Locality in the History of Science: Colonial Science, Technoscience, and Indigenous Knowledge

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INTRODUCTION

DURING THE SECOND HALF OF THE TWENTIETH CENTURY, THE "colonial world" became a prominent research focus for historians of science. In the process of establishing this new subdivision of knowledge, colonial science historians took pains to clarify their use of the term "colonial," an exercise that helped refine the terminology of the larger colonial and postcolonial discourse.[1] But these discussions were more concerned with the meaning of "colonial" than with the meaning of "science," consideration of which was generally left to philosophers and sociologists of knowledge. And during this same period, philosophers, sociologists, and a few historians (variously arrayed as positivists, realists, and constructivists) were indeed contending over the nature of science. It may now be seen that constructivist approaches,[2] because they emphasize the *locally* contingent char-

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[1] The leading scholar in this enterprise is Roy MacLeod, who has published important theoretical pieces providing a refreshing breadth of perspective. See, for example, Roy MacLeod, "On Science and Colonialism," *Science and Society in Ireland: The Social Context of Science and Technology in Ireland, 1800–1950* (Belfast: Queen's University, 1997) pp. 1–17; "Reading the Discourse of Colonial Science," in *Les Sciences coloniales: Figures et institutions* (Paris: Editions de l'Office de la Recherche Scientifique et Technique d'Outre-Mer, 1996) pp. 87–96; and "On Visiting the 'Moving Metropolis': Reflections on the Architecture of Imperial Science," *Historical Records of Australian Science*, 1982, *5*, 3:1–16. In addition, he has produced a great range of locality case studies that range across Australia, the United Kingdom, India, and the Pacific. Finally, he has edited many useful volumes, such as Roy MacLeod and Richard Jarrell, eds., *Dominions Apart: Reflections on the Culture of Science and Technology in Canada and Australia, 1850–1945* (*Scientia Canadensis,* 1994, *17*, 1 and 2); Roy MacLeod and Philip Rehbock, eds., *Nature in its Greatest Extent: Western Science in the Pacific* (Honolulu: Univ. of Hawaii Press, 1988); and Roy MacLeod and Deepak Kumar, eds., *Technology and the Raj: Technical Transfer and British India, 1780–1945* (New Delhi: Sage, 1995).

[2] There are many possible entry points into the literature of constructivist thought. In addition to books cited in the body of this paper, some recent titles that provide a useful overview include: Barry Barnes, David Bloor, and John Henry, *Scientific Knowledge: A Sociological Analysis* (Chicago: Univ. of Chicago Press, 1996); Peter Galison and David Stump, eds., *The Disunity of Science: Boundaries, Contexts, and Power* (Stanford: Stanford Univ. Press, 1996); Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge Univ. Press, 1998); Ian Hacking, *The Social Construction of What?* (Cambridge, Mass.: Harvard Univ. Press, 1999); David Hess, *Science Studies: An Advanced Introduction* (New York: New York Univ. Press, 1997); Karin

acter of the knowledge-making process, held particular promise and powerful analytic consequence for the emerging discipline of colonial science history.[3] Gradually, within the new field, explicit commitment to the prevailing positivist assumptions gave way to implicit acceptance of constructivnist perspectives.

This move from a mainly positivist to a mainly constructivist orientation was, in significant measure, empirically driven—not the result of considered debate over abstractions. When an historian studies a particular *locality*,[4] by definition one would expect that locality to become the "center" of his or her interest. Yet positivist colonial historians of, say, science in New Spain were, in reality, often writing the larger social and intellectual history of Europe, and not the history of Mexico,[5] seeking out local "traces" of European ideas and intellectual movements.[6] "'Europe'" says Dipesh Chakrabarty, "remains the sovereign theoretical subject of all histories, including the ones we call 'Indian,' 'Chinese,' 'Kenyan,' and so on."[7] When historians sought richer, deeper, "thicker" accounts of science in non-European localities,[8] they soon became dissatisfied with analyses in which every standard of truth and rationality was set in Europe, and in which the very meaning of "rationality," "enlightenment," "progress," and "useful knowledge" had been defined on that distant continent. Thus, little by little, historians of local science sloughed off a paradigm of

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Knorr-Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, Mass.: Harvard Univ. Press, 1999).

[3] For example, Bruno Latour's writings have made a particularly useful contribution, both by insisting on eliminating the "great divide" between science and traditional modes of thought, and by locating the power of modern science in its distinctive international network of institutions. The workings of that network create the conditions that make legible and commensurable (for the center) all the observations, measurements, representations, and texts produced in the various peripheries. See especially Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge, Mass.: Harvard Univ. Press, 1987).

[4] In this paper I shall use the terms "local" and "locality" flexibly to indicate "places" in which science is accomplished. A locality may be a region, country, city, or even a single institution, incorporating social, cultural, political, and economic factors and relationships, and including both centers and peripheries.

[5] In fact, Mexican historians have been somewhat less Eurocentric than historians of science in many other colonial localities. Nevertheless, at the first Mexican colloquium in the field (September, 1963), thirty-four of the sixty-one papers presented were part of a symposium on the European Enlightenment in Latin America. Enrique Beltrán, ed., *Memorias del Primer Coloquio Mexicano de Historia de la Ciencia*, 2 vols. (Mexico City: Sociedad Mexicana de Historia Natural, 1964). The history of Mexican science has a venerable and distinguished disciplinary history with antecedents in the nineteenth century. See Enrique Beltrán, "Fuentes mexicanas de la historia de la ciencia," *Anales de las Sociedad Mexicana de Historia de la Ciencia y de la Tecnología*, 1970, *2*:57–112; Juan José Saldaña, "Marcos conceptuales de la historia de las ciencias en Latino América: Positivismo y economicismo," *El Perfil de la ciencia en América* (Mexico City: Sociedad Latinoamericana de Historia de las Ciencias y la Tecnología, 1986); and Elías Trabulse, "Aproximaciones historiográficas a la ciencia mexicana," *Memorias del Primer Congreso Mexicano de Historia de la Ciencia y de la Tecnología* (Mexico City: Sociedad de Historia de la Ciencia y de la Tecnología, 1989), vol. 1, pp. 51–69.

[6] See for example, Roland D. Hussey, "Traces of French Enlightenment in Colonial Hispanic America," in *Latin America and the Enlightenment*, ed. Arthur P. Whitaker, 2nd ed. (Ithaca: Cornell Univ. Press, 1961), pp. 23–51. This book, originally published in 1942, uncovered useful material but remains a classic example of a project in European history focused on Latin America, and is one that helped set the agenda for writing colonial science history. All six of the distinguished contributing scholars were apparently English speaking and based outside Latin America.

[7] Dipesh Chakrabarty, "Postcoloniality and the Artifice of History: Who Speaks for 'Indian' Pasts?" *Representations*, 1992, *32*:1–26.

[8] Clifford Geertz referred to the study of local cases as "thick description," without which more general cultural meanings and power relationships cannot be understood. Clifford Geertz, *The Interpretation of Cultures: Selected Essays* (New York: Basic Books, 1973).

cultural *deficit*, replacing it with a paradigm of cultural *difference*. Within the "big picture" Europe was progressively "decentered,"[9] and in a very real sense, science was also decentered.

