as often as not, reflected
the belief that God had laid out the first garden in an orderly fashion,
so unlike the chaos and confusion of the postlapsarian world. This
was not invariably the case, of course. Seventeenth-century French
formal gardens used even more sophisticated geometrical arrange-
ments to express the economic success of mercantile capitalism. As an
item of conspicuous consumption or ostentatious exhibition, these
gardens declared their owners' social station in a period of burgeon-
ing elite consumerism. In so doing they moved nature from the do-
main of divine creation to secular property. As well as being sites for
accumulating botanical specimens, formal gardens were maps of
both social status and buying power.

Gardens could recover paradise. They could give decorative ex-
pression to economic might. And they could also be instrumental in
reversing the ravages of the biblical fall from grace by releasing the
medicinal powers embodied in its specimens. Spiritually, aestheti-
cally, and now medically, the garden was an exercise in restoration.
John Evelyn, in the mid-seventeenth century, asserted that gardening
was an empty occupation unless graced with some tinge of medicine.
Not surprisingly, the first " physic" gardens, as botanical gardens were
often called, flourished in the medical faculties of universities, at least
in part to shield apothecaries from unscrupulous traders in drugs and
roots. Associated teaching positions in what was referred to as the
“simples” were established to identify the curative properties of plants and to recover long-lost botanical-medical lore. The craft of the pharmacological botanist frequently involved reading the “signatures” of the vegetable world so as to specify which part of the body each plant was designed to treat. Walnuts, for instance, were understood as having the sign of the head, with an outer husk that looked like a skull, and therefore embodied substances suitable for treating head wounds. Because plants possessed virtues that could be released, the search was on to extend herbal knowledge to the newly encountered plants arriving from across the oceans. In this way the study of medicinal botany conferred on its practitioners power over nature and people alike. And gathering global plant riches into one space—the garden—was the best way of acquiring this power.

Botanical gardens, then, were multifarious spaces. They hankered after the Garden of Eden; they sought to reproduce global biogeography; they exhibited social standing; they wielded biomedical power. Whether as stages for the display of courtly ornamentation or as symbols of royal glory, as temples of divine contemplation or as theaters of useful natural philosophy, botanical gardens touched on the deepest needs of the state. Given these preoccupations, it is not surprising that it became increasingly fashionable to resort to political metaphors to describe the plant world. Plants were thought of as nations, each with its own provinces and member species. Such Enlightenment naturalists as Johann Reinhold Forster, Eberhardt Zimmermann, and Alexander von Humboldt treated plant associations as if they were political entities, and their methods of study were precisely the same as those that statesmen used in their political arithmetic. They were concerned with the social economy of the vegetable world.

Such political analogies flourished with particular vigor during the eighteenth- and nineteenth-century age of empire, when metropolitan gardens became the hub of botanical imperialism. Kew Gardens, for example, whose origins can be traced back to the 1750s, burgeoned under the vegetative booty brought back by men like the eighteenth-century botanist and scientific statesman Joseph Banks and his collectors, who engaged in worldwide horticultural plunder. Interest in the profit to be derived from economic botany, of course, was not all one-way. As in Amsterdam, crops were cultivated at Kew for export to the colonies. Thereby the gardens furthered the commercial vitality of the nation. Indeed, from the mid-1780s it became the center of a worldwide network of plant acquisition and exchange, a nodal point in what has been called the “Banksian” empire. Thousands of seeds, plants, and dried specimens, some covertly pillaged for commercial gain, others as mere instances of exotic curiosity, found their way to the ecumenical data bank at Kew. From Southeast Asia and the Pacific to the West Indies and Central America, an intricate system of plant trade came into being with the intention of harvesting the economic riches of Banks’s botanical empire. Hemp seeds, tea plants, mulberry, natural lacquers, tung oil, fiber plants, citrus, avocado, and myriad other items were sought as diet and drug, dye and decoration. As Banks exploited his contacts with diplomats and navy officers, missionaries and traders to garner the world’s plant riches, Kew took delivery of a nutmeg tree, and mangosteen from Java, plants by the boxload from Canton, Tahiti, Tasmania, and New Guinea, and packages of seeds from India. Regulating the botanical traffic that flowed back and forth between metropolitan core and colonial periphery, Kew enriched the fiscal and scientific capital of the empire. And to sustain the industry in horticultural cargo, satellites of Kew (often directed by Kew-trained curators) developed in such places as Jamaica, St. Vincent, St. Helena, Calcutta, and Sydney.

If botanical gardens were agents of empire, they were no less sites of experiment and enlightenment. Whether tropical plant species could acclimate to temperate zones, and vice versa, was a scientific question as important to imperial success as to intellectual progress. Precisely because Kew Gardens was one of the great exchange houses of the empire, it became a testing ground for trials in botanical acclimatization, a project in remaking nature to suit the new industrial order. At the instigation of Banks and his collaborators, varieties of hemp and flax, trees and vines, fruits and vegetables all crisscrossed the globe in hopes of adapting them to new climatic regimes. The
botanical garden was often their first port of call. Plant collections were a prime location in the pursuit of useful knowledge, and under Banks's influence Kew became the archetype of Enlightenment botany. As he himself noted with pride, "Our King at Kew and the Emperor of China at Jehol solace themselves under the shade of many of the same trees and admire the elegance of many of the same flowers in their respective gardens." Such pleasures attested to the run-away triumphs of botanical acclimatization.

But it was not just plants that were the subject of such inquiry. Precisely the same questions arose over animal trafficking. And discovering how animals adjusted to new climatic conditions (if they did) often became the opening gambit in campaigns for the creation of modern zoological gardens. Whether animals belonged in botanical gardens was a long-standing and unresolved dilemma. Thomas Aquinas, for example, suspected that after Adam had named them, the animals were excluded from the Garden of Eden, whereas Basil and Augustine insisted that their presence gave Adam and Eve much pleasure. So while some sought to keep the botanical garden free from animal intrusion, others thought it should incorporate all aspects of creation, and they therefore supplemented geographical planting with animal representations of the continents—the zebra for Africa, the llama for the Americas, and so on. In consequence, many royal botanical gardens such as those at Kew and Versailles housed small menageries of exotic creatures.

