E R D K U N D E

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MAKING SPACE FOR SCIENCE

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Zusammenfassung: Produktion von Räumen der Wissenschaft

Der Gedanke, dass wissenschaftliches Wissen einen Raumbezug hat, widerspricht der konventionellen Vorstellung von Wissenschaft als einem transzendenten Unternehmen, das im wesentlichen von den Besonderheiten eines Standortes unberührt bleibt. Hier argumentiere ich, dass der Raum sowohl für die Durchführung als auch für den kognitiven Inhalt von wissenschaftlicher Forschung eine konstitutive Bedeutung hat. Für die Überprüfung dieser These werden vier Schauplätze wissenschaftlicher Betätigung ausgewählt, nämlich das Labor, das Museum, das Feld und der Garten. Historische Entwürfe dieser „Räume der Wissenschaft" demonstrieren die engen Verbindungen zwischen der Beanspruchung wissenschaftlichen Wissens und den Orten des Wissens. Diese Beispiele zeigen, dass die Vorstellung der Existenz von „Geographien der Wissenschaften" eine beträchtliche Plausibilität besitzt.

Summary: The idea that scientific knowledge has a geography goes against the conventional image of science as a transcendental undertaking that remains substantively untouched by the particularities of location. Here I argue for the constitutive importance of space for both the conduct and cognitive content of scientific inquiry. Four arenas of scientific engagement are chosen for scrutiny – the laboratory, the museum, the field, and the garden. Historical sketches of these 'spaces of science' demonstrate the intimate connections between claims to scientific knowledge and the places of knowing. These go to show that the idea that there are 'geographies of science' has considerable plausibility.

Introduction

In 1998 the literary critic FRANCO MORETTI published his *Atlas of the European Novel*. In an arresting opening paragraph he makes the following observation (MORETTI 1998, 3): "An atlas of the novel. Behind these words, lies a very simple idea: that geography is not an inert container, is not a box where cultural history 'happens', but an active force, that pervades the literary field and shapes it in depth."

What I want to do in this paper, to reapply MORETTI's words, is to suggest that space pervades the scientific field and "shapes it in depth". While the idea of "literary geography" has inherent plausibility – despite Terry Eagleton's dustjacket puff about the sexiness of "geographical criticism"[1] – the suggestion that science bears the marks of its location is rather more counter-intuitive. Surely science is an enterprise devoid of local particulars, a transcendental undertaking whose universality attests to its territorial independence. Can the *location* of scientific endeavour – to put it another way – make much difference to the *conduct* of science, and even more importantly, to the *content* of science? Of all the human projects devoted to getting at the truth of how things are, to laying aside prejudices and presuppositions, and to putting in place mechanisms to guarantee objectivity, has that venture we call 'science' not been the most assiduous in prosecuting its ideals? Ever since Bacon urged that method should oust metaphysics with the hope of 'reducing all wits to one level', science has sought to banish from its empire the spectre of localism.

As a first move in tackling this issue, we might recall that because our actions and thoughts are embodied, we cannot escape from either material or mental geography. And since the positions from which interlocutors speak are crucial to what can be spoken, there are intimate connections between 'location' and 'locution'. Of course locutionary acts can no more be reduced to locational circumstance than geography can be reduced to geometry. The communities of discourse in which we participate are crucially dependent upon, but not reducible to, the settings within which they are domiciled. Social spaces, to put it another way, 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

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[1] Enthusing about MORETTI's intervention, Eagleton welcomed the book with the comment that "In a period when space is rapidly becoming one of the sexiest of critical notions, MORETTI is busily pioneering what is likely to prove the coming current of literary theory: a geographical criticism … the way is paved for a 'literary geography' in the future." Coming as I do from Ireland I find the whole idea of literary geographies altogether *understandable*; a profound engagement with place forms the warp and woof of the poetry of W. B. Yeats and Seamus Heaney, and the drama of Sean O'Casey and Brian Friel.

otherwise they could not find expression, secure agreement, or mobilise support. But ideas must also be sufficiently 'disarticulated' from their social environments to permit them to reshape the very settings out of which they emerged. Spaces both enable and constrain discourse.[2]

