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Synchronization and Synchrony in the Archive: Geology and the 1830s

Epigraphs: Herman Melville, Pierre or The Ambiguities: The Kraken Edition (New York: HarperCollins, [1852] 1995), p. 301; Herman Melville, Pierre or The Ambiguities: The Kraken Edition (New York: HarperCollins, [1852] 1995), p. 303; Francois Hartog, Le miroir d'Hderodote: Essai sur In reprdesentation de l'autre (Paris: Gallimard, 1991), p. 13; Anonymous, "Life and Works of Baron Cuvier," Edinburgh Rereiw 62 (1836): 277.

"LECTURE FIRST. Chronometricals and Horologicals, (Being not so much the Portal, as part of the temporary Scaffold to the Portal of this new Philosophy)."

Plotinus Plinlimmon in Herman Melville, Pierre or The Ambiguities: The Kraken Edition

"Bacon's brains were mere watch-maker's brains; but Christ was a chronometer; and the most exquisitely adjusted and exact one, and the least affected by all terrestrial jarrings, of any that have ever come to us."

Plotinus Plinlimmon in Herman Melville, Pierre or The Ambiguities: The Kraken Edition

Le monotheisme impose et suppose un constant travail de la memoire.

Francois Hartog, Le nziroir d'Haerodote: Essai sur In repraesentation de l'autre

The mathematician and the natural philosopher had assumed to themselves the highest locality in the temple of science, and had almost expelled the collector and the classifier from its precincts. Presuming that magnitude and distance ennobled material objects, and invested with sublimity the laws by which they are governed; and taking it for granted that the imponderable and invisible agencies of nature presented finer subjects of research than the grosser objects which we can taste, touch, and accumulate, they have long looked down upon the humble and pious naturalist as but a degree superior to the functionary of a bear garden, or the master of ceremonies to a cage of tigers. This intolerable vanity this insensibility to the unity and grandeur of nature, to the matchless structure of sublunary bodies; and to the beautiful laws of organic life, was perhaps both the effect and the cause of the low state of natural science during the preceding two centuries. Men of acute and exuberant genius were naturally led to invest their intellectual capital in researches that were likely to return them an uxorious interest in reputation; and it must be acknowledged that the richest fields of science were for a long time left to the cultivation of very humble laborers.

Anonymous, "Life and Works of Baron Cuvier"

Introduction

Information technology constitutes the twist in the Mobius strip that takes us from arguments internal to a field (how is the past conceptualized in the case of a historical science like geology) to its exterior (how is information about the past stored). Generally speaking, all things on earth can be seen as at once objects and archives (Buckland 1997). As objects they function in the world, and as archives they maintain traces of their own past. Thus a rock can be read as an object that constitutes part of the lithosphere, and equally as a document that contains its own history written into it: striations on the surface indicate past glaciation, strata indicate complex stories of deposition over time, and the relative presence of radioactive isotopes of various kinds indicates, among other things, journeys through the mantle. And so forth. The significance of these traces has been discussed in a variety of contexts within the sciences over the past few hundred years: the span is from Paley's natural theology (1802) (timeless divinity) to Allegre's new historicism (1992) (perpetual change). In general, we have gone from a very limited view of what we can know about the past to a much more ambitious view In the early nineteenth century, Charles Lyell argued that we could not know any more about the history of the earth than the period since the last revolution of its surface; today methods have been developed to trace material with varying certainty through subsumption into the earth's mantel, and even back to its interstellar origin. (Similarly, Comte in the early nineteenth century argued that we can only ever know anything beyond mere physical dynamics about those bodies in space that we can touch he saw the solar system as our ultimate limit; today we claim, improbably, to reach back in space toward the origin of time itself (Weinberg 1993).)

As we have come to see the earth as a variably legible palimpsest from which little is ever completely lost, archival technology has itself exploded over the past few centuries in two ways in the earth sciences from underneath, with the use of technological practices to visualize and to read archives contained in the earth, and from on top, with the use of computer technologies to manage the associated information explosion. (I am here adopting a soft definition of technology drawing off Foucault's "dispositif technique" (1975), which refers to integrally social and technical sets of practices that constitute particular actions in the world. The soft definition is needed in order to be sensitive to the fluid nature of both vanilla and information technology. Office procedures and computer programs are both designed as abstract machines and so can be realized interchangeably though always with great difficulty in configurations of people, the environment, and silicon.) The Mobius strip that con cerns us now, then, is one that goes from reading the earth's archive to archiving the earth in the 1830s. The archival metaphors used converged onto information practices on the one hand and earth science on the other to create a closed system where each bootstrapped the other.

Three themes run through this chapter. The first is that of synchrony and stasis. In a historical science like geology produced at the height of the Industrial Revolution in England, one might expect a progressivist telling of the history of the earth. To the contrary, we will wander a strangely synchronic world where there is no effective arrow to time, where there is in the long run no change, and where humans rather than transforming the world with the might of industry are really having no effect on it at all. The second is that of the two natures industrial and natural converging onto this isotropic time. The third is that of synchronization the work that it takes to bring the various bits of the world together into a single archival framework. Information practice its metaphors and strategies permitted the cohabitation of astronomy, political economy, industry, and geological science in this synchronic world, and, in particular, it permitted a synchronization of the social and natural worlds to the same temporality.

In and of itself, this claim of the importance of information practices is not proven or disproven by the work of this chapter alone there are many possible readings of the material presented. Any proof will cumulate over the set of readings offered in the next three chapters discussing geology in the 1830s, cybernetics in the 1950s, and biodiversity today. At each point, a central science for an epoch will be shown to be associated with an information discourse structured around the latest information technology and speaking to the histories associated with these disciplines. This line of argument in the end posits radical discontinuities in the disciplinary record of sciences in tune with the development of such discontinuities in information technologies broadly conceived (Veyne 1971, 395-424). Why these discontinuities, which have the form of Foucault's epistemic breaks, should occur as they do is discussed in the conclusion.