Insofar as zoological gardens were bound up with animal domestication and acclimatization, they were invariably implicated in colonial projects (fig. 13). Three nineteenth century zoos—in Britain, France, and Australia—nicely illustrate this association. When Stamford Raffles, founder of the Zoological Society of London, returned in 1824 from his imperial adventures in the East, he was irked to find that Britain was lagging behind other European nations in matters of zoological display. Despite its glorious global empire, Britain's facilities for exhibiting exotic animals amounted to little more than fairground sideshows and frivolous entertainments—mere spectacles for titillating the vulgar—not to be compared with the "magnificent institutions" of its Continental neighbors. To relieve this cultural embarrassment in a manner befitting the grandeur of an imperial power, Regent's Park Zoo opened its gates in 1828. When addressing its landowning constituency, the zoo rationalized its existence by stressing its concern to domesticate exotic species and acclimatize them for English parks—and men. After all, the anatomist Richard Owen of the British Museum and the London naturalist Frank Buckland, both enthusiastic advocates of acclimatization, later organized "exploratory and adventurous" dinners to support their obsession with domestication. Such delicacies as kangaroo steamer, Hondurian turkey, Syrian pig, and tripang soup made from Japanese dried sea cucumber all featured. These dinners were experiments in gustatory geography. When advertising its wares to the scientific community, by contrast, the zoo presented itself as a reservoir of taxonomic data without reference to table fare or ornamentation. The
zoo thus existed in the shared space between applied natural history and Linnaean science. Either way, the vast array of specimens displayed in the zoological gardens served to draw attention back to Britain’s ecological imperialism. The zoo, we might say, was a rhetorical site of empire, its animals intended to symbolize Britain’s biogeographical dominance of the world. The globe, it seemed, existed to serve Britain—gastonomically as well as scientifically.

Much the same was true of the Paris collections. Three generations of the zoologically inclined Geoffroy Saint-Hilaire family were vital here. Étienne founded the menagerie at the Paris Museum of Natural History in the 1790s, his son Isidore promoted the Jardin Zoologique d’Acclimatation, and the grandson Albert succeeded to the directorship of the Jardin for nearly thirty years. In one way or another, these various collections reflected the country’s colonial, diplomatic, and commercial activities, especially in North Africa; and as the century wore on, the acclimatization garden came to enjoy the imperial patronage dispensed by Napoleon III. As in Britain, here too there were tensions between pure and applied zoology. The pendulum swung from utility to science at different times, and between the needs of the naturalists and the amusement of the general public. Either way, breeding and dealing in exotic animals were seen as contributing to agriculture and industry, scientific advance and commercial success alike.

The French scientific community had had a long-standing interest in acclimatization, not least because it bore directly on matters of adaptation, inheritance, and evolutionary change. In fact by the mid-nineteenth century the Jardin, which originated as a royal physic garden, was in large measure the public laboratory of the Société Zoologique d’Acclimatation, which had come into being in 1854. Successful long-term adaptation of species to new environmental niches would do much to confirm the doctrine of the inheritance of acquired characteristics and thus the biological transformism rooted in the earlier ideas of Georges-Louis de Buffon, who had been intendant of the Jardin for nearly fifty years, and Jean-Baptiste de Lamarck, zoology professor at the Muséum d’Histoire Naturelle, its

14. Plan of the Jardin Zoologique d’Acclimatation, which opened in Paris in 1860. The Jardin presented colonial France’s faunal resources and included such exotic specimens as Moroccan wild sheep, Angora goats, and Tibetan yaks. Only exhibits of “public utility” were to be displayed, and the concern was to ensure that they could acclimatize to a new environment. As the Jardin, scientific inquiry was intimately bound up with matters of imperial practicality.

successor institution. Yaks from Tibet, wild sheep from Algeria, Angora goats, Egyptian ibis, and llamas from Chile, when gathered into zoo space and appropriately displayed, could advance French science, proclaim the nation’s colonial splendor, and help visitors conjure up an imagined round-the-world safari (fig. 14).

Acclimatization also had a central role in the genesis of the Melbourne Zoo, not least through Edward Wilson, an English-born editor of the Melbourne newspaper the Argus. Wilson was fully aware of the acclimatization projects of the Parisians, and thoroughly impressed by their ideals, he began a public campaign in the late 1850s for introducing new plants and animals into British colonies. More particularly, he passionately believed that Australians had a right to the ornithological pleasures and hunting thrills of old England. It was utterly shameful, he felt, that despite its geopolitical domination of
the globe, Britain was failing to redistribute the ecological riches of its empire to its far-flung colonies. And so he embarked on an untiring campaign to establish colonial acclimatization societies. Thanks to his efforts and those of Thomas Embly, a medical doctor and political activist, an experimental farm and zoological society emerged in 1857. Though it was short-lived, it eventually resurfaced as the Royal Melbourne Zoological Gardens.

It would be mistaken to imagine that modern zoos owe their existence exclusively to the post-Enlightenment fascination with acclimatization. For a start, menageries were in existence as long ago as 2500 BC in Egypt; Ptolemy, in the third century BC, founded a zoo in Alexandria; in ancient Rome vivaria—animal holding zones—were available for public scrutiny; and the Aztec emperor Montezuma kept a great aviary and animal enclosure. Moreover, royal households routinely collected and exhibited exotic creatures as a mark of prestige and power, and during the sixteenth century numerous menageries surfaced in the rising urban centers of Europe and North Africa—Prague, Karlsburg, Constantinople, and Cairo—at least in part as a mark of civic pride. The menagerie of Versailles, it has been said, was “first and foremost a political testament to the power and majesty of the king.” Louis XIV.

Nevertheless, the efflorescence of zoological gardens in the nineteenth century owed much to the intellectual and commercial potential of acclimatization-related matters. And there are grounds for suspecting that these preoccupations were not isolated from related anthropological questions about the effect an alien climate would have on human colonial populations. That such obsessions were never far from the minds of zoo magnates is clear from the incorporation of ethnographic exhibits into leading nineteenth-century zoos. Carl Hagenbeck, famous for his development of the zoo “panorama,” in which animals came out from behind bars and inhabited open spaces, introduced what he called “anthropological-zoological” exhibits into his Hamburg Tierpark in 1874. That year he had Lapps acting out daily life with reindeers before enthusiastic audiences. Over the following half century he orchestrated some seventy ethno-}


graphic performances, Oglala Sioux performing ritual dances in the shadow of a constructed mountain being among the most popular. Similarly, Albert Geoffroy Saint-Hilaire enlisted caravans of Nubians, Canadian Inuit, and troops of Argentinian gauchos in the hope of maintaining public interest in his Jardin. And in 1906 an African Pygmy named Ota Benga was put on display in the Monkey House of the New York Zoological Park.

Such scientific “staging” of human subjects had profound ramifications, not least when such enterprises were replicated in colonized societies. In nineteenth-century India, for instance, the Asiatic Society proposed to the government that ethnological exhibits be appended to the General Industrial Exhibition of 1869–70. The proposal that aboriginal peoples should be displayed was made partly on the grounds of their anthropological peculiarities, partly because they would make good laborers around the exhibition grounds. All this had an unforeseen double effect. By showing such “specimens” as “types of man,” it queried the normality of European conceptions of the human race. At the same time it distanced the intellectual elites of both Europe and India from those irrational bipedal members of the species.