There are a multitude of ways in which a spatial perspective may be brought to bear on the scientific enterprise. There are behavioural geographies of scientific site and cultural topographies of scientific travel to be elucidated; there is a kinematic cartography of scientific circulation and a locational geometry of scientific instrumentation to be mapped; there are regional sociologies of scientific style and political economies of scientific commitment to be explored.[3] Here I have chosen to focus on only one component, namely, *sites* within which science has been practised and from which scientific knowledge diffuses. The range is vast. But if we try to conjure up a mental picture of some of the diverse places where science is made, we will be impressed with the vastly different *atmospheres* they exude. The claustrophobic darkness of the alchemist's workshop with its roaring furnace and smelly and noisy stills, for example, stands in marked contrast to the clinical brightness and flickering screens of the modern molecular biology laboratory. Again, the wide-open, airy spaces of the field sharply contrast with the fusty alcoves of the archive and the museum, while the controlled displays of the botanical and zoological gardens are rather different from the diagnostic spaces of the hospital or the asylum. To even 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. They each constitute a different suite of optical, acoustic and olfactory spaces.

Spatial settings influence scientific practice in different ways. The disposition of equipment and other accoutrements, for example, regulates human behaviour in one form or another. Frequently the arena is constructed so as to restrain or facilitate certain interactions; in some cases entry to the space is carefully controlled by formal or informal mechanisms of boundary maintenance. Besides, it is within these spaces that practitioners absorb the core values, convictions and conventions of their tradition of inquiry. Whether it is a John Dee conjuring angels in his domestic den, 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 were immensely different, as were the ways in which the knowledge accumulated moved out from its site of origin into the public sphere.

A number of questions, then, plausibly arises from the obviously variegated geography of scientific space. How, for example, is the circuit of knowledge effected from the domain of acquisition to common currency, from locational particularity to communal exchange? If specific spaces of science were not homogeneous, then how were they internally structured? Just who was permitted access to those privileged sites of knowledge generation? Did the line which separated the 'insiders' from the 'outsiders' map onto any other contours – say, of gender, class, status, ethnic group, or professional standing? And how was the work divided up among those who *could* cross the threshold into the knowledge-making territory? Is any significance to be attached to the locations that were chosen as sites for scientific pursuits? Questions such as these serve to draw attention to the physical and intellectual geography of knowledge production and to suggest that the spaces of science are far from merely incidental to the enterprise. As illustration I have chosen four sites of engagement in the hope of conveying some sense of the power of place in scientific undertakings.

1 Houses of Experiment

We have become accustomed to the idea that scientific endeavour takes place in specialised locations like the laboratory. In part this has to do with the tools scientists need to carry out their tasks – telescopes, microscopes, pumps, retorts, test tubes all 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 much wider dimensions. And one way to think

[2] The concept of 'communities of discourse' and the ways in which they 'articulate' and 'disarticulate' with their social environments is the subject of analysis by ROBERT WUTHNOW (1989). While he does not cast his analysis explicitly in spatial terms, he does observe that "attention must be given not only to the places where new ideologies were successfully institutionalized but also to those places where ideological innovations failed to take root" (1989, 6).

[3] A somewhat different formulation is to be found in HARRIS (1998). I have set out an earlier schema in LIVINGSTONE (1995).

about the space 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 of securing knowledge that was of universal value (SHAPIN 1990). Prophets and sages withdrew into solitude and returned with insights that were devoid of parochial particulars. Ironically, it seems, 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 savant must stand outside the normal confines of society. And 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 mountaintop – all classical sites of medieval spiritual knowledge – were not suited to the needs of experimental activity. The ideal of solitude remained; but a new space had to be carved out to accommodate it.

In order to get some sense of how that new kind of space – laboratory space – began to be hewn out of pre-existing spatial arrangements, it will be useful to pause for a moment at a house at Mortlake on the banks of the River Thames. It is the home of John Dee, Elizabethan England's most celebrated natural philosopher (see HARKNESS 1997). Despite initial impressions to the contrary, this is no ordinary gentry residence. Strange sounds and foul smells emanate from certain regions of the dwelling. For the Dee household represents an early move in the relocation of knowledge-production into the domestic scene, though the study was apparently already being used in fifteenth century Italy as a restricted space for double-entry bookkeeping and the management of domestic finances.[4] Rooms were dedicated to various alchemical appliances and occult practices because Dee needed to slice a private workspace out of a public household. The securing of such a hermetic retreat within the home cannot be understood in isolation from the more general social history of the house and the way in which the unpartitioned space of the large medieval dwelling gave way to compartmentalisation where private quarters allowed for retreat and solitude (FRIEDMAN 1989). Such arrangements provided conditions into which the spatial requirements of the natural philosopher could be inserted.