Time and Memory in an Industrial World

Time management was a central issue in industrializing Britain in the early nineteenth century. Charles Babbage (1832) considered the clock a "regulator of time" in opposition to "the negligence and idleness of human agents" and "the irregular and fluctuating effort of animals or natural forces" (32-43). A century before the glorious rise of scientific management, ClaudeLucien Bergery (1829) remarked: "The worker ... must be mean with his time ... he can hardly devote 30 years or 262,800 hours to collecting the money he will need in his old age (180) ... Each minute lost will deprive him of about three thousandths of a franc (181) ... every man is capable of at least 5 movements a second, there are 36,000 seconds in a day of ten hours, which will in consequence allow 180,000 movements" (108). The working day in a factory was regulated by clocks, from the checking-in clocks that often registered the hours of the workers to the timers that made the machines run regularly. Dickens at the start of the nineteenth century and Lewis Carroll at its apogee both give accounts of the significance of timekeeping to young boys (David Copperfield) and white rabbits that would have appeared startling to any eighteenth-century social commentator. When the great geologist Charles Lyell, whose work I examine at length in this chapter, underlined the importance of the division of the history of the earth into equal periods of time, he was reflecting a fundamental obsession of the industrial world then being born.

Varieties of technoscientific work developed during the nineteenth century created a representational space and time that structured both the immediate perception of social and natural reality and the storage of these perceptions in an imperial archive (Richards 1996). The imperial archive is often, and rightly, pictured in terms of its voracious desire to collect information of all kinds, about all of its citizens all of the time. It can be seen as a lust for information that is reaching a kind of apogee today. However, there is another way of picturing this information drive. It is also a drive to save as little information as possible about something; it relentlessly pares down interactions to their absolutely minimal form and then dispenses dialogue by rote. An anecdote I have to call it this since I cannot find the trace might make this clear. When trams were introduced into Melbourne, so the story goes, the tickets were designed to contain information about the passengers. You didn't want someone (say a tall, thin person) giving away her ticket to someone (say, a short, robust one). So the conductor would punch holes in the ticket to indicate the physical appearance of the passenger along several dimensions. In a stagecoach, in days of yore, every passenger would be known by the driver --a lot of information would be held about the passenger. With the early Melbourne tram, the amount of information decreased. Finally, with the tram today when we are duly disciplined to the logic and the logic has been duly adjusted to us we have tickets with two-hour time limits that can be used multiply over their period of validity. On today's reading, the cost of interaction (constantly checking tickets, verifying identities) is too high, so only the trace of a valid transaction carried out by someone within the recent past is really all that's needed. The empire voraciously gathers as little information as it can. In Latour's terms, the oligopticon is the flip side of the panopticon. This imperial archive cannot be understood solely in terms of record keeping. The act of keeping records is itself intimately tied to the conjuring of the social and natural world into forms that render themselves amenable to recording. Thus the act of archiving is a positive act that simultaneously changes the world and creates a record of it (cf Serres 2001, on smallpox) in Derrida's terms, it is both sequential and jussive.

I am not concerned here with the origin of the modern structuring of the scientific and social archive. The scientific use of isotropic, coordinate space and time clearly predates the period I am looking at. However, it is to the nineteenth century that we must look for the growing belief that scientific record keeping and, in particular, its way of representing nature and society within that space and time could be applied to all possible social and natural phenomena. In the 1830s, Comte's Church of Positive Philosophy stands as an extreme statement of the scope of science and of the need to radically reshape the archive; by the end of the century, such scientific fervor and archival manipulation was commonplace (Rosenberg 1976). This neutral space and time coordinate frame became plausible for two tightly interlinked reasons. First, a series of infrastructural technologies were developed that actively extended the applicability of the framework. Second, the bureaucratic working procedures developed in association with these technologies took advantage of and formalized this framing. Scientific work epitomized the development and rigorous application of these procedures; here my work resonates with Serres's theory of the origins of Euclidean geometry in social science and the administration of the Greek empire (1993).

The Industrial Revolution and Regular Space/Time

One of the chief early products of the Industrial Revolution in Britain was the watch: from 1800 to 1820 at least 100,000 clocks and watches were produced every year in England (British Sessional Papers 1818, 205) at a key period between 1831 and 1841, the census revealed a jump from 8,000 to 15,000 people employed in this trade. Literary texts of all sorts from this period teem with arguments from analogy to watches. Thus animals could be understood through this analogy: `As a watch not wound up remains without motion, still retaining the power of resuming it, and when the mainspring recovers its elasticity is again enabled to act upon its wheels: so to animals heat is the key that winds up the wheels, and restores to the mainspring its powers of reaction" (Buckland 1836, 159). The analogy extended to the physical features of humanity, as evidenced by the following appeal by Neil Arnot (1827) for "medical men" to learn physics: `All these structures the medical man, of course, should understand, as a watchmaker knows the part of the machine about which he is employed. The latter, unless he can discover where a pin is loose, or a wheel injured, or a particle of dust adhering, or oil wanting etc., would ill succeed in repairing an injury, and so also of the ignorant medical man in respect to the human body" (_xxviii). It also extended to the turbulent ocean. As D. Graham Burnett (2003, 5-19) notes, Matthew Fontaine Maury spoke of a "clockwork ocean" with waves and cycles of salinity as "balance wheels."

The analogy permitted a comparison between two orders of creation through imposing a temporally mediated qualitative difference between creator and created a difference that was instantiated on the factory floor and in nature. Creators stood outside regular space and time and imposed regular temporal order. In general, scientific work was seen as the imposition of a representative framework of regular space and time on social and natural time. This is brought out in a work by Ajasson de Grandsagne and Parisot, French translators of Lyell's Principles of Geology (itself a work whose vision of a changeless world did much to develop regularities in space and time as a key to the representation of global process). They started from the position that "industry, so it is said, is a second nature" (Grandsagne and Parisot 1836, 8). A historical section demonstrated how humanity had gone from being initially weak to currently king of nature. Science, they argued, caused the change, and was now all-powerful: "Thus, in raising itself above everything else, science has achieved its full extent: all the arts have been submitted to it, industry has recognized it for its regulator; it has served and protected humanity in all its states, and it has interwoven itself in the most intimate and sensitive manner with all social relations" (ibid., 21). Science had emerged from previous intellectual disorder to govern this second nature: if, in principle, science has had some element of chance, and if common people have made some useful advances, henceforth it is only through the meditation of superior spirits that it can spread new benefits (ibid., 20). Thus science stood in the same relation to the second nature industry as did God to the first; the new scientist created order in artifacts as God did in the motions of the material world. Science was industry's "regulator": a word that refers to the timing of the industrial process. Science was making society conform to the same spatiotemporal representational framework it was "discovering" in nature: a process that I call "convergence" (Bowker 1994). This is a key aspect of the synchronization of the social and natural worlds.