The zoo, then, sometimes presenting itself in the metaphorical shape of the laboratory, took on the dimensions of theater. In so doing it also renegotiated the boundary between the animal and the human, the spectacle and the spectator, the viewer and the viewed, the rational and the wild—a boundary line that followed the contours of what was considered strange, exotic, peculiar, outre, other. The zoo thereby became a space reinforcing the profound sense of difference between exhibits close to nature (both animal and human) and visitors above nature.

Seen in this light, the zoo emerges as both a scientific and a theatrical space. The African Plains exhibit at the New York Zoological Society in the 1940s, for example, was little short of a simulated safari. Here a tribal village—surrounded by everything from warthogs to zebras—was re-created to instill a sense of adventure. Soon other wildlife parks were defending their existence on the scientific claim
that exotic species had to be studied in their natural habitats. To achieve that, big game had to be enclosed by invisible, but no less real, steel fencing. In this guise the zoological garden fused the functions of field station and open-air stadium. Besides, the zoo was also a space of domination. By imposing order on the animal kingdom, organizing its exhibits along a rigid linear pathway, and caging dangerous large carnivores a tantalizing arm’s length away, the nineteenth-century zoo testified to human triumph over the wild. Zoos, it has been said, “reenacted and celebrated the imposition of human structure on the threatening chaos of nature.” The keeping and showing of wild animals was simultaneously emblematic of human power over the natural order, of metropolitan control over peripheral territory, and of imperial dominion over colonial empires.

Botanical and zoological gardens occupy a distinctive niche in the ecology of scientific practice. Spaces both of experimentation and exhibition, and open to the gaze of public visitors, they nonetheless accommodated inquiries very different from those carried out in the laboratory and the museum. Whether as agents of empire, sanctuaries of contemplation, or theaters of art, whether as symbols of power, reservoirs of medication, or maps of knowledge, gardens embody their own distinctive spatial formations of scientific knowledge.

**Spaces of Diagnosis**

Like the museum, the garden, and the zoo, the hospital stands both within the worlds of science and public culture and between them. Here, however, the concern is with diagnosis rather than display, with delivering care rather than accumulating objects. Still, it is only in the past century or so that the hospital has come to enjoy whatever positive images these pursuits convey. Before the twentieth century, most health care was dispensed in the home, and the hospital was disparaged as a site of destitution and danger. It was a risky space occupied by the destitute and friendless who had no option but to place themselves under the care of strangers. Indeed, in France and Italy these places had more general correctional purposes. Paupers, petty criminals, and prostitutes, among many others, shared space with the ill and infirm. It was not until the end of the eighteenth century that efforts were being made to disentangle the hôpital Dieu for the sick from the hôpitaux généraux for social outcasts of various stripes. The history of the modern hospital can be traced back to the monastic infirmary, the almshouse for the hopeless, army barracks adapted to tend the wounded in wartime, plague houses, and various other institutions that from time to time had to care for the sick. Modern hospitals, it is clear, had to carve their own specialist space out of existing establishments that happily mingled spiritual discipline, forced labor, psychotic restraint, cold charity, and treatment of the ill.

At the same time they had to work hard to shed the image of contamination and corruption in order to dispel the fears of those who condemned hospitals as pestilential swamps exhalting illness. After all, in late eighteenth-century Paris hospitals had beds occupied by as many as half a dozen patients, with little effort to keep separate those with contagious diseases, women in advanced stages of labor, and the dying. To overcome negative images of this sort, physicians themselves made such radical proposals as demolishing hospitals every half century or so to interrupt the cycle of disease transmission because, as one observer noted in the mid-1870s, hospitals did more harm than good. Sir James Simpson, who introduced chloroform anesthesia into Victorian medicine, even coined the term “hospitalism” to describe these morbid conditions. He once remarked that in hospital surgery patients were “exposed to more chances of death than was the English soldier on the field of Waterloo.” Given that Victorian surgeons operated on sawdust-covered tables in old, blood-crusted garments and generally washed their pus-smeared hands only after surgery, it is small wonder that the rich elected to stay at home when sick.

As the meaning of hospital space moved with social judgment, so its changing architecture mirrored shifts in disease theory. In the nineteenth century, the miasmic theory dominated, postulating that disease was a consequence of noxious emanations. The matter of air
flow through wards was understandably paramount. Florence Nightingale, for example, was preoccupied with ventilation because she was convinced that infectious diseases moving through the air could pollute a hospital’s entire atmosphere. And her *Notes on Hospitals* of 1859 cited grim statistics to support her case. Hospital designers became obsessed with countering miasmas and giving priority to open spaces and patient isolation. The so-called Nightingale Ward—an oblong structure with windows on both sides, stripped of all unneeded accoutrements—was designed to prevent air stagnation and maximize circulation (fig. 15). This basic prototype spread rapidly through postbellum America and famously crystallized in the one-story pavilion style developed by John Shaw Billings in 1875 for the Johns Hopkins Hospital. With the triumph of the germ theory, such arrangements were deemed neither necessary nor desirable. Hospitals were no longer regarded as dangerous disease quagmires; rather, they were specialist sites where infectious germs were identified, isolated, and dealt with. This transformation meant that the hospital could now promote itself as a scientific shrine with diagnostic laboratories and clinical technologies; and the wealthy willingly came for care. Architecturally, the flat pavilion began to disappear, to be replaced by the towering column. Culturally, the general public met the world of high-tech science when it crossed the threshold of hospital space. The hospital had established itself as the scientific nerve center of the medical world.

But it was not just miasmas and germs that were the objects of medical management within the confines of the hospital; the patients too were subject to various forms of disciplinary regulation. For hospitals have also been moral spaces manifesting the values of their surrounding cultures. Under the patronage of charitable institutions, for example, hospitals expressed their patrons’ spiritual ideals. In such environments patients were often treated as “moral minors” in need of correction and instruction. Medical prescription and moral orderliness thus went hand in hand. Rigid rules governed behavior in communal wards. To meet the demands of centralized supervision and training in moral compliance, an austere architectural structure was

15. Plan of a typical Nightingale ward. The spatial layout reflected Florence Nightingale’s miasmatic conviction that circulation was of primary importance in hospitals in order to prevent air stagnation. The requirements of light and ventilation were to be met by one window to every two beds. This spatial arrangement was a radical departure from eighteenth-century practices where the walls directly hindered natural ventilation.
believed necessary to provide patients with both medical and moral therapy. Decorated porticoes and fancy arches may have graced the main entrance, but the patient annexes were plain and unvarying. While the hospital’s public facade celebrated its donors’ munificence, the patient wings conveyed virtue through orderliness and regularity (fig. 16). Seen in this light, hospital design was a sermon in bricks and mortar on the medical benefits of moral discipline as fundamental to healing. The hospital’s walls silently but sternly let its occupants know how doctors and patients were supposed to relate to each other, how visitors should behave, who was in authority, and where medical and moral power resided. And lest the message be missed, a plaque in every ward of St. Thomas’s Hospital in London told its pauper sick, “Cleanliness gives Comfort; Sobriety brings Health.” In this way medicine played its part in managing the social body by disciplining individual bodies. The aesthetics of hospital space have thus always articulated the core values and beliefs of the medical profession.