Acquiring alchemical space in his own home was a tricky enough 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. Besides, the large number of servants in the dwelling, together with the various assistants that Dee had in his employ over the years, made finding a piece of privacy a difficult task. 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. Poised between the library and the laboratory, Dee's predicaments represent a key moment in the early construction of experimental space.

But it was not just the seemingly furtive crafts of the occult sciences that were secreted within inner chambers, frequently in basements. A host of key players in the emergence of English science in the mid-seventeenth century had laboratories either in their own homes, or in the homes of gentleman patrons (SHAPIN 1988). The circumstances at Robert Boyle's home in Pall Mall in London, where he spent the last twenty years of his life and more in the home of his sister Katherine, Lady Ranelagh, are worth a moment's perusal. Here, it seems, the laboratory was again in the basement; but had 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 crucial sense, a *public* matter. So while Boyle lamented over disturbances, he still needed to facilitate the new science's strictures on the public attestation of natural knowledge.

And yet. The new experimental arenas that surfaced in the period were far from public in today's sense. To be sure *gentlemen* were permitted access, according to the social norms of the day. But what was most important was what STEVEN SHAPIN calls 'the experimental public', namely, those whose presence was essential to the confirmation of empirical findings. Occupying the laboratory's physical space was one thing; occupying its discursive space quite another. This means that the laboratory's *social* space was differentiated in a number of ways. On the one hand there was an epistemological chasm between figures like Boyle and Hooke and the numerous attendants who worked the equipment. The latter had craft competence; but they lacked the standing to make scientific knowledge. What we find here is the spatialization of a suite of socio-intellectual dualisms running the length and breadth of English society in the seventeenth and eighteenth centuries – soul and body, mind and brain, head and hand, philosopher and artisan. On the other hand, casual callers inhabited a different epistemic space from those socially and cognitively sanctioned to ensure experimental reliability. Here were boundaries that, though unmarked in

[4] MARY POOVEY (1998), drawing on the work of Mark Wrigley, discusses this subject.

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.[5] 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 spatialisation of the move from the context of scientific discovery to the context of justification.

I don't have time now to say anything about the intricate history of connections between scientific demonstration and dramatisation, and how, for long enough, experimental display occupied a zone straddled between conjuring trickery and scholarly authority, between – if you will – the theatre and the academy (STAFFORD 1994). 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 end-product of long drawn-out negotiations is nicely disclosed in the origins of the modern university physical laboratory where space had to be sequestered to provide instruction and demonstration to students on the one hand, and research facilities for teachers on the other.

As illustration of the sorts of manoeuvre here afoot, let me draw on SIMON SCHAFFER's (1998) analysis of the founding of the Cavendish Laboratory in Cambridge in the 1870s. The establishment 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, with its savour of the mere technical, was *terra incognita* to the University's established order. More, it was threatening to the moral economy of the *ancien régime*. 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 crucial reconfiguration of the geography of Cambridge science, a glance at the apologia made for the new space by James Clerk Maxwell is illuminating.

Maxwell knew only too well that the values of the factory workshop were alien to the dominant university ethos of his time, and that what he needed was to find some way of domesticating the world of the lab to the prevailing discursive culture. 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 mathematical curriculum. For he retained, as was typical of late Enlightenment Scottish intellectual endeavour, a strongly metaphysical cast of mind, and applied it to the disputed connections between algebra and geometry. This enabled him to urge that providing facilities which would ensure precise mensural standards was analogous to the work of the Anglican God of calculation and measurement. Thereby he could forge a strategic alliance between God and mammon, between philosophy and the factory in a move akin to what Kelvin had earlier accomplished in Glasgow where he merged the culture of the classroom with the craft of the foundry. The new physical laboratory was a spatial and symbolic intervention into the University's scholarly domain.

2 Cabinets of Accumulation

The laboratory, of course, is not the only site of scientific endeavour. Alongside, and indeed predating, it were spaces of accumulation, like the museum, in which specimens were collected and organised according to the prevailing norms of the time. In these chambers, the aim was less to *manipulate* the natural world by experiment than to *arrange* it through classification. Whereas the drama of the laboratory lay in its staging of demonstrations, the museum's theatricality is expressed in its amassing, ordering, labelling and displaying exhibits of all kinds.