Neither nature nor second nature were, of course, as regular as this spatiotemporal framework: and indeed there developed a strain of politically radical science that attacked Newtonian physics for its attempted imposition of such a form of representation (e.g., Mackintosh 1840). Thus ex-St. Simon- ianJules Leroux wrote of a different kind of time in science: "Beside the philosophy of human history is placed the philosophy of natural history; for there is in fact only one science. The cosmogony of nature and humanity. To make science, art and politics converge more and more towards the same goal, to introduce more and more in science, as in art, as in politics, the notion of change, progress, succession, continuity, life, and by that to submit them to the same law: this is the goal, the outline, the plan of philosophy" (Reformateur, October 16, 1834, 4). Radical geologist Constant-Prevost Daurio (1838) put ethereal motion at the center of his system and excoriated the space of "that dry and scowling science, which has for head a sphere powdered with alphas and betas, a cube for body, cylinders and cones for arms and legs; which lives only in square and cube roots, and doesn't offer the world anything but formulas, which dandy geometers find very elegant; a science which can only move with the aid of winches, pulleys, and the steam engine. Lacking sensation, it is sensitive as a monolith" (220).

Conservative scientists and political philosophers endeavored to demonstrate that beneath the appearance of chaos and irregularity both in first and second nature could be found the reality of regularity. This time was quintessentially spacelike: it lacked direction and granularity. At first blush, this might seem an odd representational framework to develop for the brash progressivism of the Industrial Revolution (compare the progressivist historical vision of the science of Victorian certainty, as described in Young 1973). However, as acute observors such as Dickens and Zola noted across the span of the century, the primary apperception of industrialization may well have been the irregularities of boom and bust as much as the annihilation of space and time (I am thinking here of David Copperfield's and Denise's tortuous working childhoods marked more by staccato syncopation than regular rhythms). Tracing the logical structure of this archival framework in two domains political economy and astronomy I will begin to demonstrate its attachment to synchrony and synchronization.

G. Poulett Scrope was a geologist and political economist. As a geologist, Scrope (1833) was very sensitive to the importance of time: "The leading idea which is present in all our researches, and which accompanies every fresh observation, the sound of which to the ear of the student of Nature seems continually echoed from every part of her works, is Time! Time! Time!" (165). When it came to political economy, the trouble was that people were not regular: "The rules of Political Economy are as simple and harmonious as the laws which regulate the natural world, but the strange and wayward policy of man would render them intricate and difficult" (ibid., title page). From a similar vantage, Charles Babbage (1832, 3-49) asserted that the machine regularizes "man": processes synchronizing him to industrial time ... which is also natural time. For Scrope, it is the capitalist order. Thus he wrote of the periodic slumps that were much more visible to the early Victorian observer than the unremitting progress that was to be the mark of later Victorian science and political economy: "It is ... strongly to be suspected that such epochs of general embarrassment and distress among the productive classes ... are anomalies, not in the order of events which flow from the simple and natural laws of production, but occasioned by the force of some artificial disturbing cause or other, introduced through the fraud or folly of the rulers of the social communities they so grievously affect" (Scrope 1833, 152). Here we see already an astronomical influence: astronomy at this period was "saving" Laplacean determinism through the analysis of anomalies. Scrope makes the analogy tighter still: "There is, in fact, a continual oscillation ... going on in the returns of capital in most employments, about the mean level or average of net profit." This, he claimed, went along with or was, rather, caused by "an analogous oscillation in the Market value or selling price, of commodities about the mean cost of their production" (ibid., 162-163).

The same horror of waywardness and its solution through the imposition of a regular spatiotemporal representational framework was common in astronomy in this period. Consider the following proud announcement concerning Halley's comet: "The return of the comet of Halley at its predicted time has been remarked with intense curiosity and satisfaction by astronomers, and by the public. This has now become a regular and well ordered member of our system" (Anonymous 1836a, 160). The author claimed that this was a good augur for the development of science: "That a body, differing so much in its appearance and habits from the ordinary tenants of the sky, should reappear so nearly at the time and in the place appointed for it by our excellent associate Rosenberger, is a convincing instance of the progress towards certainty of physical astronomy" (ibid.). The regular flow of time, itself inspired by the watch analogy, was the central discovery of astronomy, and thence of the human spirit: "In effect, we only know completely one single law; that is the law of constancy and uniformity. It is to this simple idea that we seek to reduce all others, and it is uniquely in this reduction that science, for us, consists.... Such is, I believe, the natural movement of the human spirit ... of which Astronomy offers us the clearest image" (Poinsot 1837, 386-387). Geology's task was to bring this representational framework down to earth. The result is typified by Huot (1837, 3):

"Everywhere one sees such a uniform disposition, that only differs in a few details ... that often presents lacunas but never inver sion. This order that one admires, despite so many traces of violent revolutions, of upheavals and shocks that the Earth has felt, does it not seem, if one dare say it, in rapport with the regular march imprinted on celestial bodies?" (3). This, as we will see, was Charles Lyell's whole project.