If hospitals have been vehicles for transmitting moral values, they are no less sites where new ethical dilemmas have been created. Consider how this is dramatically revealed in the emergency room. And bear in mind that a century ago accident victims were not brought to a hospital at all; they were routinely treated in domestic space, often the kitchen. The concept of a medical “emergency” was not even part of the clinical lexicon a century ago. Nowadays, in the case of cardiac arrest, the patient is frequently rushed to the hospital by a paramedic team, kept technically alive by rhythmic chest compressions, artificial respiration, and a whole repertoire of electronic devices during a speedy transit from the point of attack. In a space dedicated to emergency treatment and equipped with an impressive range of laboratory-style appliances, the physicians on call find themselves facing new ethical problems—generated by the very clinical technology that has delivered the latest case to them—whether to continue trying to resuscitate. Doing the “right” thing is not just a clinical calculation or a fiscal assessment. It is a moral judgment, and one extraordinarily local to the conditions of its making. Just who the doctor is, is under negotiation; for in encountering a patient who has

no say in the matter, the physician faces up to his or her self-understanding as a “healer” in the frontier zone between life and death. The space of emergency medicine is a space of ethical practice where unique clinical and moral choices have to be made.

While we now routinely think of hospitals as sites of scientific knowledge and medical education, their acquisition of such functions has a history too. At least in part these initiatives—which surfaced in late Enlightenment Europe—reflected broader changes in natural philosophy as the new medicine found inspiration in the empirical methods championed by the likes of the English philosophers Francis Bacon and John Locke. In eighteenth-century France, for instance, the triumph of experience over theory that Locke’s disciple Étienne Bonnot de Condillac advocated was taken up by P. J. G. Cabanis, who preached the value of hospitals for medical instruction and investigation and railed against the sterile speculation of “the old medicine.” In Edinburgh John Rutherford began clinical lecturing in the mid-
1700s, and a dedicated teaching ward was established. Besides, the hospital could provide a steady supply of unclaimed cadavers for anatomical instruction in dissection halls. By the middle third of the next century, the practices of bedside diagnosis, medical students' "walking the wards," and daily visits to the morgue had been firmly established. All of these confirmed that medical knowledge was gleaned from local, on-the-spot experience and from deciphering patient symptoms. Not surprisingly, it was out of such experience that the primary importance of standard clinical arts like inspection and percussion, the invention of the stethoscope (by R. T. H. Laennec in 1816), and the use of the compact case history were born. The bedside had emerged as itself a diagnostic space where the student was trained to read the signs of disease. Medical knowledge acquired and applied in hospital settings was thus part and parcel of a wider economy of healing that encompassed technical know-how, hard-won local wisdom, hands-on experience, and moral management.

The idea that hospital interiors are readable cultural spaces is perhaps nowhere more clearly disclosed than in what were called insane or lunatic asylums. Certainly asylums did not exhaust the spaces of insanity. In the medieval period, for instance, the "mad" might be found wandering in fields and forests, restrained in jail-like constructions, sheltering in havens of relief, or hanging around quasi-religious sites of holy waters. Our focus, though, is on the asylum, and here the multilayered character of institutional space dramatically surfaces. To begin with, asylums have regularly been sites of surveillance dominated by the imperatives of supervision and control. This means that, unlike the general hospital ward, their inpatient units have often been small or single rooms, organized to maximize scrutiny. To be sure, detailed architectural arrangements differed from place to place: in Germany, the 1655 plan of Joseph Furtenbach took the form of a Roman cross, the late eighteenth-century French asylum at Salpêtrière had back-to-back cells around a central square, and Glasgow's lunatic asylum erected in 1810 was built using a panoptical cross ward system. But the emphasis was on prisonlike surveillance. As for the internal management of space, the ways in-

mates have been spatially organized is itself a commentary on the social order. At Salpêtrière during the era of the French Revolution, the layout segregated patients into a bipolar taxonomy of "curable" and " incurable" and reserved enclosures for "idiots," "escapists," and "sowers of discord." Clearly the asylum was as much a space of social policy as of medical treatment.

Asylums were scientific spaces too. Take the fact that until the early nineteenth century the insane were deprived of heat in their cells. This was done on the literally dehumanizing medical principle that since they had lost their reason—the feature that distinguished human beings from the rest of the animal order—they were simply beasts and therefore did not feel the cold. Such designations made it entirely "reasonable" to deploy a frightening arsenal of restraining equipment—leg locks, iron chains, screw gags, restraint chairs, and so on—to exercise medical control. In the Middle Ages the aim of incarceration was exorcism; in the seventeenth century it was reestablishing political order; during the Enlightenment it was disciplining "unreason." Whichever applied, the asylum was a site of scientific and moral therapeutics. Not surprisingly, behind the sometimes palatial exteriors—as with the infamous Bethlem Hospital (Bedlam), built in London in 1676—was an interior landscape of fear (fig. 17). Indeed, in some institutions "fear therapy" replaced chains as the favored mode of treatment. Francis Willis, famous for his treatment of King George III in the mid-eighteenth century, boasted that he could tame a maniac merely by the mesmeric power of eye control. Here, as in France, Germany, and Italy, was a moral regimen of authority that traded in a compound of rewarding good behavior with favors, instilling terror of chastisement, and gently distracting a patient from delusions. In large measure the idea was that treatment should be aimed at the emotional and intellectual faculties alike.

Asylums have been spaces both of surveillance and of scientific-moral therapy. They have no less been sites of public entertainment, at least until the end of the eighteenth century. At the colloquially christened Bedlam, visitors could pay a penny to walk around the wards for amusement. At times this took the form of active spectator
the constitution of the Age of Reason itself. Enlightened thinking simultaneously created those benighted spaces and expelled them to the edges of social significance.