PERIPHERAL CENTERS AND CENTRAL PERIPHERIES

Because modern science arose principally in one geographic locale,[10] historians of science had taken the wheel as the metaphor for its international structure: its center was in Europe (displaced this century to the mid-Atlantic), with the rest of the world revolving around. But the metaphor of the wheel is exceedingly misleading. From the time of its cosmopolitan birth in the correspondence of Marin Mersenne (1588–1648) and Henry Oldenburg (1618–1677) and in institutions like the much neglected Casa de la Contratación in Seville (1539?), the Florentine Accademia del Cimento (1657), and the Royal Society of London (1660), modern science is better understood, both metaphorically and actually, as a polycentric communications network.[11] During the nineteenth and twentieth centuries that network was fully institutionalized, which represented a revolution in knowledge making more significant for both science and society than the theoretical advances of the seventeenth century traditionally known as the Scientific Revolution. Thus, from the very beginnings of the scientific movement,

> Centrality or peripherality was not primarily a matter of geographical location, but the combined effect of social, scientific, and—not the least—power relations. . . . Scientists, like other people, bore identities, they belonged somewhere, and they were loyal to something. Even more importantly, the daily activities of scientists were carried out in a framework of institutions, agendas, career opportunities, working language, financial support and patronage systems.[12]

This is to suggest that the idea of science having a European center and a global periphery perpetrated a confusing, and ultimately spurious, understanding of the relations of science and place. Then and now, Europe had major centers, minor centers, and peripheries; cities like London, indeed, had central institutions and peripheral institutions. Of course, progressively other localities developed scientific centers and peripheries. Furthermore, within Europe and without, centers rose and fell.

→ Andrew Cunningham and Perry Williams, "Decentring the 'Big Picture': The Origins of Modern Science and the Modern Origins of Science," *British Journal of the History of Science*, 1993, *26:*407–32.

[10] "Modern science" as distinguished by its institutions, procedures, and technologies.

[11] See Latour, *Science in Action* (cit. n. 3), pp. 215–57, and Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump* (Princeton: Princeton Univ. Press, 1985). Sverker Sörlin has given a clear description of early processes of scientific internationalization: "National and International Aspects of Cross-Boundary Science: Scientific Travel in the 18th Century," in *Denationalizing Science: The Contexts of International Scientific Practice*, eds. Elizabeth Crawford, Terry Shinn, and Sverker Sörlin (Dordrecht: Kluwer, 1993), pp. 43–72. See also Lorraine Daston, "The Ideal and Reality of the Republic of Letters in the Enlightenment," *Science in Context*, 1991, *4:*367–86; and for the role of the Casa de la Contratación, see David Turnbull, "Cartography and Science in Early Modern Europe: Mapping the Construction of Knowledge Spaces," *Imago Mundi*, 1996, *48:*7–14, and J. Pulido Rubio, *El Piloto mayor de la Casa de Contratación de Sevilla* (Sevilla: Escuelade Estudios Hispano-Americanos, 1950).

[12] Sörlin, "National and International" (cit. n. 11), p. 45.

And whenever a scientific center arose within a locality, both science and the locality were changed by the event.[13]

Eurocentric explanations of the growth of science received a great boost with the appearance of historian George Basalla's widely known model describing "the introduction of modern science into any non-European nation."[14] The model predicted that localities peripheral to the European center would progressively "receive" the ideas of Western science, slowly establishing their own scientific organizations and personnel, perhaps producing along the way a few "heroes of colonial science."[15] In the final stage, after the colony had accomplished "seven tasks," a broad and "independent" institutional support base for science would have been established, thus allowing the given locality to compete scientifically in the world of nations.[16] The seven tasks, which are rarely discussed in the critical literature, included such activities as "overcoming" and eventually "eradicating" recalcitrant local "philosophical and religious beliefs," founding scientific societies "patterned after" the major European organizations, and importing European technologies. This unrelenting Eurocentrism was only one of the many reasons that the Basalla model was finally rejected by most historians.[17]

COLONIAL TO NATIONAL TRAJECTORIES

Basalla's model was initially attractive because it showed—in fact, seemed to prescribe—the straight and narrow path to national scientific development. Each locality was to rise in invariant sequence from a colonial to a national stage, from scientific dependency to autonomy. Colonial science was, in effect, considered a scientific adolescence that might eventually grow with the new nation-states into the maturity that Europe had long since achieved. In countries like Australia, where European settlers predominated, the predictive capacity of the model might, at first glance, seem reliable. In just a little over two hundred years, Australia moved from its first European scientific expedition (Cook/Banks) through a clearly "colonial" period to a remarkable degree of national scientific sophistication. Melbourne, for instance, is a locality that seemingly forms a perfect exemplar of how this can happen. The story of the city's move from scientific periphery to scientific center develops around the person of Frank Macfarlane Burnet (1899–1985), who became an outstanding

[13] Bruno Latour, "Give Me a Laboratory and I Will Raise the World," in *Science Observed*, eds. Karin Knorr-Cetina and Michael Mulkay (London: Sage, 1983), pp. 141–70.

[14] George Basalla, "The Spread of Western Science," *Science*, 1967, *15:*611–21. This paper, perhaps more than any other, set the initial research parameters for colonial science history. Patrick Petitjean amusingly and accurately describes Basalla's model as the work "le plus cité, et le plus réfuté aussi" by historians of science working in the field. Patrick Petitjean, "Sciences et empires: Un théme prométteur, des enjeux cruciaux," in *Science and Empires: Historical Studies about Scientific Development and European Expansion*, eds. Patrick Petitjean, Catherine Jami, and Anne Marie Moulin (Dordrecht: Kluwer, 1992), p. 6.

[15] Basalla, "Spread of Western Science" (cit. n. 14), p. 614.

[16] *Ibid.*, pp. 617–20.

[17] Although it has been subjected to devastating critique, Basalla's model continues to be cited long after every vestige of its explanatory power has disappeared. The "fall" of the model among historians of science has been well documented. This literature is extensively reviewed in David Wade Chambers, "Locality and Science: Myths of Centre and Periphery," in *Mundialización de la ciencia y cultural nacional*, eds. Antonio Lafuente, Alberto Elena, and María Luisa Ortega (Madrid: Doce Calles, 1993), pp. 605–18.

theoretician of virology and immunology.[18] Burnet declined chairs at Harvard and in London, as he was determined to make Melbourne an international center for medical research. He eventually attracted several future Nobel laureates to work with him. Today, Melbourne has seven major institutes for medical research and currently attracts sixty-four percent of the institutional awards from Australia's National Health and Medical Research Council.[19]

Thus, especially for the "neo-Europes" of the colonial world,[20] there might seem to be a hopeful and discerning congruity in Basalla's schema, especially in its postulation of a clear nexus between scientific activity and nation building. If the model works anywhere, one might expect it to be in those countries that had the decided "advantage" of European cultural, legal, economic, and technological frameworks—that is to say, in the colonies of those nations whose socioeconomic conditions had first given rise to modern science. This is especially true in invader/settler societies,[21] like Australia, where destruction of the indigenes and their traditional cultures had been ruthlessly accomplished, thereby effectively eliminating the need to "eradicate" and "replace" prevailing traditional philosophies, the first of Basalla's seven tasks of Europeanization. Australia, although obsessed with its great distance in kilometers from Europe, was socially, culturally, politically, economically, and racially closer to Europe than most of Europe's near neighbors (such as Egypt, Turkey, and many parts of the former Soviet Union).[22] But the apparent fit of the Basalla schema even with the Australian case lasts only through a very superficial reading; indeed, some of the model's leading critics actually use Australia as a counterexample.[23] At the very least, the Australian story is "richer and more complex" than the Basalla model allows.[24]

In Roy MacLeod's apt phrase, "science became a convenient metaphor . . . for

[18] Of Australia's six Nobel Prize winners in the sciences and medicine, all but Macfarlane Burnet spent most of their professional careers abroad.