The origins of museum culture can be traced back to those 'cabinets of curiosities' into which courtly gentlemen of the sixteenth century crammed curios of all kinds (IMPEY a. MACGREGOR 1985; DASTON 1991). The more rare in occurrence, or exotic in appearance, or distant in origin the object happened to be, the more likely it would end up in some 'world of wonders' housed in some secluded antechamber. By the same

[5] On the role of trust in the experimental science of the seventeenth century see SHAPIN (1994).

token the acquisitive impulse that manifested itself in the culture of the museum made it a key site for the pursuit of another form of scientific knowing. The dazzling variety of the natural order, with its profusion of *particularity*, that the museum accumulated, did much to feed the nascent scientific craving for facts, more facts and yet more facts. In contrast to Albertus Magnus who had insisted in the mid-thirteenth century that "there can be no philosophy of particulars", Francis Bacon, in his *Novum Organum*, called for 'particular natural history' and the accumulation of 'Singular Instances' because these very things were crucial to overthrowing the *a priori* deductivism, impromptu generalisation, and the syllogistic reasoning so beloved of contemporary natural philosophy. To be sure, wonder at such things might be nothing but open-mouth gawking or cloying admiration, vain astonishment or reverential awe; but when harnessed by curiosity it could do scientific work.[6] Thereby, collecting became established as a valuable and valid way of knowing.

Originating in the *studio*, the museum had become, by the end of the seventeenth century, a *galleria*. And this shifting internal geography had important ramifications for the kind of institution it turned out to be. As a setting for scientific inquiry and human interaction alike the museum was – both socially and acoustically – a synthetic space. Socially, it mediated between private and public domains; accoustically it was, as PAULA FINDLEN (1994, 101) puts it, "located between silence and sound". Thus 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. As it renegotiated the relationships between intimacy and sociability, museum space socialised privacy and cloistered civility.

At the same time, because the gallery was no longer a *static* site of contemplation but an *active* space through which patrons *passed*, it signalled a move away from the contemplative life towards the *vita activa* as the road to genuine knowledge. Bodily movement, discursive exchange and ordered display were all part and parcel of a domain whose very existence was dependent on a never-ending ebb and flow of commodities. But as objects streamed in from near and far, they were reassembled, positioned, and displayed in the way in which the curator believed the most appropriate. Thus even while museums exhibited real-world objects they refashioned reality through classification, location, and genealogy. Museums have thus always been, in a crucial sense, hermeneutic practices in which the spatial allocation of phenomena fundamentally reconfigures the world of nature.

As a means of expressing knowledge claims, the museum's spatiality has often been an arena of contestation. In the 1930s, at the American Museum of Natural History in New York, for example, the differing views of William King Gregory and Henry Fairfield Osborn on the evolution of primates found expression in their respective exhibition Halls (RAINGER 1991). 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. Precisely the same was true of cultural anthropology. Ideas about how museum space ought to be regulated conjugated the differences between the anthropology of Franz Boas and John Wesley Powell (STOCKING 1999). While the latter employed an evolutionary narrative to account for – and to display – certain ethnographic inventions, Boas urged the virtues of exhibition by tribal group. To Powell the very purpose of the museum was to disclose *progress* – of anthropology, of science, of human culture; for Boas, ever impatient with taxonomic systems, schemes of unilinear evolution, and what we might call 'object fetishism', the goal was to confirm the *relativity* of human civilisation. Space management thus crystallised the differences between evolutionary and ethnic modes of anthropological understanding, between temporal and territorial ways of thinking. The physical layout of the exhibits expressed differences between anthropological leaders on the very nature of their projects simply by disclosing radically different ways of reading the story of the species.

If the internal geography of museums could condition the cognitive shape of the science produced, the external iconography could speak to the society in which those institutions were domiciled. Museum architecture can thus be understood not simply as a sequence of structural answers to practical problems, but as itself a symbolic writing of space (FORGAN 1986; 1994). The very buildings within which scientific endeavour was housed were often pronouncements spoken in the language of stone, site and plan about the place science should occupy in the wider culture. Consider, for example, how museum architecture echoed

[6] On the role of wonder and the wondrous see DASTON and PARK (1998). The quotation from Albertus Magnus is taken from this source.

ecclesiastical forms (CAMERON 1972; SHEETS-PYENSON 1987a; 1987b). For example, Waterhouse's Natural History Museum in South Kensington, which opened to the public in 1881, was often referred to as 'nature's cathedral', a gothic 'temple of science' in romanesque style (STEARN 1981). Such celebratory ascriptions, of course, 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.[7] 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', joined the 'church scientific', and were ordained to the 'scientific priesthood'. In such circumstances architectural symbolism became a weapon in the arsenal of cultural conflict.