By the nineteenth century the hellish associations with which many madhouses were yoked began to be replaced by different imagery—though abuses certainly remained. Psychiatric practitioners like John Conolly and W. A. F. Browne now celebrated the asylum as a progressive institution. Inside, asylums were to be spacious, airy, and elegant, fitted out with galleries and music rooms; outside, they were to be positioned on elevated sites and surrounded by gracious gardens with extensive walks (fig. 18). Exterior geography, it was believed, was as important as interior design. Consider the opinions routinely advertised in the *Asylum Journal of Mental Science*—a serial that came into being in the mid-nineteenth century on the cusp of psychiatry’s efforts to both professionalize and medicalize itself. Strenuously protesting that it was physicians who should care for “lunatics,” it sought to synthesize medical and moral treatment of the insane. And it was in the context of this “medical-moral discourse” that extensive grounds and gracious gardens were promoted as a means of removing patients from disturbing sensory inputs. In practice this often meant that rural situations were preferred. An antiurban rhetoric predominated because towns were supposed to militate against the required medical-moral regimen. Tranquillity and serenity were the mental conditions sought within the asylum; they were to be diagnostic of its natural landscape too. In seeking to secure such environments, visiting magistrates would evaluate everything from soil type and rock form to water supply and climatic conditions in both moral and medical terms. “A poor, cold, stiff clay,” a contributor to the *Asylum Journal* insisted in 1856, “is by no means eligible for the site of a lunatic asylum.” Plainly, an asylum’s geographical location was as fundamental to the recovery of mental health as its interior spatial arrangements. For as the superintendent of the Coppice lunatic hospital in Nottingham observed, landscape views could divert deranged minds from “imaginary grievances” and “gloomy and distressing thoughts.” Here again medical knowledge was located

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17. The palatial facade of Bethlehem (Bedlam) Hospital in 1676. Behind this regal frontage was a landscape of fear where most patients were kept behind bars to leave the corridors free and safe for visitors who came for amusement.
within a wider moral order in which connections between interior psychology and external geography were assumed. Moral judgment, mental state, and medical treatment were intricately interwoven.

The Body of Scientific Knowledge

Spaces of therapy are not restricted to architectural structures like the hospital or the asylum. The body itself has often been a site of scientific diagnosis. Edward Jenner, for example, who discovered that dairy workers who had been exposed to cowpox were immune to smallpox, deliberately infected people with cowpox in 1796 to protect them from smallpox. Animal bodies too continue to be spaces of scientific knowledge. It has been estimated that over 100 million animals are used each year in scientific experiments. Whether in laboratories, in the field, on spacecraft, or in a dozen other places, the animal body has been used to test pharmacological, cosmetic, and medical products and devices. Rabbits have been used in toxicology work, rhesus monkeys for experimental surgery, rats in polio research, and horses in investigations of emphysema. And perhaps most spectacular of all, the humble fruit fly was the subject of intensive research in experimental genetics at the University of Columbia's Drosophila fly lab throughout the first half of the twentieth century.

In this basic sense, the body is a space of scientific endeavor. In many sites—some sinister and secretive, others curative and civic—bodies have been the objects of experimental inquiry. But body space merits our attention in various other ways too. Scientific knowledge has routinely been considered incorporeal and transcendent. And yet, as we will presently see, science has been profoundly embodied in all sorts of ways. Attending to this most local of scales—the body itself—is thus an essential component in cultivating a geography of scientific knowledge and practice.

Because we have just been considering the hospital as a diagnostic space, it will be useful to continue this theme for a little while and dwell on the body as a site of medical experiment. Medical trials, of course, are always executed in some social space, and this is what gives meaning to the practices that are undertaken. Tests carried out on women using oral contraceptives are illustrative. Though the results were routinely presented as demonstrating the effects of the drugs on the “female body,” in fact the contexts within which women’s bodies became scientific sites made dramatic differences to the very nature of the project. Initially tests were carried out on infertile women in the early 1950s with the aim of inducing pregnancy. The discovery that progesterone inhibited ovulation resulted in larger-scale trials of the pill. The original project was significant because immediately after World War II childlessness was regarded as undesirable. Within a decade mores were changing, and millions of women were turning to oral contraception as a means of planning families for a modern world. Conditions were radically different for the Puerto Rican women who were used in another pilot study in 1955. The long history of colonial population policies that Puerto Rico had already experienced, the fact that contraception was illegal in many states of the
United States in the 1950s, and a fear of possible breeding grounds for communism all made the United States’ former colony an ideal space of experimental practice. In this context, contraception was regarded as an essential weapon in a racial struggle for global dominance in a world now believed to be carrying a population time bomb. Here the female body—construed as biologically fecund and ecologically risky—was at once a scientific site and a space of cultural conflict.

The human body, however, has been a site of scientific knowledge in altogether more sinister circumstances. Witness the grotesque medical experiments in what was euphemistically known as racial hygiene in Nazi Germany. In a culture mesmerized by a xenophobic politicizing of biology, the idea that there were “lives not worth living” began to grip. Adult and child euthanasia of the physically and mentally retarded fit comfortably with the campaign to eliminate various ethnic groups. The notorious experiments during the 1940s in such concentration camps as Dachau, Auschwitz, Buchenwald, and Sachsenhausen were merely the extension of an already well-established social policy. Here the adjective in the label “Nazi science” certainly makes sense. For in these corrupt spaces victims were compelled to drink sea water, to undergo limb transplants, and to endure temperature extremes to provide scientific knowledge. How long could a person survive in icy water? What effects do particular bacteria have on the body? How effective was a newly developed vaccine for spotted fever? How long does it take a man to die in very low pressure? What happens when a woman is infected with some malignancy and then treated with a new drug? Answering these scientific questions in the dark space of Buchenwald alone cost eight thousand Russian lives. Here the price of scientific light was moral darkness.

But it is not just in the context of medical experiment that bodies have been sites of scientific inquiry. Alexander von Humboldt, Prussian geographer and scientific traveler, used his own body as a recording instrument on his expedition to South America between 1799 and 1804. To be sure, he took with him a seemingly endless supply of standard apparatus—chronometers, sextants, dipping needles, compasses, barometers, thermometers, rain gauges, aeromotors, theodo- lites, an achromatic telescope, a cyanometer (for measuring the blueness of the sky), and on and on. But instrumentation, we should recall, was intended to extend the range of human sensory organs. The seventeenth-century moral and political philosopher John Locke suspected that angels were blessed with microscopical eyes. Other contemporaries added that the biblical Adam had no need of spectacles, living as he did in a pre-Fall world. Optical devices, it was suggested, could overcome the sensory frailties of fallen humanity and endow natural philosophers with Edenic faculties. Thus Robert Hooke, in his Micrographia of 1665, insisted that instruments could help observers come close to Adam’s prelapsarian capabilities. So, even with the use of appliances, science was still a profoundly embodied pursuit.