[19] Christopher Sexton, *Burnet: A Life*, rev. ed. (Oxford: Oxford Univ. Press, 1999). For a detailed account of the Walter and Eliza Hall Institute, see Max Charlesworth, *et al.*, eds., *Life Among the Scientists* (Melbourne: Oxford Univ. Press, 1989). The Melbourne case was suggested by Barry Jones, former Australian minister for science and technology, personal communication, 1999.

[20] Alfred W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe* (Cambridge: Cambridge Univ. Press, 1986). Crosby offers ecological explanations for the quick demographic dominance achieved in "neo-Europes." For a more recent and very interesting treatment of environmental history issues in which colonialism (and particularly colonial science) play a role, see two recent books by Richard Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600–1860* (Cambridge: Cambridge Univ. Press, 1995) and *Ecology, Climate and Empire: Colonialism and Global Environmental History, 1400–1940* (N.P., White Horse Press, 1998).

[21] The term "settler society" should not be used. It conveys an inaccurate picture of the European invasion and is offensive to the memories of millions who died in the peaceful-sounding process of "settlement." See Henry Reynolds, *Frontier: Aborigines, Settlers and Land* (Sydney: Allen and Unwin, 1987), pp. 192–3; A. Grenfell Price, *White Settlers and Native Peoples* (Cambridge: Cambridge Univ. Press, 1950), and Tom Griffiths and Libby Robin, *Ecology and Empire: Environmental History of Settler Societies* (Carlton: Melbourne Univ. Press, 1997).

[22] See David Wade Chambers, "Does Distance Tyrannize Science?" in *International Science and National Scientific Identity*, eds. R. W. Home and Sally Gregory Kohlstedt (Dordrecht: Kluwer, 1991).

[23] In particular, see MacLeod, "Moving Metropolis" (cit. n. 1), pp. 1–16, and Ian Inkster, "Scientific Enterprise and the Colonial 'Model': Observations on Australian Experience in Historical Context," *Social Studies of Science*, 1985, *15*:677–704.

[24] R. W. Home, "Introduction," in *Australian Science in the Making*, ed. R. W. Home (Cambridge: Cambridge Univ. Press, 1988), p. x.

what the Empire might become."[25] Indeed, for colonial scientists, science served as metaphor *and* means of legitimate colonial aspiration. Eventually, both colonizer and colonized came to believe that the promotion of science also promoted the cause of independence. For example, after losing the vast majority of her empire, Spain was not slow to sabotage local attempts to reform and modernize educational and scientific institutions in such remaining colonies as Puerto Rico and Cuba. Without a doubt, on both sides of the colonial divide, science was seen to provide a mechanism for increased colonial autonomy and self-sufficiency.[26] And we may speculate that the long-lasting popularity of the Basalla model may lie in its clear depiction of staged scientific growth moving ever nationward.

It is sometimes forgotten that Basalla's "three stage model" was deeply ensconced in the intellectual assumptions, not to mention the cold war ideological baggage, of the early theories of development. His famous essay appeared when W. W. Rostow's *Stages of Economic Growth*, published seven years earlier,[27] was at the height of its influence. Rostow's five stages precisely parallel Basalla's three stages. If Rostow's model provides the *economic* development corollary of modernization theory, Basalla's similar model plays a kindred role for *scientific* development. But there were flies in the ointment of modernization theory: some regions could not escape perpetual underdevelopment, dependency, exploitation, or cultural breakdown. In significant measure, these problems bedeviling world economic development—which have discredited "stages of economic growth" theories—also infect the international science system. In other words, many localities are held structurally in scientific underdevelopment due to such factors as brain drain, the high costs of technoscientific labs and equipment, inability to support the full range of scientific disciplines in any one locality, and a subjugated position in the institutional relations of knowledge and power.

The Basalla/Rostow approach to modernization assumes that the patterns that characterized scientific/economic development in the West provide a model for other localities around the world to follow. Without considerable modification this assumption is effectively blind to both history and culture, and is premised on the notion that "pre-scientific" localities, today, start from a position similar to Europe's before scientific take-off hundreds of years ago. Furthermore, the philosophy, religious beliefs, values, and institutions of traditional societies are considered probable obstacles, in effect, so much chaff to be blown away on the winds of scientific change.[28]

These considerations alone—without surveying the full critique that has been mounted over the last twenty years against staged, linear, and progressive models—suggest the need for a new framework for comparing histories of local science. From the extensive discussion of the Basalla model over the years, we have learned much about how such a framework ought to look. It should be symmetrical and interactive across the great divides—center/periphery, local/global, national/colonial, and tradi-

[25] MacLeod, "Moving Metropolis" (cit. n. 1), p. 244.

[26] See David Wade Chambers, James E. McClellan, and Heidi Zogbaum, "Science/Nation/Culture in the Caribbean Basin," in *Cambridge History of Science*, ed. Ronald Numbers, vol. 8 (Cambridge: Cambridge Univ. Press, forthcoming).

[27] W. W. Rostow, *Stages of Economic Growth* (Cambridge: Cambridge Univ. Press, 1960).

[28] Michael Shermer, *Why People Believe Weird Things: PseudoScience, Superstition and Other Confusions of our Time* (New York: Freeman, 1997).

Figure 1. *Joseph Dalton Hooker in the Himalayas receiving colonial tributes (in this case scientifically undescribed rhododendrons). Hooker insisted that plants be sent to Kew Gardens to be described; indigenous people and colonial botanists had only local knowledge. By William Tayler (1849). (Reproduced with permission of the Trustees of the Royal Botanic Gardens, Kew.)*

tional/modern. It should be nonlinear, nonstaged, and nonprescriptive, but it should specify a set of parameters that allow systematic comparison of the great array of independent and interdependent local histories of the production, application, and diffusion of natural knowledge. It should be dynamic and flexible and should identify vectors of communication, exchange, and control. Finally, the framework should take careful note of the social infrastructures that support knowledge work in both "Western" and "traditional" settings, without privileging one knowledge system over the other, thus allowing examination of both local and global contingencies of knowledge production and inculcation in the chosen locality.[29]

[29] Needless to say, this is a tall order. It is no wonder that some have suggested it unlikely that such a model will ever be devised, especially considering the cultural, social, and economic diversity of the cases for which the model must account! See Petitjean, Jami, and Moulin, *Science and Empires* (cit. n. 14), pp. 6–9.