The museum, it is clear, has played a variety of different roles in the historical unfolding of scientific inquiry. Occupying a distinctive niche in the ecology of science, it constituted a space where items were accumulated and allotted their 'proper place' on the stage of history. In this way museum culture played an important role in the history of 'viewing'; in the museum people learned how to view the world, how to value the past, and how to visualise the relationships between specimens. And yet no matter how extraordinary the exhibit or dramatic the diorama, the museum was not the world itself. To view *that* required moving outside the confined spaces of the collectors' cabinets and into the open spaces of the field – yet another site of scientific endeavour.

3 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 first-hand, is anything but the obvious claim that it might at first appear to be. DORINDA OUTRAM's (1996) delightful essay on the contrast between the field naturalist and the sedentary naturalist is a suitable point of departure. When Georges Cuvier passed comment on the scientific travels of Alexander von Humboldt in the early nineteenth century, he sharply contrasted the styles of the field worker with the 'sedentary naturalist'. Because the former quickly traversed territory and viewed many things in sequence, their observations were inevitably 'broken and fleeting'. By contrast, the bench-tied student of nature had the time to spread out samples, to collate and analyse them, and thereby 'to reach reliable conclusions'. To Cuvier, the laboratory naturalist occupied a kind of hyperspace: because the 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 frankly precarious claims of the field worker. For Cuvier the most wonderful voyages of discovery never weighed anchor and pushed out to sea; they never left the workshop.

Whatever the merits of Cuvier's partisan analysis, his interventions serve to call attention to the markedly differing cognitive styles that characterised open- and closed-space naturalists. To the sedentary naturalist it was *absence* from wild nature that secured epistemic privilege – precisely what advocates of field science strenuously repudiated. To them it was *presence* – not absence, *closeness* – not distance, that underwrote their claims to authenticity. The dissection of specimens in the lab and the demonstration of exhibits in the museum were all well and good; but it was only in the field that nature could be encountered in the raw. The workshop bench only delivered a virtual world – valuable enough, but not to be substituted for the real thing.

Nor was Cuvier's dispute with von Humboldt a unique episode. Consider the mid-nineteenth century Edinburgh student of Alpine glaciers, James David Forbes (HEVLY 1996). To him it was only "protracted residence among the Icy Solitudes" that warranted genuine scientific knowledge of the phenomenon, for it was only *presence* in the ice fields that could replace rumour 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. The culture of field science, redolent with the rhetoric of valour, gave every impression that first-hand heroism conveyed its own authority. Laboratory opponents, by contrast, felt that high adventure in an uncontrolled wilderness delivered nothing like the precision good science demanded. It might be fun; it wasn't physics.

Just exactly what 'the field' meant, moreover, was never clear cut. As an open space it was less easily defined, bounded and policed than its intramural counterparts like the laboratory or the museum whose confines are more clearly circumscribed. For this very

[7] The strategies of the new scientific elite to secure the moral authority hitherto resident in the Victorian clergy have been scrutinised by a number of scholars including TURNER (1978) and HEYCK (1982).

reason the field is inhabited rather differently from these other scientific spaces. For a start, the scientific 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 usually not the scientific experts engaged in research. And, of course, there are likely to be other transient sojourners; they may be tourists, or campers, or foragers, or artists, or hunters, to name but a few. The variegated nature of the field's dynamic occupancy necessarily makes for an unstable network of social relations; the field thus discloses precisely the kind of sociology that the laboratory seeks to subvert with its formal and informal disciplines in the promotion of subcultural stability.

In these, and in other ways, the field has been a space where the structures of social life are – at once – reproduced and destabilised. The ambiguities of both presence and absence are significant here. Take, for instance, the presence of amateur participants in field sciences. While fundamentally important to everything from archaeological digs to botanical survey, their presence has been regarded as cognitively compromising by those promoting the supposed rigor of laboratory standards. 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 only passed as genuine science when warranted by the accredited professional. A similarly ambiguous position has been occupied by women in the field (BONTA 1991; ROBINSON 1990). On the one hand, the field has often been promoted as a *manly* site of intrepid heroics and its narratives cast in an epic form that celebrates the virtues of stoicism, resilience, pragmatism, and inventiveness. On the other, the foreign field has sometimes afforded women the opportunity to escape from the rigid regimens of the homeland, their personal experiences far away occasioning domestic equivocation (BLUNT 1994; MCEWAN 1994).