And yet, in an even more immediate sense, Humboldt had to depend on the reliability of his own body to acquire knowledge of the environments through which he passed. When he applied electrodes to himself to ascertain the effects of an electric current on a secretion of blood and serum derived from deliberately raised blisters on his back, he was using his body as itself an instrument. Undeterred by the decidedly uncomfortable results, he later repeated the test, this time using the cavity left after a tooth extraction. And then in South America both he and his companion Aimé Bonpland used their own bodies as virtual Leyden jars to test the discharge from electric eels—with fairly nasty results. In a yet more general sense, bodily changes registered the shifting environmental conditions that both Humboldt and Bonpland experienced as they made their ascent of Mount Chimborazo in June 1802: they got dizzy, their eyes became bloodshot, breathing was difficult, their lips oozed blood. Yet this was precisely to be expected because, as Humboldt himself later reflected, the body was “a kind of gauge” registering atmospheric rarefaction. Barometric readings merely confirmed what their bodies had already told them. For Humboldt these were life-changing experiences. They established his massive reputation as a scientific traveler. But they had such a visceral impact that forever after he kept his dwelling quarters back home heated to tropical temperatures. Whatever effect he had on the tropics was nothing to the effect the tropics had on him.
In acting as an incarnate Leyden jar, Humboldt was not unique. A whole clutch of electrical experimenters during the eighteenth century had freely used their own, and sometimes others', bodies as instruments. In the 1730s, for example, Charles Dufay, intendant of the Jardin du Roi, suspended himself from silk threads to demonstrate how leaf metal was attracted to a body after electrification. He thus went further than an English counterpart who recruited a schoolboy for the same experiment. Besides all this, others subjected themselves to the ecstasies of gas, exposed themselves to blinding sunlight, and used electrical currents to stimulate muscular spasms. In one celebrated case, a seventeenth-century Cambridge graduate allowed fellows of the Royal Society to transfuse sheep's blood into his veins.

When experimenters conducted trials on themselves, they were as often as not engaged in critical exercises in scientific warrant. By this I mean that calling on direct bodily experience was a strategy to provide firsthand testimony that was literally self-witnessing. This seemingly simple appeal to what we could call "the body of evidence," however, was never conducted outside some wider culture of inspection. For a start, in an era of theatrical illusion, public scientific demonstration had to divine ways of avoiding the charge of mendacity or delusion. Moreover there were always questions about precisely whose body—and whose mind—could be trusted to deliver truths. Only the genteel, it was widely believed, were sufficiently self-possessed to bring rational minds to bear on unruly bodies. With too much love of the fabulous and too little love of integrity, "menials," as they were called, could not to be relied on to bear witness. Bodily evidence thus followed the contours of social geography. One mid-eighteenth-century French student of medical electricity, Jean-Antoine Nollet, was unwilling to admit into the circle of experimentation "either Children, Servants, or People of the lower Class." This effectively barred from the "republic of learning" whole sectors of society whose testimony to their own bodies could not be trusted. Self-evidence was always a social product. Appeals to direct perception as the justification of knowledge were thus largely rhetorical. What passed as "immediate experience" was actually the result of negotiations over who was a reliable witness and who had the standing to provide dependable reports.

Josef Mengele's repulsive experiments, Humboldt's embodied collisions with the tropical world, and the electrifying of limbs by eighteenth-century experimentalists serve, in morally different spaces, to remind us that scientific knowledge has taken bodily form in that the body has been the locus of experiment. But we might press a little further in entertaining the thought that scientific rationality has been incarnated in an even more profound sense. Traditionally, reason has been seen as a bodiless thing, incorporeal and transcendent. The processes of thinking, and the products of thought, were considered purely rational undertakings; ideas seemed to float free and clear above the messiness of material existence. In this way knowing could be divorced from living, head work separated from manual labor, minds severed from bodies. The standard breach between embodied life and disembodied knowledge, however, is not all that easy to sustain in the light of several considerations. And here we will pause to consider just three issues that render the rupture troublesome—what I will call self-denial, sex, and situatedness. All point to the inescapably embodied nature of knowledge making.

In earlier times it was widely believed that there was a close connection between bodily discipline—not least dietary temperance—and the capacity for knowledge and wisdom. Brain and belly, spirit and stomach were not divorced in the way they are today. In both the ancient world and the medieval Christian tradition, self-denial was taken to be a precondition for genuine knowing. Asceticism and wisdom routinely went together, as implied by the New Testament record of Christ's fasting and withdrawing into the wilderness to meditate. Insight and indulgence, scholarship and sensuality were incompatible. Rather, bodily subjection and regulated consumption were seen as a prerequisite for achieving enlightenment. In large measure, what motivated these associations was fear of uncontrolled carnality, because gluttony was believed to incite moral mayhem. Temperance was thus venerated as a sacred and a cognitive virtue; spiritual health and intellectual clarity alike required bodily modera-
tion. Two ironies are noticeable here. First, the ideal of disembodied
knowledge could be achieved only through rigorous management of
bodily appetites. One had to be obsessed with the body to escape from
it. And second, the very religion that seemed to call for disembodied
truth was equally committed to the idea that, in the person of Jesus
Christ, truth had taken bodily form. The incarnation was precisely
about the word of truth becoming flesh. These ironies notwithstanding,
the rigid regimens of disciplined consumption the philosopher
was required to engage in bore testimony to the suspicion that genu-
ine knowing was anything but disembodied.

If the kingdom of natural philosophy was forbidden territory to
the undisciplined body, it was no more accessible to other bodics—
particularly those of women. For all the rhetorical claims to the dis-
embodied character of scientific knowing, there was a long-standing
"understanding" that female corporeality rendered women unsuit-
able for intellectual pursuits in general and for science in particular.
Scientific space, by and large, was masculine space. This is not to say
that women have never engaged in scientific pursuits. In early mod-
ern Europe, for example, noble birth or craft skills did allow some
women to participate to some degree in science. But on the whole
women were excluded from the domain of natural philosophy, often
on corporeal grounds. In the ancient world, given the idea that the
body was composed of the four elements of earth, air, fire, and water,
the female body was considered inferior because it was supposedly
deficient in heat. Much later, in the eighteenth century, the female
skeleton was declared to be unfinished and distorted, the configura-
tion of the skull in particular being taken to show intellectual inferior-
ity. Soon evolutionary speculation would lead some to suggest that
the female body was in a state of arrested development. And the same
line of anatomical argument was used to marginalize non-Western
peoples.