SCIENCE AND PLACE

How does one articulate the *place* of knowledge or the *locality* of science? To some, even to formulate such a question is nonsense. According to intellectual legacies inherited from the Greeks and, more recently, from empiricist portrayals of scientific knowledge, "the place of knowledge is nowhere in particular and anywhere at all."[30] In other words, under the old philosophical paradigm, "the significance of place is dissolved."[31] Not surprisingly, then, historians of science have, on the whole, shown little interest in the complex interactions of science and place.[32] Exigencies of place might have been seen to present obstacles against, or encouragement for, doing or applying science, but so-called externalist explanations have been effectively isolated from the central processes of knowledge construction. On the other hand, *colonial* science historians very early began to realize that their stories were made interesting primarily by parameters of locality.[33]

Parameters of Locality

Until recently within the field, the most commonly found unit of locality was the colony or the nation-state. But to confine our interest to national cases would be arbitrary, needlessly limiting, and ultimately unsound. Localities mark the intersection of history, environment, language, and culture, and geographic boundaries are only one of the possible desiderata in defining a case study. Localities may be bounded by tangibles, such as socioeconomic circumstances, legalities, colonizing forces, topographies, and technologies; and by abstractions, such as beliefs about time, space, and progress. They may be further shaped by such factors as race and gender, ideology, and religious belief. To define a scientific locality, then, is simply to nominate a local frame of reference within which we may usefully examine the role of knowledge construction and inculcation.

[30] See Steven Shapin's delightful essay examining the social uses of solitude, "'The Mind Is Its Own Place': Science and Solitude in Seventeenth-Century England," *Sci. Context*, 1990, *4:*191–218, quotation on p. 191. Shapin also reminds us that "Most writers who insist both on the global character of mathematical and scientific knowledge and its universal application tend to overlook the immense amount of work that is done to create and sustain the artificial and formal environments in which 'application' happens," p. 209. See also Adi Ophir and Steven Shapin, "The Place of Knowledge: A Methodological Survey," *Sci. Context*, 1991, *4:*3–21; and Steven Shapin, "Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science," *Transactions of the Institute of British Geographers*, n. s., 1998, *23:*5–12.

[31] Joseph Rouse, *Knowledge and Power* (Ithaca: Cornell Univ. Press, 1987), p. 77. This book is still extremely valuable for colonial science historians beginning to think about the concept of local knowledge.

[32] The ramifications of taking "place" seriously have been extensively discussed in theoretical writings in many fields, such as geography, anthropology, postcolonial studies, and feminist studies. See for example, Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), pp. 183–202; Michael Keith and Steve Pile, eds., *Place and the Politics of Identity* (London: Routledge, 1993); Bill Ashcroft, Gareth Griffiths, and Helen Tiffen, eds., *The Post-Colonial Reader* (London: Routledge, 1995), and others cited below. For further discussion of the notion of knowledge "spaces," → David Turnbull, "Reframing Science and Other Local Knowledge Traditions," *Futures*, 1997, *29*, 6:551–62; Stanley Jeyerada Tambiah, *Magic, Science, Religion, and the Scope of Rationality* (Cambridge: Cambridge Univ. Press, 1990); Edward W. Soja, *Thirdspace: Journeys to Los Angeles and Other Real-and-Imagined Places* (Cambridge, Mass.: Blackwell, 1996); and homi bhabha, *The Location of Culture* (New York: Routledge, 1994).

[33] As we have seen, the diffusionist slant of the Basalla model allowed us to maintain the fiction that we were dealing with universal truths variously transmitted and applied.

What does this approach mean for studies of, say, the history of Caribbean science? One might define the locality geographically as the chain of islands, or as a particular island, or as the entire basin including an outer rim reaching to North, Central, and South America. Additionally, one might look at the area as a "colonial locality," within which a number of empires acted and interacted over a particular time frame. Or the colonial locality might simply be made up of the Spanish colonies. Alternatively, one might construct a "traditional knowledge locality," examining how tribal knowledge was constituted and the intellectual roles it played. In Mexico City, a university locality for the construction of knowledge might be differentiated from a mining-school locality. For some purposes, the world of medicine and health might be seen to constitute a separate knowledge space. And so on.

Such interpretive flexibility, allowing overlapping hierarchies of locality within a single geographical area, might seem daunting to the historian. Clifford Geertz comments that, in trying to explain phenomena, to turn from invoking master narratives ("grand textures of cause and effect") to providing "local frames of awareness" is to exchange "a set of well-charted difficulties for a set of largely uncharted ones."[34] But colonial historians of science have already begun mapping these uncharted localities; one might even say that their developing focus on locality is one of the field's greatest achievements within the history of science. The problem remains, however, that if we do not find a separate "other" vantage point from which to interpret and compare—whether we call it master narrative, theoretical model, or third space—we are left with the certainty of sinking into a vast sea of nativist ethnohistories.

Is this an infinite regress, leading in one direction to solipsism and in the other to a pretense of universal objectivity that hides the subjugation of local culture and local knowledge? Perhaps the best way forward, based on what we have learned, is to construct a new, more responsive, democratic, and self-questioning global discourse.[35] This process would necessarily nourish and sustain the local histories and local cultures that alone can provide "external" critique of the modernity project and the structures of power that it affords. The local and the global are a dialectical pair and must remain so in our histories.[36]

Vectors of Assemblage

In any colonial locality, vectors of assemblage encompass elements of process and of accumulation: the historical emplacement of the institutional and the physical framework for science. Telling this story has been the major work of most colonial science historians. The local scientific infrastructure is made up not only of organizations, buildings, museums, gardens, laboratories, instruments, chemicals, minerals, disciplines, schools, textbooks, and journals, but also of ideas and strategies,

[34] Clifford Geertz, *Local Knowledge: Further Essays in Interpretive Anthropology* (New York: Basic Books, 1983), p. 6.

[35] Chakrabarty calls for "a history that deliberately makes visible, within the very structure of its narrative forms, its own repressive strategies and practices." Chakrabarty, "Postcoloniality" (cit. n. 7), p. 25.

[36] See a→ Edward W. Said, "Figures, Configurations, Transfigurations," *Race and Class*, 1990, *32:*1–16; Katherine Hayles, *Chaos Bound: Orderly Disorder in Contemporary Literature and Science* (Ithaca: Cornell Univ. Press, 1990), pp. 213–14; ; → David Turnbull, "Local Knowledge and Comparative Scientific Traditions," *Knowledge and Policy*, 1993–4, *6:*29–54.

metaphors, theories and taxonomies, values, communities of trained personnel, and new socioprofessional roles for them to fill. David Turnbull usefully suggests the use of Deleuze and Guattari's term "assemblage" to denote, in his words, this "amalgam of places, bodies, voices, skills, practices, technical devices, theories, social strategies and collective work that together constitute technoscientific knowledge/practices." The term "vectors of assemblage" suggests active and evolving practices as well as the constructed social and physical environments. For historians, the term "implies a constructed robustness without a fully interpreted and agreed upon theoretical framework."[37] In truth, there is a fine assortment of theoretical approaches that illuminate our understanding of the various elements of this assemblage of people, places, ideas, and things: biography, environmental history, medical history, cultural studies, material culture, feminist theory, etc.