At once restrictive and liberating, fieldwork offered greater space for the renegotiation of personal and vocational identity by virtue of its social flexibility. Whether breaking down gender roles, encouraging the transgression of social conventions, blurring the line between amateur and professional, or affording an occasion for furthering the mythology of hardy heroism, the field regularly exhibited a borderland sociology and a frontier mentalité. While these arise in some measure from the *human* geography of the field's occupants, its *physical* geography also plays its part. For the field is an inherently unpredictable scientific site, and for that very reason practical rationality and functional imagination are often at a premium there. Local conditions pose local problems needing local solutions. In such circumstances science is an inescapably local practice. Here, the good scientist is the skilled hand, the resourceful artisan. Not that these aptitudes are irrelevant in the laboratory; to the contrary, they are greatly prized there too. But in the field replication is not so easily effected, the environment is less readily controlled, and impromptu ingenuity is in correspondingly greater demand. Yet however innovative *in situ* practices may be, the crafts deployed in the field are 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 behaviour"[8]. And this is not only the case for the *acquisition* of field knowledge; it is no less crucial to the *communication* of findings. The singular experiences of the field can only be expressed using a common lexicon and drawing upon shared cultural resources. To that extent the homeland is always present with the scientific traveller.

The field, of course, is often thought of as a scientific site that just *is there* in a taken-for-granted kind of way. Not so. It is constituted *as the field* by the activities of the scientific investigator. Because of the power that the academy has to define 'the field' and thereby, in many cases, to legitimate its own 'field of inquiry', the field site is always politically negotiated. In fact in some academic disciplines, notably anthropology, fieldwork has been a kind of fetish that normalised the domain's practices, empowered certain styles of knowledge while impeding others, and sanctioned some objects of study. Malinowski's role was crucial here; by installing fieldwork as central to the institutionalisation of the discipline he effected a move away from the worldview of Victorian gentlemen-scholars who considered going to the field to be beneath their dignity.[9] Courtesy of his organisational skills, the field methods Malinowski had deployed in the Trobriand Islands rapidly became the legitimating insignia of the profession, "the central ritual of the tribe" as GEORGE STOCKING (1983) puts it.

The field, we can conclude, turns out to be anything but the obvious scientific site it might initially seem to be. Not only is it constructed by the activities of the aca-

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[8] This phrase comes from the introduction to the collection of essays drawn together by HENRIKA KUKLICK and ROBERT E. KOHLER under the title *Science in the Field* as volume 11 of *Osiris* (2nd series) for 1996.

[9] Malinowski's role in establishing fieldwork as the anthropological method *par excellence* is highlighted in KUKLICK (1991) and VINCENT (1990). The significance of Rockefeller Funding in advancing Malinowski's vision is revealed in STOCKING (1995). KUKLICK (1998) discusses the suspicion of fieldwork by Victorian gentlemen-scholars.

demy, but it has provided – at least for some traditions of scientific inquiry – an operational answer to questions about appropriate ways of knowing. 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 labour. Here, epistemological warrant was built upon the foundations of spatial practices.

4 Gardens of Display

Between the archive and the field, the world of the museum and the world of nature, stands the garden.[10] Enclosed yet expansive, open yet delimited, the garden is located in a space between the great outdoors and the cloistered cabinet. It was always so. Was God not the first gardener when he planted the Garden of Eden? It was a spiritual space in which its human inhabitants walked with their Creator (PREST 1981). 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, the primordial paradise. From earliest times, the garden has been seen as a place of renewal, an outdoor temple of contemplation in which spiritual well-being could be maintained. At the same time, the garden's very existence depended on its capacity to represent order over against chaos, cultivation in opposition to wildness, 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. While field explorers lusted for new knowledge, early gardeners yearned for the recovery of ancient wisdom often in the hope of retrieving the powers of Adam.

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 place in the garden's spatial taxonomy. The early Botanic garden was both a re-creation of paradise *and* a key moment in the genesis of modern science. Thus 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 recreated by reassembling in one location the scattered fragments of the globe's plant jigsaw (to use one of John Prest's choice metaphors). The first modern botanical gardens established in Padua and Pisa in the early 1540s, and, for the English speaking world, Oxford in 1621, thus served the interests of both theology and science.[11]

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, the four continents were each being allocated their literal 'quarters'. John Hill, for example, specified in 1758 that the sections should be "appropriated to the four great regions of the earth". 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, and a dozen other variations. Either way the prodigality of the natural order was systematically tamed by symmetrical reconfiguration, its blithe randomness brought under the reign of enlightened rationality.