To complete the circuit back from the heavens to humanity, historian and geologist Philippe Joseph-Benjamin Buchez (1833) believed that the greatest good would emerge from imposing this astronomical representational framework (based on infinite space and a timeless present) on our understanding of human affairs. Thus he wrote that, to all appearances, "harmony is nowhere, not even in the circle of the smallest families" (6). This apparent disharmony would, with the proper analytic framework, be dissolved into regularity: "When one examines the position of humanity vis-a-vis the phenomenal totality in which it exists, one easily gets to see that it is a function of the universe, in the full mathematical rigor of this term.... Thus one comes to understand that the very large revolutions of humanity correspond to small revolutions of the planetary system (ibid., 109-110). In a similar move, political theorist Charles Dunoyer (1837) averred that the underlying astronomical order would, through the "spirit of industry," assert itself on humanity:

Under its [the spirits of industry's] influence, peoples will begin by grouping themselves more naturally... Peoples will come closer together, mass according to their real analogies and according to their real interests. Given this, the same arts will soon be cultivated with an equal success among all peoples, the same ideas will circulate in all countries ... ; even languages will get closer ... ; uniformity of costumes will be established in all climates no matter what the conditions of nature: the same needs, a similar civilization, will develop everywhere.... and finally the largest countries will end up by only representing a single people, composed of an infinite number of uniform aggregations, between which will be established, without confusion or violence, relations both as complex and as easy, as peaceful and as profitable as may be. (I: 452-453)

In this Laplacean era, then, both astronomical and political bodies would converge onto regular time and henceforward be fully deterministic.

In sum, a cosmology inspired by factory production developed in the early nineteenth century in Britain and France. According to this cosmology, humanity was working on two fronts. First, disordered human events were being made orderly through the development of the capitalist mode of production on the one hand and by the coupling of wayward people with regular machines on the other. Second, the human spirit was discovering that all apparent disorder and disharmony in the wider universe (as revealed to astronomers and geologists) could, with the appropriate representational framework, be dissolved into a regular ordering of processes in periodic time. In each case there was an appearance of disorder and secular or progressive, taken with the emphasis on "stepping" rather than "forward" change (the appearance of comets, booms, and slumps); in each case, the underlying reality was an eternal present discovered through the use of a representational framework of temporal regularity. The convergence of these two fronts meant that each could find rhetorical and philosophical support in the other.

Within a fully regularized temporal framework, one can read backward into the past and forward into the future, without recording the shocks of the present. The real archive told a tale of stasis. The emphasis is on a single Law, with perturbations and oscillations providing noise that true understanding would filter out. There is no need (as we shall see in Comte's analysis in chapter 2) to actually record the past as it happened; all one need record in order to act now is the past as it would have happened if there had not been perturbation. The nature of the archive itself changes (over time, with the perfection of the human spirit) from being one of the chronicling of difference to a synchronized display of sameness; within which there is no falling back or leaping forward but rather the smooth operation of regular law

An ideologically charged eternal present lurks beneath the veneer of change and underwrites the archive. Such lurking is native to significant political and scientific argumentation today. Consider the case of climate change. The political framework for the debate is that time should stand still (the current climate is perfect and natural; a hard argument for Mancunians, whose city grew during the industrial revolution partly because of the desire of textiles for moisture rather than humans for comfort, to follow), and in particular human agency should be removed from the flow of time and rendered nugatory. In such a perfect world, we would be subject to regular cycles (orbital forcing of climate change for example), which would in the long run be as nothing. One can structure a reading of biodiversity politics very similarly: the goal of much current policy is not the preservation of change and its potential but the preservation of current species and the imposition of stasis. (It can of course be argued that what is being opposed in climate change arguments is the catastrophic rate of change rather than the fact of same in the same way that it was feared universally in the 1970s that the catastrophic onset of the next ice age was nigh, unless perhaps the U.S.S.R. could seed the air with carbon dioxide (Lamb 1995, 333). It is my reading that in general arguments about rates of change are really about the fact of change). The act of record keeping would become one of mapping the apparently wayward present onto an eternal, unchanging present ever just out of reach. Beyond dharma, at the heart of the industrial revolution, there is stasis.

Synchronization of the World and Its Archive into Cartesian Space/Time

Shortly after the development of the locomotive, Wolfgang Schivelbusch (1986, 18) asserts: "the uniform speed of the motion generated by the steam engine no longer seems unnatural when compared to the motion generated by animal power; rather, the reverse becomes the case" (18). He opines that mechanical uniformity became "the `natural' state of affairs, compared to which the `nature' of draft animals appears as dangerous and chaotic" (ibid.). This latter was a favorite theme in industrializing Britain and France in the nineteenth century.

Indeed, the abstract space and time within which scientific representations have been made since Newton are in turn reinforced by the railway. Schivelbusch (1986) speaks of the train "realizing Newton's mechanics in the realm of transportation" (59). He makes the rich point that what was left to the train traveler (after you took out sounds, smells, and so forth from the countryside) was a Newtonian world of abstract qualities size, shape, quantity, and motion. He goes on to point out that there was a definite learning process involved. Early railroad travelers literally could not look out of the window at all: they found it disturbing, confusing; it gave them headaches. Only when they learned to deal with the new form of representation on its own terms were they able to look out the train window and appreciate the landscapes that lay before them.

This new space created a new kind of geographical representation: abstract and regular. Schivelbusch speaks of the "annihilation of space,", by which he means the de facto and representational annihilation of lived space between. William Cronon (1991) has described this same effect in a passage describing the long-distance transportation of meat in refrigerated railway cars: "Once within the corporate system, places lost their particularity and became functional abstractions on organizational charts. Geography no longer mattered very much except as a problem in management: time had conspired with capital to annihilate space. The cattle might still graze amid forgotten buffalo wallows in central Montana, and the hogs might still devour their feedlot corn in Iowa, but from the corporate point of view they could just as well have been anywhere else" (259). It is perhaps unsurprising that it was within the featureless great plains of the Midwest that space should first be annihilated!

Historians of America's Great West have been struck by the commodification of nature that occurred in the midcentury. This commodification itself was tied to the development of new means of communication (especially the railway and the telegraph) and the associated new ways of doing business. Across the vast, flat prairies, Cronon (1991) notes, the land came to resemble the maps that were drawn of it by government surveyors in the distant east. Fields, fences, and firebreaks "were concrete embodiments of the environmental partitioning that made farming possible" (102). The Midwest was indeed peculiarly suited to the government practice of "subdividing the nation into a vast grid of square-mile sections whose purpose was to turn land into real estate .... By imposing the same abstract and homogeneous grid pattern on all land ... government surveyors made it marketable" (102). As Cronon says, the grid: "turned the prairie into a commodity" (103); he talks of a "second nature" being created by the railways, one that came to seem quite natural (56). Thus again representation in an abstract, regular space and commodification go hand in hand. Globalization is an ever-incomplete movement to impose a uniform representational time and space on a heterogeneous collection of lived spaces and histories.