In colonial localities, the vectors of assemblage sustain the imperial metropolitan connection to the science system, but if deliberately so constructed may also allow the attainment of nationalist cultural and socioeconomic objectives. Although exceedingly rare, in some cases these institutions may provide a base for the preservation of traditional local knowledge systems.[38] Recently, debates over intellectual property have recognized the value of indigenous knowledge of taxonomy in relation to health, but the resulting property laws, rather than protecting indigenous rights, have often served to transform this knowledge into commodities, profitable only to large corporations.[39] This development has now progressed to the point where any analysis of the infrastructure of late-twentieth-century science must look at the vectors of assemblage devoted to commodification in science, including such social mechanisms as copyright laws and the privatization of university research, as well as the appropriation of indigenous knowledge.

Around the globe, indigenous voices have been raised against these changes in the infrastructure of technoscience—changes that threaten the traditional social ethos and moral economy of science as much as the rights of indigenous peoples. In the words of Victoria Tauli-Corpus, "We are told that the companies have intellectual property rights over these genetic plant materials . . . this logic is beyond us . . . we indigenous peoples . . . have developed and preserved these plants over thousands of years."[40] To understand the weight of Tauli-Corpus's argument, it is useful to consider what lies behind her use of the words "developed and preserved." Aside from

[37] See Turnbull, "Local Knowledge" (cit. n. 36), p. 34.

[38] In nineteenth-century Mexico, for example, there was an attempt, especially by José Antonio Alzate, to support the indigenous natural taxonomies rather than those of Linnaeus. See, for example, Patricia Aceves Pastrana, *Química, botánica y farmacia en la Nueva España a finales del siglo XVIII* (Mexico City: Universidad Autónoma Metropolitana, 1993), pp. 55–74. In some localities traditional medicine has been partially sustained, or at least tolerated, in relation to Western medical practice.

[39] The intellectual property rights debate has now given rise to its own large literature, which cannot be reviewed here due to lack of space. But see C. Lind, "The Idea of Capitalism or the Capitalism of Ideas? A Moral Critique of the Copyright Act," *Intellectual Property Journal*, 1991, *7*:70–4; E. C. Hettinger, "Justifying Intellectual Property," *Philosophy and Public Affairs*, 1989: 35; and Laurie A. Whitt, "Cultural Imperialism and the Marketing of Native America," *American Indian and Culture Research Journal*, 1995, *19*:1–31.

[40] Victoria Tauli-Corpus, "We Are Part of Biodiversity, Respect Our Rights," *Third World Resurgence*, 1993, *36*:25, quoted in Laurie A. Whitt, "Metaphor and Power in Indigenous and Western Knowledge Systems," International Conference on Working Disparate Knowledge Traditions Together, Deakin University, Victoria, Australia, 1994.

the fact that indigenous bodies of knowledge may often be sophisticated in content, as has been increasingly recognized in areas like taxonomy, indigenous knowledge localities employ complex vectors of assemblage, which may include maps, calendars, training of personnel, techniques, procedures, skills, manipulation of material, interpretation of results, prediction, meetings, and the preparation of texts.[41] In other words, indigenous involvement in the production of natural knowledge is neither trivial nor inconsequential. By exploring indigenous knowledge localities in the same way that we explore Western scientific localities, we attain a better position for effective comparison of these quite disparate knowledge systems.[42]

Network of Exchange and Control

As the process of assemblage develops in any locality, vital connections and linkages are made both locally and internationally. We have seen how the letter writers and travelers of the early science movement led in a direct line to the first global information network. This network, the international science system, becomes ever more polycentric and hierarchical, with major and minor centers and close and distant peripheries defined not geographically but in terms of scientific authority and social power. The network includes laboratories, journals, public and private funding agencies, museums, libraries, educational institutions, corporations, doctors' surgeries, administrative reports, and so on. It is important to keep the assemblage and the exchange network analytically separate, although both are required to participate in modern science. Other knowledge systems have their own assemblages and networks, but the fact that they are socially incommensurable may, in some cases, be more important than their conceptual differences.

In the conglomerate vectors of assemblage that form the local infrastructure of technoscience, most people and things are tied directly into the international science system. This system does such varied work as formulate priorities for research funding, privilege certain modes of inquiry, set standards for the size of things, authorize knowledge claims, and establish regimes of cultural transmission, including education and popularization. The history of colonial science is arguably little more than the gradual connection of the locality into this global scientific communications

[41] Many of these elements have been entirely overlooked or underestimated as parts of knowledge production and communication. Texts, for example, may be inculcated in song, dance, architecture, and ceremonial business. Calendars have received some attention, but until very recently indigenous mapmaking traditions were completely undervalued as evidence of sophisticated natural knowledge. See David Turnbull, *Maps Are Territories: Science is an Atlas* (Chicago: Univ. of Chicago Press, 1993), pp. 19–53; David Woodward and G. Malcolm Lewis, eds., *Cartography in the Traditional African, American, Arctic, Australian, and Pacific Societies, The History of Cartography* (Chicago: Univ. of Chicago Press, 1998); Barbara Mundy, *The Mapping of New Spain: Indigenous Cartography and the Maps of the Relaciones Geográficas* (Chicago: Univ. of Chicago Press, 1996); Mark Warhus, *Another America: Native American Maps and the History of Our Land* (New York: St. Martin's Press, 1997); G. M. Lewis, ed., *Cartographic Encounters: Perspectives on Native American Mapmaking and Map Use* (Chicago: Univ. of Chicago Press, 1998); Laura Nader, *Naked Science: Anthropological Inquiry into Boundaries, Power, and Knowledge* (New York: Routledge, 1996); and David Turnbull, "Mapping Encounters and (En)Countering Maps: A Critical Examination of Cartographic Resistance," *Knowledge and Society*, 1998, *11*:15–44.

[42] Such a detailed comparison can be found, for instance, in Helen Watson and David Wade Chambers (with the Yolngu community at Yirrkala), *Singing the Land, Signing the Land* (Geelong: Deakin Univ. Press, 1989).

network, which historically was based in and controlled by the metropolitan center. In other words, this is the system that monitors, coordinates, authorizes, legitimates, classifies, and situates theoretically the flow of observational and experimental information. Perhaps the best description of these vectors is found in Latour's "centers of calculation."[43] Without this connection, a scientific locality cannot be taken seriously, no matter the perfection of its assemblage or the quality of work being done.