Given these preoccupations, it is not surprising that speculations
of this stripe were called on to keep science a white, male preserve. On
the racial front, such celebrated eighteenth- and nineteenth-century
philosophers as Hume, Kant, and Hegel were certainly in sympathy
with this viewpoint. Hume insisted that the people of the tropics were
"incapable of all the higher attainments of the human mind"; Kant
dismissed the peoples of the same zone as cripplingly lethargic; and
Hegel insisted that Africans had "not progressed beyond a merely
sensuous existence." As for the exclusion of women, it was in the very
1834 publication where he coined the term "scientist" (tellingly, a re-
view of a scientific work by Mary Somerville) that the English as-
tronomer and philosopher of science William Whewell confessed
that there was, after all, "a sex in minds." Forty years later Henry
Maudsley, professor of medical jurisprudence at University College
London and a leading advocate of an evolutionary science of mind,
spelled out the wider implications of this stance in an article titled
"Sex in Mind and Education." By then, many Victorian scientists
were regularly feeling the urge to declare themselves on science and
"the woman question." Darwin told the readers of *The Descent of
Man* in 1871 that "man is more powerful in body and mind than
woman." A few years earlier Thomas Henry Huxley had expressed
his disquiet at what he called the "new woman-worship," not least be-
cause he was sure that "five sixths of women . . . stop in the doll stage
of evolution." And George John Romanes went so far as to claim that,
psychologically speaking, males and females belonged to different
species. Meanwhile a host of figures felt the need to remark on the
childlikeness of women or on woman as "undeveloped man." The
late nineteenth- and early twentieth-century American psychologist
G. Stanley Hall, for instance, insisted that girls should be educated
primarily for motherhood. In the light of these prescriptions, it is not
surprising to find observations like that of the American Edward
Clarke, author of *Sex in Education* (1873), disparaging female college
graduates as "mannish maidens" for whom the price of education
was "undeveloped ovaries." It became a common thing to find writers
turning to current biological wisdom to justify what they called the
physiological division of labor. No less common were the medical
warnings issued to women travelers about the heavy toll a tropical cli-
mate exacted on the female body and psyche. Women who engaged
in field science or had educational aspirations not only were risking
their own bodies and their children, they were jeopardizing the race by taking a retrograde evolutionary step.

The female body, then, was long seen as an illegitimate site of scientific learning. Ironically, only certain bodies—male and white—had the capacity to generate disembodied knowledge. And that “disembodied knowledge” included the idea that mental differences between the sexes were biologically based! Women had become the victims of the pursuit from which they were by and large barred—science itself. The consequences were certainly long lasting, not least on the institutional geography of science. It was only in 1945 that women were admitted to the Royal Society; and it was not until over thirty years later—1979—that the French Académie des Sciences opened its doors to women.

The rigors of self-discipline as a precondition of readiness to receive wisdom, and the edging of women’s bodies to the margins of scientific pursuits, suggest that, despite robust protestations to the contrary, there has been a persistent suspicion that scientific knowledge is all too embodied. And for good reason. If it is true that scientific instruments help knowers “sense” the world in ever more subtle and sophisticated ways, then implements can be considered extensions of sense organs. The twentieth-century chemist and philosopher Michael Polanyi fastened on this feature of scientific instrumentality when he judged that using instruments enlarges our senses. In one way or another, then, the body is always in service as the “basic instrument” of our intellectual engagement with the world. “Every time we assimilate a tool to our body,” Polanyi wrote in 1959, “our identity undergoes some change; our person expands into new modes of being.” Accordingly, “in all our mental achievements we rely ultimately on the machinery of our body.” And there are additional inferences to be drawn from the necessarily embodied nature of knowing. Given that bodies are resolutely located in space, there are grounds for suspecting that scientific knowledge is always positioned knowledge, rationality always situated rationality, inquiry always local inquiry. The physicality of human bodies and the artifacts they employ mean that the knowledge humans produce is inescapably partial. It constitutes a view from some particular location. On this account, science displays rather than transcends human particularity—in terms of race, gender, class, and in all likelihood a host of other factors. The aggregate judgment of Victorian biologists on the intellectual ineptitude of women certainly seems to support this suggestion. Because the body is a site of science, scientific understanding is always a view from somewhere. It is always local knowledge. After all, whether science is practiced in a laboratory, a museum, a botanical garden, a field station, a hospital or wherever, these spaces are always occupied by embodied investigators.

Of Other Spaces

The sites we have visited so far certainly do not exhaust the spots where scientific knowledge has been generated. Laboratories, museums, hospitals, and so on are conspicuous landmarks in the landscape of scientific endeavor. But other locations have been important too. Cathedrals are a case in point. In medieval times the church’s need to ascertain when Easter would fall each year was easily determined in theory. It was the Sunday after the first full moon after the vernal equinox. But it was extraordinarily tricky to figure out in practice. Because the time of the sun’s return to the same equinox was a key feature of the calculation, one preferred means of addressing the problem was by laying out a meridian line from south to north in a darkened building and observing the shifting position of the sun’s noon image on different days as it shone through a hole high up in the structure. From the late Middle Ages right up into the eighteenth century, cathedrals were used for this purpose. They were thus key sites of astronomical observation and remarkable accompanying mathematical computations. Ironically, in the very heart of the Papal States, the oldest of these cathedral observatories recorded measurements that called into question such standard dogmas as the doctrine that celestial motion was perfectly circular.

Other sites of scientific inquiry have been a good deal less stable.
Consider the ships used during voyages of scientific discovery. Many of these have achieved near mythic status in the annals of science—La Pérouse’s Astrolabe, Cook’s Endeavour, Darwin’s Beagle, Huxley’s Rattlesnake, Wyville Thomson’s Challenger. Not only did these carry scientific instruments, they frequently were scientific instruments in their own right. James Cook’s charting of New Zealand is illustrative, on board a ship that incidentally carried botanical equipment, artists, and French-horn players! For it was through his tracking of the Endeavour’s geodetic position that Cook inferred the contour of the coastline. In this way the ship became a surveying instrument that delivered the lineaments of the coastal fringe without ever touching it. The very computations that permitted Cook to set his course delivered him a cartographic shadow of the coast his vessel left behind. In its capacity as a surveying device, as in its housing instrumental gadgetry, the ship has been an important site of science.

Another mobile site of scientific inquiry is the tent. Functioning as a transitory workshop, it has bridged the gap between the laboratory and the field. But it has performed other roles too, not least in anthropology, where “getting under canvas” became a rite of passage that both conferred professional status on the initiate and established ethnographic authority. Moreover, in at least some places—mid-twentieth-century Rhodesia, for example—tent dwelling enabled anthropologists to trade on the standing already enjoyed by colonial officials and government surveyors. Political and scientific authority were mutually reinforcing. Yet in the long run the association was counterproductive. Emerging nationalism raised suspicions that anthropologists were government spies, so new techniques of fieldwork, compatible with decolonization, began to be devised. Since the tent was associated with colonial officialese, anthropologists who wanted to distance themselves from government administrators began to use trailers and campers for rural fieldwork because they were seen as more politically neutral.