The story of the imposition of a new social and representational time has been well told by Schivelbusch, Chandler, and Cronon. As with the annihilated space, this story is clearly tied to organizational needs. Schivelbusch (1986) gives the sparsest account: "Regular traffic needs standardized time this is quite analogous to the way in which the machine ensemble constituted by rail and carriage undermined individual traffic and brought about the transportation monopoly" (48) (for a fuller account, see O'Malley 1996, 55-98). The analogy he is drawing here is to the fact that you could not run a railway line with everyone running their own personal train (Latour 1996). You needed a centralized bureaucracy and effective monopoly in order to operate with any efficiency. Similarly, you could not have every train running on its own (local) time: you need a centralized time in order for the railway company to be able to create the representations that would permit efficient operation. Thirty-five years before the U.S. government recognized standard times across the United States, the railways imposed them in their own system (Cronon 1991, 79).

Chandler (1997), Campbell-Kelly (1994), and Yates (1989) have each chronicled the development of new office and accounting procedures in the railroad companies. All three chart how standardized annual reports, which represented the companies' operation within an absolute time and annihilated space (in Schivelbusch's sense) allowed the railroad companies to deal with the control and communication issues that arose. Thus Yates traces how the various genres of internal communication the general order, the circular letter, the memorandum and the report grew up in railroad companies (Yates 1989, 68). Her tracing of the development of the report form is indicative of the general movement. In the early days (the 1830s and 1840s): "railroad annual reports were generally designed as letters with opening salutations and complimentary closes" (ibid., 78). Thus they were historically specific events, tied to a given locale and addressed to a particular person. Over time, however, "tables would becomes increasingly important, and the letter form would disappear" (ibid.). The local dropped out and a regular x andy axis covering time and distance predominated. Reports became far more frequent too: the weekly report morphed into an hourly report marking the position of each train on the New York and Erie railroad. As Chandler (1977) notes, the new accounting forms developed by the railroads were adopted with minimal changes by the emergent new large-scale industries of the 1880s. Indeed, he asserts that they "remained the basic accounting techniques used by American business enterprise until well into the twentieth century" (117). Thus the new industries were made possible by the railroads and produced organizational representations modeled on the railroads. Small wonder that we can find features of the new dominant infrastructural technology so widely spread. Its organizational form (accounting techniques, reports, and so forth) synchronized with its own impact on the world (regularizing it) providing both a material and metaphorical impulsion to order any particular form of enquiry or activity along these synchronized lines.

Technoscientific representations were socially and organizationally imposed by means of the new infrastructural technology with a dual process of commodification and representation central to the shift. The same infrastructural technology that permits a qualitative leap in the process of commodification (the railway) also enforces a form of representation (abstract space and time) that is inherent in commodification. It enforces this form of representation not out of some kind of weird magic (or, worse, Hegelian dialectic) but for very good organizational reasons of control and communication. You need to be able to represent the world in a coherent and standard form in order to run railways and deal in commodities. Emerging here is Michel Serres's insight (1987) that since we live in a world where the human/nonhuman (nature/society) boundary is increasingly less well-defined, then we need analytic categories that allow us to account for the unified representational time and space applied to both bureaucratic and scientific work.

I have reproduced here some key findings from Alfred Sohn-Rethel's work on Galilean space-time. In his classic Intellectual and Manual Labour: A Critique of Epistemology, Sohn-Rethel (1978) focused on the relationship between the commodity form and the process of intellectual abstraction. His premise was that "the form of commodity is abstract and abstractness governs its whole orbit" (19). Thus, he continued, where use-value was concrete (one could use a commodity for a certain purpose in the real world), exchange-value was abstract, quantitative reckoned in terms of the quintessentially abstract quality of money. Sohn-Rethel noted that when a commodity is up for sale, it is by definition not to be used; it exists in a kind of "frozen time" outside the normal flow of time. It moves in an abstract spatiotemporal world (which he calls some score of years before Cronon-"second nature") unlike the concrete world of "first nature."

The commodity, then, sketches out (by moving in) a new kind of representative space. The links in his chain are the arguments that

(1) Commodity exchange is "an original source of abstraction." The basic act of representation-separating properties of a thing from itself and charting those properties in a new medium (with its own time and space) is a feature of capitalist organization. (2) This abstraction out there in the economic world (out there in second nature) "contains the formal elements essential for the cognitive faculty of conceptual thinking". Thus when people observe and describe the flow of commodities, they are in fact creating a representational space and time of much more general import. (3) This is more than a possible link it actually describes the creation of "the ideal abstraction basic to Greek philosophy and to modern science." (Sohn-Rethel 1978, 28)

The concrete creation of a representational space and time comes first; abstract work by philosophers and scientists in this new space and time is consequent on that prior creation and epiphenomenal to it.

The act of synchronization brings material forms (commodity flow, train travel) together and when, as we will now see, geological and historical time are mapped into the same time, powerful possibilities emerge for the metaphorical, ideological, and material to interact. And when they do, a new archive is created with the industrial age as the marker of a new time and space that henceforth will hold all records be they business, scientific, or governmental.

Tales from the Past: Archives and Technology in the 1830s

In history, as in geology, a number of systematizers in the 1830s began to adumbrate a new kind of reasoning that operated in a flat space and time and which created a new kind of record of the past. For example, Michelet's systematization took the form of a nested series of regions that centered ultimately on Paris. The world was divided into several major climatic zones: "Follow from East to West the route of the sun and of the magnetic currents of the globe, the route of man's migrations, observing over this long voyage from Asia to Europe, from India to France, you will see that at each stagingpost the fatalistic power of nature diminishes, and the influence of race and of climate become less tyrannical" (Michelet 1971, 229). This would be true for someone doing the trip today (synchronic extension) as well as for someone tracing the records of times past, where the Indian Empire preceded the Egyptian preceded the Persian preceded the Western empires. A second world, Europe, is contained within this larger world: "Man has, step by step, broken with this natural Asian world, and constructed, through industry and trial a world informed by liberty" (ibid., 238). In so doing, He has created a second nature: "In general, after the great empires that lived according to nature, as one sees in Asia, have arisen states which are against nature, small, artificial states" (Michelet 1959, 229).