But this network is more than a science system, more than just an information exchange. It also enables mechanisms of social control, commodity transaction, exploitation, and appropriation. For example, Warwick Anderson suggests that "The recognition that even the most formally structured technical knowledge may be implicated in colonial accumulation and acquisition is long overdue. . . . inquiry into the textual economy of the laboratory . . . indicates an expansion of the power of the laboratory to represent and, in so doing, to constitute, regulate and legitimate colonial social realities. . . . The appropriation of colonial bodies and their insertion into a metropolitan discourse is in a sense a simulacrum of the whole colonial enterprise."[44]

INDIGENOUS KNOWLEDGE SYSTEMS

In the final section of this paper, we would like to follow a slightly different tack, introducing (though not fully arguing) the case that historians of science, in their accounts of particular localities, should be prepared to take stock of the nature, content, and role of indigenous knowledge systems.[45] There are a number of reasons why this is important. From studying "non-Western" cultures and their knowledge of nature, we contribute to our understanding, and to the conservation, of great intellectual traditions that are tens of thousands of years in the making. In doing this we enhance our understanding of the human mind, of human culture, and most especially of the noble—and sometimes ignoble—encounter of humans and nature. The twentieth century introduced the final stages of a half-millennium of global multicultural engagement, marked principally by conflict and holocaust.[46] By helping preserve the multiple varieties of human understanding of the natural world, we go to the heart of preserving cultural diversity. And perhaps we will improve the possibility of constructive cultural reconciliation in a deeply troubled world.

Finally, from a practical point of view, there is an increasing realization that indig-

[43] Latour, *Science in Action* (cit. n. 3), pp. 215–57.

[44] Warwick Anderson, "Where Every Prospect Pleases and Only Man Is Vile: Laboratory Medicine As Colonial Discourse," *Critical Inquiry*, 1992.

[45] This is not to suggest that all historians of science must drop their tools and start working on indigenous research projects, but we do believe that the study of science in any geographic region must include reference to indigenous knowledge systems (sometimes called IKS). Furthermore, we believe that responsible teaching will include reference to IKS in all generalist courses in history and social studies of science. ⇒ David Wade Chambers, "Seeing a World in a Grain of Sand: Science Teaching in Multicultural Context," *Science and Education*, 1999, *8:*633–44; *idem*, preface to Turnbull, *Maps Are Territories* (cit. n. 41), p. v. See also the chapter on ethnoscience in Sally Gregory Kohlstedt and Margaret W. Rossiter, eds., *Historical Writing on American Science: Perspectives and Prospects*, *Osiris*, 1986, *1:*209–28.

[46] Sadly, but not surprisingly, modern technoscience has been an active agent in the European global conquest, which has brought devastating consequences for nature and for other cultures. This fact is not lost on indigenous peoples.

enous knowledge has a crucial part to play in the preservation of biodiversity and the management of natural resources. The desire for environmentally sustainable development has prompted attempts to establish a dialogue between science and indigenous knowledge, combining the strengths and perspectives of both systems.[47] This interest in bringing disparate knowledge systems together in productive collaboration is also seen in medicine and public health.[48] Scholars have also drawn upon indigenous knowledge to counter what they see as the dangerous reductionism and culture-bound nature of Western science, its negative impact on native peoples, and its influence on the way we perceive the natural environment.[49] Indeed, some have argued for the incorporation of value systems into the sciences.[50]

Historians of science have a reasonably good record in relation to some of the more obvious traditional cultures. For instance, it is not uncommon for major general histories—in attempting to provide the big picture—to treat scientific civilizations of the Old World (China, India, Islam) and the New (Maya, Aztec, and Inca).[51] But if these major cultures are among the best known, they are by no means the only interesting indigenous bodies of knowledge available to historians.[52] It is essential that locality studies of these other knowledge traditions become incorporated into the archive of human history. Such a project, wherever carried out, must recognize the dangers of exploitation and repression that are in some measure inherent in ethnographic studies conducted from the center. For these reasons, such projects must allow the voice of the colonized and subjugated cultures to be heard in their own terms. Of course, local/global contention will not cease in this endeavor, but the local will be strengthened and the possibility of mutual exchange and contribution will be increased.

The call to recognize the intellectual stature and continuing validity of indigenous modes of thought reflects a growing international concern that has come to prominence over the last twenty years. UNESCO has commissioned a number of reports on issues relating to knowledge, culture, and development, all of which have opposed past policies of cultural assimilation (policies that have been almost

[47] Graham Baines and Nancy M. Williams, "Partnerships in Tradition and Science," in *Traditional Ecological Knowledge: Wisdom for Sustainable Development*, eds. N. M. Williams and G. Baines (Canberra: Centre for Resource and Environmental Studies, Australian National University, 1993) pp. 1–6.

[48] Gregory Cajete, *A People's Ecology: Explorations in Sustainable Living* (Santa Fe, N. Mex.: Clear Light Publishers, 1999).

[49] Vine Deloria, Jr., *Red Earth White Lies: Native Americans and the Myth of Scientific Fact* (Golden, Colo.: Fulcrum Publishing, 1997); Peter Knudston and David Suzuki, *Wisdom of the Elders* (St. Leonards, New South Wales: Allen and Unwin, 1992).

[50] Gregory Cajete, *Igniting the Sparkle: An Indigenous Science Education Model* (Skyand, N.C.: Kivakí Press, 1999); Gregory Cajete, *Native Science: Laws of Interdependence* (Santa Fe, N. Mex.: Clear Light Publishers, 2000); Zia Sardar, *Explorations in Islamic Science* (London: Mansell, 1989).

[51] For a recent attempt at the big picture that gives a good account of certain areas of indigenous knowledge, see James E. McClellan III and Harold Dorn, *Science and Technology in World History* (Baltimore, Md.: Johns Hopkins Press, 1999).

[52] Preliminary access to these knowledge systems has been improved by several recent publications: Helaine Selin, ed., *Encyclopaedia of the History of Science, Technology and Medicine in Non-Western Cultures* (Dordrecht: Kluwer, 1997); Douglas Allchin and Robert DeKosky, *An Introduction to the History of Science in Non-Western Traditions* (Seattle: History of Science Society, 1999); Sarah Franklin, "Science as Culture, Cultures of Science," *Annual Review of Anthropology*, 1995:163–84; David Hess, *Science and Technology in a Multicultural World: The Cultural Politics of Facts and Artifacts* (New York: Columbia Univ. Press, 1995).

universally viewed by indigenous peoples as nothing less than genocidal). For example, an influential 1981 report stated that one major international objective should be the "rehabilitation of traditional forms of knowledge and, above all, of the potentialities which have been stifled by the pressure of the dominant countries or groups."[53] And in 1995: "a culturally distinct people loses its identity as the use of its language and social and political institutions, as well as its traditions, artforms, religious practices and cultural values, is restricted. *The challenge today . . . is to develop a setting that ensures that development is integrative and inclusive.* This means respect for value systems, for the traditional knowledge that indigenous people have of their society and environment, and for their institutions in which culture is grounded."[54]

Importantly, this understanding is seen to apply to technoscientific knowledge in its relationship to indigenous knowledge systems. In 1999, in a declaration adopted by the UNESCO-sponsored World Conference on Science in Budapest, this position was developed in some detail, acknowledging

> that traditional and local knowledge systems as dynamic expressions of perceiving and understanding the world, can make and historically have made, a valuable contribution to science and technology, and that there is a need to preserve, protect, research and promote this cultural heritage. . . . Governmental and non-governmental organizations should sustain traditional knowledge systems through active support to the societies that are keepers and developers of this knowledge, their ways of life, their languages, their social organization and the environments in which they live. . . . Governments should support cooperation between holders of traditional knowledge and scientists to explore the relationships between different knowledge systems and to foster interlinkages of mutual benefit.[55]

There are many problems associated with this international call to support the study and preservation of indigenous knowledge systems (IKS). It might easily degenerate into a rush for profiteering exploitation of botanical knowledge. Furthermore, even if the IKS project is pursued with the most honorable of intentions, it is possible to view it as a lost cause. Some knowledge systems have disappeared, some are known only in fragments, some involve sacred knowledge that cannot be made public, and most can be uncovered only by learning relevant languages and by working in collaboration with native scholars, elders, and practitioners. The comparison of Western science with indigenous knowledge systems is fraught with all the difficulties associated with understanding the similarities and demarcations between markedly different cultures; these problems are compounded by looking at precisely that aspect of Western culture that is believed to provide an objective, disinterested, and non-culture-bound account of the natural world.