Even as the garden was intended to recover paradise, it was also to be instrumental in reversing the ravages of the biblical Fall from Grace through the release of the medicinal powers embodied in its specimens. Aesthetically, spiritually, and now medically, the garden was an exercise in restoration. 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 botano-medical lore. The craft of the pharmacological botanist thus frequently involved the capacity to read the 'signatures' of the vegetable world so as to specify which part of the body each plant was de-

[10] A useful brief introduction to the idea of the garden can be found in CUNNINGHAM (1996).

[11] Other early Botanic Gardens include Zürich established in 1561, Lyons in 1564, Rome in 1566, Bologna in 1567, Leipzig in 1579, Leyden in 1587, Montpellier in 1592, Giessen in 1605, and the Jardin Des Plantes in Paris in 1635. A chronology of early Botanic Gardens can be found in *Hortus Botanicus: The Botanic Garden and the Book. Fifty Books from the Sterling Morton Library Exhibited at the Newberry Library for the Fiftieth Anniversary of the Morton Arboretum* (The Morton Arboretum, 1972).

signed to treat. In this way the science 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.

Botanic gardens, then, were polysemic spaces. They hankered after the Garden of Eden; they sought to reproduce global biogeography; they wielded biomedical power. 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 their own provinces and member species. Such analogies flourished with particular vigour during the eighteenth and nineteenth century age of empire when metropolitan gardens became the repository of what might be called botanical imperialism. Kew Gardens, whose origins can be traced back to the 1750s for example, burgeoned under the vegetative booty brought back by men like Joseph Banks and his collectors who engaged in world-wide horticultural plunder (DESMOND 1995).[12] From the mid–1780s it became the centre of a world-wide network of plant acquisition and exchange, a nodal point in what is often called the Banksian empire. Thousands of seeds, plants and dried specimens, some covertly pillaged for crass commercial gain, others as mere instances of exotic curiosity, found their way to the ecumenical data bank at Kew. Hemp seeds, tea plants, mulberry, natural lacquers, tung oil, fibre plants, citrus, avocado, and a myriad other items were sought as diet and drug, dye and decoration.

If botanical gardens were agents of empire, they were no less sites of experimentation and enlightenment. Whether or not tropical plant species could acclimatise to temperate zones, and vice-versa, was a scientific question as crucial to imperial success as to intellectual progress. Precisely because Kew Gardens was one of the great clearing houses of the empire, it became a testing ground for trials in botanical acclimatisation, a project in the remaking of nature to suit the new industrial order. But it was not just plants that were the subject of acclimatisation inquiry. Precisely the same questions arose over animal trafficking. And resolving the issue of how, if at all, animals adjusted to new climatic regimes often became the opening gambit in campaigns for the creation of modern zoological gardens.[13]

Insofar as zoological gardens were bound up with matters of animal domestication and acclimatisation, they were invariably implicated in colonial projects. Two different nineteenth century zoos – in Britain and France – 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 (RITVO 1996). 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 neighbours. In order to remedy this cultural deficiency, Regent's Park Zoo opened its gates in 1828. When addressing its landowning constituency, the zoo rationalised its existence by stressing its concern to domesticate exotic species and acclimatise them for English parks … and menus. When drawing its value to the attention of the scientific community, by contrast, the zoo presented itself as a reservoir of taxonomic data without reference to gastronomy 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 redraw attention to Britain's ecological imperialism. The zoo, we might say, was a rhetorical site of empire, its animals intended to symbolise Britain's biogeographical dominance of the globe.

Much the same was true of the Paris collections (OSBORNE 1994; 1996). In one way or another, these various collections reflected the country's colonial, diplomatic and commercial activities especially in North Africa. As in Britain, here too there were tensions between pure and applied zoology, with the pendulum swinging from utility to science at different points in time, and also between the needs of the naturalists and the amusement of the general public. Either way, the concern with acclimatisation and domestication, the breeding and dealing of exotic animals was seen as contributing to agriculture and industry, scientific advance and commercial success alike. Of course the French scientific community had a long-standing interest in acclimatisation, not least because it bore directly on matters of adaptation, inheritance, and evolutionary change. In fact the Jardin was in large measure the public laboratory of the Société Zoologique d'Acclimatation which had come into being in 1854. If successful long-term acclimatisation of species to new environmental niches could be effected, that would do much to confirm the doctrine of the inheritance of

[12] For the role of Kew in the 'Banksian empire' see the essays in MILLER and REILL (1996) especially the chapter by MACKAY.