This European world has its own poles, its own India (Germany) and its own extension through time mirroring the macrocosm (Athens, Rome, Venice, Holland, the Hanseatic League). Nested within this world is the world of France, which operates the same regular spatial and temporal logic. Equally, within France is nested Paris the greatest city, at the center of the world and riding the very crest of the wave of the present: "Germany has no center, Italy does not have one any more. France has a center; a single and unique center for several centuries it has to be considered a person which lives and moves. The sign and guarantee of the living organism, the power of assimilation, is found here to the highest degree" (Michelet 1971, 247). A center of calculation indeed (Latour 1987)!

The great battle cry of the human spirit in this glorious race into the future was the destruction of nature: "With the world itself began a war which will finish with the world, and not before; that of mankind against nature, of spirit against matter, of liberty against fatality. History is nothing other than the tale of this interminable struggle" (Michelet 1971, 229). The grand determinant of his set of ordering devices for storing facts about the world (and without such a set of devices, histories are unruly, singular things) was the climate: `As you follow from east to west, along the route of the sun and of the magnetic currents of the globe, you see the migrations of humankind. And you see in it that at each station along the way on the long journey from Asia to Europe, from India to France, the fatal power of nature declines, and the influence of race and climate becomes less tyrannical" (ibid., 230). So we are being drawn into a land in which "temps" (weather) doesn't matter, and in which to a large extent "temps" (time) will not matter either. For in this world, history will become increasingly irrelevant. No room here for Herbert Read's suggestive "I freeze therefore I am an abstract painter" line of argument (1968). Nor will there be any environmental constraints whose tale must be told to understand the history. True liberty, for Michelet, does not have a past and does not have a grounding either on the face of the earth or in the present. It is fully emergent.

We will see this theme of the irrelevance of the past for a purified (real) present in Lyell's work later this chapter and in Comte's in the next. A similar theme can be found in Buchez's work. He argued that syllogistic reasoning from the Fall was pushing Christian people always back upon the past. He does not spell out the syllogism, but I suppose that runs something like this: `All individuals have original sin, society is composed of the set of all individuals, therefore society is subject to original sin." He depicted a world in which the timeless present would be free from the stain of past time:

In society there is not, in reality, anything equivalent to what is called youth and senility in individuals: generations do not follow on one after another; all is mixed, in such a way that birth, death, adolescence, maturity, old age are always present at the same time, and in the same numerical proportions. It is a collective being destined to live indefinitely with an energy equal to what it had on its first day; for which the present is never anything, and for which the future is all; which is placed between a past that it continually leaves to advance towards a future that renews itself without end. Where to find an inexhaustible formula like social activity a formula which never passes, and always contains within it an indefinite future. (Buchez 1833, 47-48)

His new formula (replacing the syllogism) was powered by the principle of the division of labor. This principle allowed acts that were carried out successively by individuals to be carried out in rapid succession approaching simultaneity of groups of people: "The succession of acts of which a single act is composed, is the same thing as the succession of diverse works necessary to arrive at a result which is nevertheless single. So this succession gives rise to what is called the division of labor" (ibid., 208-209). The division of labor used to lead to social inequality: "The order of generation in space becomes the order of subordination in time" (ibid., 209). However, in the (almost) eternal present of the well functioning society, things will be different: "The movement of this logic is so inherent to human nature, that it can only disappear with humanity; but one understands that it may in the future exercise itself almost simultaneously, in such a way that one ceases to see the other immense lacunae [the inequalities] we have been talking about" (ibid., 343). As society loses its mooring in the historical time of the Fall, the past (seniority) becomes effectively irrelevant.

For both these spatiotemporal systematizers and historians (Michelet and Buchez), as for Lyell and Comte as historians of science, the past as story would increasingly be a thing of the past. What should be recorded, increasingly, is not the context of any particular discovery or event. Thus for Michelet, when you get to Paris, upbringing and race are irrelevant to a person's actions, since all have the same upbringing and there is no difference between races further away from Paris or further back in time, you need that information. Now, there will be no contest only text. Similarly, for Buchez, in earlier times, the principle of the division of labor constantly evoked the past in the form of sen iority and power inequalities, whereas now the collective being of society will act effectively simultaneously and be constantly outside of time it will never pass; it can only ever be present. The past could be generated from knowledge about causes such as climate or race; but contemporary humanity would move completely outside the flow of narrative time. The end of history, anyone?

The Memory of the Earth

In the 1830s, geology was a science in which, between the Plutonists belching volcanoes and the Neptunists spouting water, the catastrophists and the creationists had fashioned a history as a science of singularity and secular change (Porter 1977). The records of the earth were the records of catastrophic events that affected the body terrestrial; much as political events affected the body politic. Charles Lyell set out to refound this science much as Buchez and Michelet refounded history through a spatiotemporal systematization that reconfigured the world from a tapestry of tales to a random access archive.

Lyell saw himself setting down the basic laws that other geologists working empirically could draw on in their own studies. He gave a general rule that the kinds of forces acting in the world at the moment were the same kinds of causes that had always existed, at least as far back as the geological record went. This was a powerful rule. It meant that one could not refer back to a time when there were more earthquakes than at present, or when mountain ranges were thrust up in a single moment, and so on. One had to find slowacting, steady causes in place of the "catastrophic" causes often referred to by his opponents, religious and otherwise. He offered one possible intellectual foundation for geology: the very title of his work echoes that of Newton's Principia, which was the paradigm case of a foundation text at the time Lyell was writing and which had done much to set the conditions for isotropic spatiotemporal analysis.