It is possible to conceive how a culture can accept and appreciate another culture's aesthetics—although European interest in indigenous art was a long time coming,

[53] UNESCO, *Domination or Sharing?: Report on Indigenous Development and the Transfer of Knowledge* (Unesco Publishing, 1981), p. 31

[54] UNESCO, *Our Creative Diversity: Report of the World Commission on Culture and Development* (Unesco Publishing, 1995), pp. 70–1 (italics in original); see also D. Michael Warren, L. Jan Slikkerveer, and David Brokensha, eds., *The Cultural Dimension of Development: Indigenous Knowledge Systems* (London: Intermediate Technology Publications, 1995).

[55] UNESCO, *The Declaration on Science and the Use of Scientific Knowledge: Report of the World Conference on Science* (Unesco Publishing, 1999).

and popular appreciation has sometimes involved the development of a specific product for white consumption. But the idea that very different cultures may be able to reconcile some aspects of their knowledge of the natural world has been considered an impossible project in some quarters. After all, the old paradigm argued, there is only one objective reality, and only science has developed a reliable method for describing and explaining that reality. The history of science, in such a view, is the history of pushing back the frontiers of superstition and ignorance, with religion and belief retreating in the face of superior scientific explanation.[56]

Science, like any other social activity, bears the imprint of the society of which it is part. All knowledge systems are "situated" in power relationships, value assumptions, and historical frameworks.[57] As a culturally specific knowledge system—albeit one with enormous power and one that remains a source of both good and evil—Western science, in our intellectual calculations, cannot be accorded a privileged status over indigenous knowledge. Far from being an abstract intellectual debate, this issue goes to the heart of how different cultures view one another and their ways of seeing the world.[58] Furthermore, indigenous knowledge systems demand respect as powerful cultural expressions of ways of knowing nature—ways that have clear implications for how humans should live and prosper in particular environments. The reassessment of the character of IKS in light of these findings is only just starting, and the history of science has an important role to play in this. By considering both Western science and indigenous knowledge systems as forms of local knowledge and practice, the locality approach opens up a space for more equitable comparison.

BRINGING DISPARATE KNOWLEDGE SYSTEMS TOGETHER

In the last few pages, we offer an account of taxonomy intended to illustrate some of the things that can be learned when disparate knowledge systems are brought together. Science typically is the dominant knowledge system because it resides within international networks very different from those of a politically marginalized indigenous community. For example, an elaborate system of commissions, publications, and institutions lies behind contemporary botanical and zoological classification and nomenclature; it is inconceivable that an indigenous taxonomy—no matter how internally cohesive, how comprehensive and differentiated, or even how similarly speciated—could continue to exist within that system.[59] An ethnoscientist is

[56] Mera Nanda, "The Epistemic Charity of the Constructivist Critics of Science and Why the Third World Should Refuse the Offer," in *A House Built on Sand: Exposing Post-Modernist Myths About Science*, ed. Noretta Koertge (New York: Oxford Univ. Press, 1998). Nanda makes the case that science is the "last stand" against religious bigotry and superstition.

[57] John Law, ed., *Power, Action and Belief: A New Sociology of Knowledge?* (London: Routledge and Kegan Paul, 1986); *idem, A Sociology of Monsters: Essays on Power, Technology and Domination* (*Sociological Review Monograph*, 1991); Sandra Harding, ed., *The Racial Economy of Science: Toward a Democratic Future* (Bloomington, Ind.: Indiana Univ. Press, 1993); Helen Longino, *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry* (Princeton, N.J.: Princeton Univ. Press, 1990).

[58] Ivan Karp and Steven D. Lavine, eds., *Exhibiting Cultures* (Washington, D.C.: Smithsonian Institution Press, 1991).

[59] Brent Berlin, *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies* (Princeton, N.J.: Princeton Univ. Press, 1992); Ralph N. H. Bulmer, "Why is the Cassowary not a Bird? A Problem of Zoological Taxonomy among the Karam of the New Guinea

likely to focus on how indigenous taxonomies differ from scientific taxonomy. And the history of taxonomy has much of interest to say on this issue. For example, it may be useful first to consider how scientific taxonomy emerged from earlier European folk taxonomies. Like indigenous taxonomies, those recorded by Aristotle and in early herbals of the fifteenth and sixteenth centuries listed around eight hundred taxa at the level of genus or species. Indeed, at the local level there was often no difference between genus and species, because most genera were monospecific in a given environment, and where two or more species occurred, they were often morphologically different because they were pursuing different ecological strategies.

Several technological changes transformed folk taxonomy. The printing press and woodcut permitted the printing of books that compared taxa from different regions and across time. Voyages of discovery brought back large numbers of new specimens, which were stored in herbaria, botanical gardens, and museums. Naturalists began to specialize in plants or animals, and then in more restricted groups such as birds, fishes, or insects. These huge increases in the number of recorded taxa, which were largely the result of technological change rather than intellectual breakthrough, posed practical problems of ordering and management that had to be resolved. Linnaeus began to introduce the higher categories of class and order (above genus and species).

In the late eighteenth and early nineteenth centuries, as the genus lost its place as the chief taxonomic rank, scientific taxonomy moved farther from folk taxonomy. Scientists increasingly used biological functions and anatomical structures to define species in families and other higher-order taxa. Meanwhile, genera were split again and again under the weight of newly discovered species. No plausible explanation was offered for why it was possible to sort organisms into "natural" groups based on shared characteristics until Darwin argued that the similarities between organisms were due to the "propinquity of descent." But this did not make the procedures of taxonomy any simpler; if anything, it simply raised the stakes by requiring that taxonomy also indicate evolutionary history. An obvious difference between scientific taxonomy and indigenous classificatory systems is that the latter are not based on the theory of evolution, with taxa reflecting genetic or phylogenetic groupings. However, it would be inappropriate to say that this was a way of fundamentally distinguishing scientific taxonomy from indigenous classification, or we would be forced to conclude that all taxonomy prior to Darwin was nonscientific.