[13] The standard general history of zoological gardens remains LOISEL (1912).

acquired characteristics and thus the biological transformism rooted in the ideas of Buffon and Lamarck. Yak from Tibet, wild sheep from Algeria, Angoran goats, Egyptian ibises and llamas from Chile, when gathered into zoo space and appropriately displayed, could at once advance French science, proclaim the nation's colonial splendour and deliver to visitors an imagined round-the-world safari.

The efflorescence of zoological gardens in the nineteenth century thus owed much to the intellectual and commercial potential of acclimatisation-related matters. And there are grounds for suspecting that these preoccupations were not pursued in isolation from related anthropological questions about the impact 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, for example, 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 (REICHENBACH 1996). That year he had Lapps acting out daily life with reindeers before enthusiastic audiences; over the following half century, it has been estimated that he orchestrated some seventy ethnographic performances – Oglala Sioux performing ritual dance in the shadow of a constructed mountain proving to be among the most popular. Similarly Albert Geoffroy Saint-Hilaire mobilised caravans of Nubians, Canadian Inuit and troops of Argentinian guachos in the hope of maintaining public interest in his Jardin. And in 1906, an African Pygmy by the name of Ota Benga was put on display in the Monkey House of the New York Zoological Park (BRADFORD a. BLUME 1992).[14] Here the zoo – sometimes presenting itself in the metaphorical shape of the laboratory – took on the dimensions of theatre. In so doing it also renegotiated the boundary between animal and 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, outré, other (ANDERSON 1995).

Seen in this light, the zoo emerges as a scientific *and* theatrical space. At the same time, it was also a space of domination. By imposing order on the animal kingdom, organising its exhibits along a rigidly linear pathway, and caging large carnivores a tantalising arm's length away from danger, the nineteenth century zoo testified to human triumph over the wild. Zoos, as HARRIET RITVO (1987) puts it, thus "re-enacted 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.

5 Conclusion

In this paper I have only considered a few of the sites in which scientific knowledge is produced. To the laboratory, museum, field and garden we could easily add the hospital, the asylum, the body, the public house, the coffeeshop, the court, the cathedral, the tent, the ship, and a myriad others – all sites of scientific discourse. In all of these, distinctive ways of speaking about the subjects of scientific inquiry have developed producing what we might call a geography of *talk* about the world. In each case access to the conversation means access to the social space; in each case the character of the social space is determined by who is equipped or permitted to engage in the exchange.

Instead of anticipating what investigation of these arenas might disclose, however, I want to end on an interrogative note. In cultivating a geography of science that goes beyond the mere mapping of institutions or the diffusion of innovations across space and time, we will sooner or later confront the same kind of cognitive quandary that has dogged the sociology of knowledge. As CLIFFORD GEERTZ (1987) characterises it: "Sociologists of knowledge ... have been caught between asserting the strong form of the doctrine – that thought is a sheer reflex of social conditions – which nobody, themselves included, can really believe, and the weak one – that thought is to some degree influenced by social conditions and influences them in turn, which hardly says enough for anyone to want to deny it". Precisely the same dilemma, namely how to avoid the extremes of what we might call spatial reductionism and spatial 'containerism', faces those of us intent on constructing a geography of (scientific) knowledge. To be sure, spaces are crucial in the attainment of facticity. Scientific claims achieve the status of 'facthood' in highly specific places. To put it another way, propositions are accepted as facts, at least in part, because of the spaces in which factual assertions are made. Facts aren't uncovered *just anywhere*; they are only appropriately disclosed and displayed in very particular places. Whatever it is to understand the natural world, that

[14] DRIVER (1994) has discussed a comparable case of the exhibiting of two African boys in the 'Stanley and African Exhibition' held in London in 1890.

experience is different when nature is encountered on the laboratory bench, in the museum cabinet, behind bars in the zoo or in the open field. Location at once facilitates and legitimates facticity. Exactly *how* this is so, of course, is another question, and one which, in my judgement, is the central item on the agenda of the 'geography of scientific knowledge'.

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