Geology was by far the dominant scientific discipline of the period. Aime Boue, with the accounting passion so common at this time, summarized its phenomenal expansion in the following way: "Comparing the number of books published in 1833 to those in the years 1830, 1831 and 1832, the approximate proportion is established by the numbers 300, 450, 500 and 900" (Bulletin de la Societe Geologique de France, 1833). In France, according to the Echo A Monde Savant, publications on geology and palaeontology in 1833 were far more numerous that those of all other sciences put together: "Physical and natural sciences (among them astronomy, physics, magnetism, meteorology, chemistry, hydrography and natural history): 144 books, 276 papers; palaeontology and geology: 61 books, 414 papers" (Echo A Monde Savant, June 20, 1834).

Everywhere one went in Paris, geologists were treating the glitterati and literati to their readings of the rocks of ages. The Echo du Monde Savant allows us to follow step by step the peregrinations of Parisian geologists:

In Paris this year Saturday and Sunday are essentially geological days. Saturday: at 9 in the morning, Al. Brongniart begins his lecture on geological mineralogy at the Museum [of Natural History]; at 9 M. Boue delivers his private lecture in the rue Guenegaud; at 2 o'clock M. Elie de Beaumont steps on to the rostrum at the College de France; at 7 in the evening M. Boue delivers his public lecture at the Societe de Civilisation; and at 8 o'clock Al. Rozet starts at the Athenee. Sunday: MM. ConstantPrevost and Boue lead, separately, their troops, armed with hammers, canes and bags for rocks, rousing here and there the fear of the Republic or the edification of a school; while M. Boue explains, from 3 to 4, in the rooms of the Societe, the geological relationships of the countries of Europe to those who, unwilling to expose their heads in the villages or their feet on bad roads, prefer to travel on the maps spread out for them by M. Boue. Nevertheless, it must be said that Saturday is going to lose M. Rozet and Sunday Al. Boue. These two geologists finished their precious lectures last week, but in compensation Al. Cordier's course, which will start soon, will offer a geological meeting and excursions with Al. Elie de Beaumont. The organization of these will be announced soon, offering similar advantages on Sundays to a third band of rock-hunters. (Echo A Monde Savant, April 10, 1834)

There was a similar efflorescence of geological enthusiasm in England.

Geology was in the spirit of the time, and it had things to say about the time of the spirit. There are two types of time at work in Lyell. One is time as a passive container: it involves the attempt to give a chronology to the history of the earth, to trace its origin or to deny that there is any evidence that it has one. The second is time as process: it involves the attempt to pick out certain types of changes that are invariably associated with the history of the earth at any age and are thus in a sense a feature of time itself. Lyell addressed both religious time (sacred history) and human time (secular history) in such a way as to create a special time for geology that could be dealt with by professional geologists. Central to the understanding of the earth was an understanding of the nature of the archive. The heavily accented features of the earth were for Lyell a product of the way that the earth keeps its own records about itself and not a feature of variations over time in the constitution and virulence of its governing forces.

Lyell said that for all intents and purposes the earth could be taken as being eternal. It may once have had an origin, but no sign of this remains. This loss of the origin could be explained by the fact that the earth was molded by complementary destructive and creative forces. The latter (flowing water, tides and so on) visited each corner of the earth, grinding it down, dissolving it. The former (silt deposition, volcanoes, and so on) redistributed this formless matter, which thus bore no traces of its state before its dissolution. Each and every part of the earth only bears traces up to its last dissolution, and since there has been an indefinite number of these, there is no point in trying to discuss the origin of the earth. Lyell's geology has been taken as the triumph of "linear" time because it locates the earth along an indefinitely long line between the past and the future; however, beneath this crust of linearity we find a core of cyclical morphology for the earth.

In the following passages, we can get some picture of the workings of this calculus of temporal regularity:

There can be no doubt, that periods of disturbance and repose have followed each other in succession in every region of the globe; but it may be equally true, that the energy of the subterranean movements has been always uniform as regards the whole earth. The force of earthquakes may for a cycle of years have been invariably confined, as it is now, to large but determinate spaces, and may then have gradually shifted its position so that another region, which had for ages been at rest, became in its turn the grand theatre of action. (Lyell 1830-1833, 1:64).

In order to confine ourselves within the strict limit of analogy, we shall assume, 1st, That the proportion of dry land to sea continues always the same. 2dly, That the volume of land rising above the level of the sea, is a constant quantity; and not only that its mean, but that its extreme height, are only liable to trifling variations. 3dly. That both the mean and extreme depth of the sea are equal at every epoch; and, 4thly, It will be consistent, with due caution, to assume, that the grouping together of the land in great continents is a necessary part of the economy of nature. (ibid., 1:112)

On this base, he argued for a climatic "great year"; the phrase is a reference to the Stoic's Great Year, which marked the period for the repetition of history. (ibid., 1: 116)

We have now traced back the history of the European formations to that period when the seas and lakes were inhabited by a few only of the existing species of testacea, a period which we have designated Eocene, as indicating the dawn of the present state of the animate creation. But although a small number only of the living species of animals were then in being, there are ample grounds for inferring that all the great classes of the animal kingdom, such as they now exist, were then fully represented. (ibid., 2:225)

Species could, conceivably, survive complete "revolutions" of the earth's surface. (ibid., 2:225)

There is a consistent patterning to the disparate quotes of this text. In each, the part is taken as varying, as liable to be created or destroyed, whereas the whole is immutable and eternal just like Buchez's society. Mediating between the two is cyclical change: a "cycle" of years attached to a region, a climatic great year attached to the earth over time, and "revolutions" of the earth's surface attached to species change.

The first volume of Principles of Geology gives a series of causes of change and shows how each destructive cause is equally, and in the same degree, constructive. Thus he writes with respect to sea currents: "In the Mediterranean, the same current which is rapidly destroying many parts of the African coast; between the Straits of Gibraltar and the Nile, preys also upon the Nilotic delta, and drifts the sediment of that great river to the eastward. To this source the rapid accretions of land on parts of the Syrian shores maybe attributed" (Lyell 1830-1833, 1:308). Similarly, volcanoes on the surface of the earth seem to increase the general area of land mass, but submarine volcanoes raise the level of the sea, so the two cancel each other out (ibid., 1: chap. 18).