A more fundamental difference lies in the social realm: scientific taxonomy seeks to create a global system of nomenclature and a hierarchical structure, based on an elaborate system of publication, formal rules, and congresses. The preamble of the International Code of Zoological Nomenclature states that "the object of the Code is to promote stability and universality," and this contrasts noticeably with the flexible use of terms in indigenous classifications, which are part of the everyday language of the community and are used in many different contexts.[60]

Clearly, classificatory systems are an integral part of culture, whether we are talk-

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Highlands," *Man*, 1967, *2*:5–25; Paul Sillitoe, *Roots of the Earth: Crops in the Highlands of Papua New Guinea* (Kensington: Univ. of New South Wales Press, 1983), chap. 8.

[60] Ernst Mayr, *Principles of Systematic Zoology* (New York: McGraw Hill, 1969); Ralph Bulmer and Chris Healey, "Field Methods in Ethnozoology," in Williams and Baines, *Traditional Ecological Knowledge* (cit. n. 47), pp. 43–55.

ing of indigenous or scientific taxonomies. With regard to indigenous knowledge, Ralph Bulmer has observed that

> ethnozoological data do not exist as a readily separable body of knowledge in traditional societies, where generally no distinction is made like that between science and other systems of knowledge in contemporary western culture. Consequently, the investigator is likely to be confronted with what may, at first sight, appear to be an unsystematic blend of detailed, credible information, mystical ideas, and superstition. It is important to realise that such a mixture of what Europeans might consider rational, empirically based knowledge and mystical or supernatural beliefs must be understood within its cultural context.[61]

There is something forced in wrenching out the zoological classification system of the Kalam of Papua New Guinea and comparing it to scientific taxonomy, because it privileges scientific knowledge and uses it to assess the "validity" of indigenous knowledge in a culturally imperialist manner. Indeed, this charge can be made against much of what is done under the label of ethnoscience. We often forget that the validity of scientific taxonomy also suffers when taken from its cultural context. If you doubt this, try to explain (without reference to evolutionary theory or the Code of Nomenclature) the reasons for the many scientific taxonomic distinctions that ignore obvious similarities or differences of structure and function.

Bulmer was always conscious of these dangers in his work, and sought to locate Kalam classifications within the whole of Kalam culture, as he understood it. But like other anthropologists, he remained the author and authority (the etymological similarity is revealing), drawing upon his Kalam informants and then ordering the material into an ethnographic narrative for others in his profession. In his later work, Bulmer formed a more equal collaboration with his major informant, Ian Saem Majnep. In their *Birds of My Kalam Country*, Majnep spoke directly to the reader (based on taped conversations with Bulmer), and the material was primarily arranged according to Majnep's cultural categories.[62]

Conversations across cultures are even more subject to all the difficulties of multiple interpretations and readings that are characteristic of conversations between individuals. Our comments above on indigenous knowledge have been constructed within a context of writing *about* indigenous peoples, not *for* indigenous peoples.[63] Written from a Western perspective, this essay is not a replacement for indigenous views of the relations between science and indigenous knowledge. On the other hand, we do hope it will usefully contest some traditional Western biases, while opening up crosscultural spaces for new research directions within the history of science in local contexts.

[61] Bulmer and Healey, "Field Methods," (cit. n. 60), pp. 43–4.

[62] Ian Saem Majnep and Ralph Bulmer, *Birds of My Kalam Country* (Auckland: Univ. of Auckland Press, 1977); George E. Marcus, "Notes and Quotes Concerning the Further Collaboration of Ian Saem Majnep and Ralph Bulmer," in *Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer*, ed. Andrew Pawley (Auckland: Polynesian Society, 1991), pp. 37–45.

[63] Both of the authors have worked with indigenous people and one is of Cherokee ancestry. See Bain Attwood, introduction to *Power, Knowledge and Aborigines*, eds. Bain Attwood and John Arnold (Melbourne: La Trobe Univ. Press, 1992), pp. i–xvi.

Figure 2. *A Kob, or Papuan Lory* (Charmosyna papou). *The most important bird in the Kalam category* Yakt ok, b noman ay ayak, *or birds which men's souls can turn into. Drawing by Christopher Healey from Ian Saem Majnep and Ralph Bulmer,* Birds of My Kalam Country *(Auckland: Univ. of Auckland Press, 1977).*

CONCLUSION

For at least four hundred years, the world has witnessed the rise and growth of the technoscientific movement,[64] inculcating such enormous power and authority that it has been able to confront, overwhelm, and absorb the insights of traditional knowledge systems around the planet. This social and organizational triumph is sometimes interpreted as evidence of the universality of scientific knowledge claims. The locality approach focuses on the conditions under which this *appearance* of universality arose and is maintained. These conditions include, for example, Europe's successful politico-economic colonization of the world; the close integration of its institutions of technoscientific knowledge with its institutions of power; its unique social mechanisms of authoritative communication and intercultural exchange, employing new devices like laboratories for knowledge making and networks for retranscribing, moving, and incorporating local knowledge into the global discourse; and, finally, the enormous instrumental successes of technoscience in the manipulation of nature and in the development of technologies of control.

By understanding modern science as the spread of the ideas and institutions of rationality and progress, the old paradigm perpetuated a clear agenda for colonial historians. We searched for local "traces" of European Enlightenment. We identified when and how these ideas and institutions first appeared in a new locality, recording when the far-flung provincials finally "got it right," sometimes offering reasons for the slow uptake of European ideas. We accepted, as patterning sciences, astronomy and physics rather than chemistry and engineering; natural history rather than agronomy or mineralogy.[65] And we dutifully attempted to distinguish center from periphery, science from technology, colonial science from national, dependent science from independent, and basic science from applied, even though these categories and distinctions completely dissolved, or at least seemed less useful, when analyzed in concrete case or local context.[66]

By the 1990s, many of those questions and assumptions seemed outmoded. As historians of the colonial world embraced new perspectives—which we have here called the "locality approach"—our histories became less defensive, analytically richer, and more firmly fixed on local dimensions of the rise of the science movement. If modern technoscience was considered to be embedded in the social, cultural, and intellectual context that produced it, then the failure of European science to take hold in another locality was best explained not by seeking out backwardness or deficiency in the target culture but by uncovering the local intellectual and socioeconomic interests that stood to gain or lose by its introduction; and by understanding the structural aspects of the international science system that favored the "West" and the "North."

What, then, is the future of colonial science history as a scholarly field? To define a locality simply as a "colony" is to invite neglect of much that matters culturally

[64] Surely the phrase "modern science and technology" has passed its use-by date. The term "technoscience" is perhaps a little less problematic and feels especially appropriate for the "jacked in" (computerized) sciences that dominate the beginning of the new millennium.

[65] Simon Schaffer, "Field Trials, the State of Nature and the British Colonial Predicament" (manuscript, 1999). In this important paper Schaffer reminds us that the Enlightenment also set up agronomy as a model science. Had agriculture become a patterning science, needless to say, we would think about science differently in ways that especially matter in colonial and indigenous localities.

[66] Nader, *Naked Science* (cit. n. 41).

and historically. In any case, colonies and empires are primarily the products of a particular moment in history, whereas colonizing forces that dominate and exploit are always and everywhere with us. Concentrating on the multidimensional—cultural, political, and socioeconomic—*local* contexts of scientific endeavor will help to end another "great divide," the one that has seen historians of science writing about centers and historians of colonial science writing about peripheries.