The ship and the tent are constituted as elite spaces of scientific practice because of the activities carried out by their temporary inhabitants—scientific surveyors and specialist ethnographers. But other elite arenas, less professional though more aristocratic, have been sites of scientific knowledge too, not least the royal court. In the late sixteenth century, Galileo’s performances in the cause of the Copernican theory before the nobility of his day, for example, conformed to the accepted modes of communication that were embedded in the courtly culture of early modern Italy. As an expressive space no less than a civic one, the court maintained chivalric codes that set limits on how Galileo could expound his views in this princely setting. The court has also been a performative space where understandings of the natural order were theatrically enacted. During the first half of the seventeenth century, court masques in Britain were often the vehicle for declaring the unity of the British Empire and its supposedly special destiny. This species of political theatrics routinely resorted to geographical factors to guarantee national identity under the wise authority of the monarch. In this way the court became an arena in which natural knowledge—of woods, mountains, ancient ruins, and so on—was mobilized to justify political order.

Elite spaces have not had an exclusive monopoly over scientific endeavor. A range of public places have also played host to the production and dissemination of scientific knowledge. Such sites are perhaps less visible to the scholarly eye, though, in view of their role in popular culture and a long-standing sense that they could be, at most, venues for popularizing science. But the boundary line between philosophical gentlemen and what has been colorfully called “gimcracking virtuosos” is harder to draw than one might imagine. For one thing, many eighteenth- and nineteenth-century “popularizers” were serious experimenters themselves—the chemist Humphry Davy, the pioneering student of electromagnetism Michael Faraday, the quarryman-geologist Hugh Miller, and Darwin’s “bulldog,” Thomas Henry Huxley. Any attempt at rigid demarcation here is therefore likely to be misplaced. What is significant is the way science washed up in what we might now think of as unlikely public places and was connected with social classes markedly different from aristocratic patrons and professional elites. Two instances will serve as illustration—the coffeehouse and the public house. In each case, even
though we are entering spaces accessible to the public, our finger is on the pulse of a different segment of the social body.

The coffeehouse was a key site, along with the lecture theater and salon, in the making of what has been called "the public sphere"—that realm of social interaction vital to the emergence of critical sociability, rational dialogue, and the exchange of information. Fundamentally a place of bourgeois encounter and thus central to the genesis of commercial capitalism, the eighteenth-century coffeehouse was a space created for the public use of reason, chiefly through the medium of newsprint. These spaces were protopolitical institutions. But they were also sites for promoting Restoration science. London coffeehouses, for example, hosted scientific lectures and experimental displays and thereby bridged the gap between early entrepreneurs and natural philosophers from Gresham College and the Royal Society. The seventeenth-century experimentalist Robert Hooke regularly visited the London coffeehouses, where he engaged in scientific discussion with Robert Boyle, Henry Oldenburg, and other key figures from the Royal Society. And in Plymouth, the local coffeehouse sponsored a debate in the 1680s on whether brain wounds were curable. Given these activities, it is not surprising that the coffeehouse was sometimes dubbed the citizens' academy—a popular university in which class divisions were broken down and useful knowledge was propagated. For these very reasons the institution was, from time to time, suspect among those who thought it hostile to both tradition and monarchy. Coffeehouses, one critic remarked, made every porter into a statesmen and were hotbeds of cultivated sedition. Whichever is the case, as George Steiner has recently noted, the coffeehouse defines "a very peculiar historical space"—"of discourse, of shared leisure, of shared exchange of disagreements."

The public house conjures up an entirely different social atmosphere. For one thing, coffeehouses admitted women, and their patrons thus soon attracted the charge of effeminacy. Moreover, they were seen to be in contention with the traditional sports of the tavern, such as cockfighting. A marked cultural difference thus characterized these two public spaces from the start and became more pro-
nounced as time went by. In the twenty years between 1830 and 1850 the English village inn, in which all classes had eaten and drunk together, was transformed into an exclusively working-class space. And this was the environment par excellence in which artisan botany was practiced in early Victorian England. Science carried on in this location bore highly distinctive marks. Artisan botanists would congregate in public houses on Sunday mornings for botanical meetings where they shared plant knowledge, exchanged specimens, and consulted botanical textbooks. The practical nature of this interchange was paramount, as befitted florists, gardeners, and herbalists, though many participants displayed a thorough command of Linnaean taxonomy. Joined by a love of plants, these enthusiasts created botanical societies within public houses and pooled hard-earned cash to purchase horticultural books and create herbaria that were looked after by the innkeeper. In such spaces, a renegade scientific community, mutually self-rewarding and smitten with collectors' contagion, became sufficiently expert for gentlemen like J. D. Hooker of Kew Gardens to resort to them for specimens and skills alike. Science in the public house thereby challenged the long-standing opposition between head and hand, between philosopher and craftsman. It also re-opened scientific discourse to popular interest groups long denied access to elite spaces of scientific inquiry like the laboratory. Seen in this light, the public house was a cultural space that contested the dominant scientific regime of the time.

By reminding ourselves that science has been part of the public sphere and has been practiced in a variety of popular arenas, we considerably widen our awareness of the range of spaces in which scientific knowledge has been produced and propagated. Doubtless the list could be elaborated in extenso, for science has been conducted or communicated in one way or another in libraries, lecture theaters, salons, nurseries, observatories, churches, workshops, artists' studios, mechanics' institutes, learned societies, stock farms, shipyards, game reserves, and on and on. What all these spaces share, both popular and elite, is that—in common with all other places—they are made. They become what they are through the activities that "take place" in them.
and the human practices that constitute them. In turn these arenas are active in producing the kinds of subjects humans are in those spaces. Space is therefore not dead, inert, and fixed; rather, it is lively, shifting, fluid. Space is animated by events. It is always a production. And scientific space is no exception.

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The enterprise we casually refer to as "science" embraces a huge range of activities carried out in many venues. In these miscellaneous spaces, nature has been differently experienced, objects have been differently regarded, claims to knowledge have been adjudicated in different ways. It is only when the practices and procedures that are mobilized to generate knowledge are located—sited—that scientific inquiry can be made intelligible as a human undertaking. In important ways, scientific knowledge is always the product of specific spaces. To claim otherwise is to displace science from the culture of which it is so profoundly a part.