Lyell's assertion of a number of things that never change land mass, degree of force of volcanic activity, and so on seemed, in the opinion of his contemporaries, directly antithetical to the geological evidence. They also seem a long way from the kind of time we would expect to be associated with the Industrial Revolution, which was reaching its peak as Lyell wrote. The stillness, the ineluctable equilibrium between creation and destruction, contradicted the facts available to Lyell's contemporaries in various ways. One set of contradictions revolved around the whole schema, others around the position of humanity within it. In brief, the overarching problem was this: for all that Lyell might say that "present causes" explained all past geological occurrences, it was hard to believe that mighty mountain ranges were even now thrusting upward. Nature had left a series of monuments that looked for all the world like products of cataclysmic change of an order undreamt of today. Whole species disappeared in a flash from the fossil record. It scarcely seemed likely that massive continents had pushed out of the sea at an inch a century. Great truths demanded great causes. More probably, it seemed to most geologists, times had once been different, and the world was younger and more lively.

This image of an earth once lively going through a peaceful middle age was commonly used by Lyell's rivals, the catastrophists (Porter 1977). The catastrophic time that these geologists employed was used to reconcile the fossil and geological record with the Bible. The argument here was that it may seem difficult for all the evident changes on the face of the earth to have happened in six thousand years, yet what really happened is that time went faster then: there were more earthquakes, more volcanoes, and so on. This argument -a counterbalance to the generally perceived reality that human time was going faster now than it ever had in the past (a powerful myth still stalking our collective discourse today) was used to give humanity a privileged position within the geological record. For, it was said, God waited until the earth was in repose before He introduced humanity for whom it was created onto its face. Lyell met both these privileged times head on in his work of defending the existence of a separate time for geology.

Lyell departed from previous traditions referring to the Book of Nature in explicitly developing the concept that the earth formed its own archive though it was not a very good archivist. In so doing, he drew on the analogy of the information practices of statistics developed in large-scale government in the late eighteenth and early nineteenth centuries (cf Hacking 1990; Foucault 1991). He noted that fossils were only created where new strata were being formed, and wrote the following:

These areas, as we have proved, are always shifting their position, so that the fossilizing process, whereby the commemoration of the particular state of the organic world, at any given time, is effected, may be said to move about, visiting and revisiting different tracts in succession. In order more distinctly to elucidate our idea of the working of this machinery, let us compare it to a somewhat analogous case that might easily be said to occur in the history of human affairs. Let the mortality of the population of a large country represent the successive extinction of species, and the births of new individuals the introduction of new species. While these fluctuations are gradually taking place everywhere, suppose commissioners to be appointed to visit each province of the country in succession, taking an exact account of the number, names, and individual peculiarities of all the inhabitants, and leaving in each district a register containing a record of this information. If, after the completion of one census, another is immediately made after the same plan, and then another, there will, at last, be a series of statistical documents in each province. When these are arranged in chronological order, the contents of those which stand next to each other will differ according to the length of the intervals of time between the taking of each census. If, for example, all the registers are made in a single year, the proportion of deaths and births will be so small during the interval between the compiling of two successive documents, that the individuals described in each will be nearly identical; whereas, if there are sixty provinces, and the survey of each requires a year, there will be an almost entire discordance between the persons enumerated in two consecutive registers. (Lyell 1830-1833, 3:31)

Lyell observed that disease and migration might cause variance, and concluded: "The commissioners are supposed to visit the different province in rotation, whereas the commemorating process by which organic remains become fossilized, although they are always shifting from one area to another, are yet very irregular in their movements [so that] ... the want of continuity in the series may become indefinitely great, and ... the monuments which follow next in succession will by no means be equidistant from each other in point of time" (ibid., 3:31-32). This passage provides a litany of apparent disorder. It argues the uniformitarian case whereby, despite appearances of catastrophic change in the past history of the earth, the underlying reality was of incremental change. It was not that the earth was irregular, it was the earth's archival process that was less than efficient.

If the earth was a bad archivist, then it was up to the geologist to pull together information from a wide variety of sources so as to demonstrate the real regularity of its change. The earth's archival technology would have to be supplemented by an efficient use of what we now call information technology. Geologists in the 1830s saw this information-gathering effort as being heavily technologically mediated. Thus leading French geologist Leonce Elie de Beaumont gave a lecture in 1834 entitled "The Specialty of Geology deduced from the Special Nature of the Geologist's Life-Style." In his notes for the lecture, he wrote:

The nature of geological science deduced from the order which establishes itself in the work of geologists ... the geologist is therefore of all the classes of scientist the most obliged to displace himself ... // that fact makes it even more likely to make him part of a distinct class than that this circumstance calls on a particular type of person ... // of all the sciences, it is geology that relies most on improvement of the means of transport// means of transport are for the geologist what telescopes are for the astronomer. // the new roads that criss-cross Europe make the latter in some way a geological preparation ... // remarks of Cuvier on steam boats//geology has in some way become a profession ... where does geology begin and astronomy end? These two sciences are sisters and what above all places a line of demarcation between them is the different lifestyle they demand of their cultivators ... one of the things which characterizes and even constitutes the progress of civilization is the division of occupations. ... The establishment of railways will have the effect of enlarging geological localities, diminishing the distance between the geologists and the astronomer. (Beaumont 1832-1843, 1st lesson, December 7, 1839: f. 11)

Astronomy was in the nineteenth century the science of regularity (all the apparent perturbations in the earth's orbit were reckoned to be embedded in cycles of varying duration), so that the universe was effectively a clockwork mechanism. This was the dream of Laplace (1799) celebrated in the Bridgewater treatises, for example (Whewell 1833). It was also the ideal science, to which all others aspired. For Beaumont, then, the means to achieving the beauty and regularity of astronomy within the burgeoning science of geology was by going through the growing transport infrastructure. At the end of the day, when the roads had been well enough traveled, the two sciences would merge. He wrote that both specialties dealt with the following:

periodic oscillations around a mean state.... However the heavenly bodies don't leave in space any trace of their passages ... solar system a clock ... the hands do not leave any traces.... As an archivist, the earth was a special kind of clock, an hourglass: This hourglass is the surface of our globe, and the scientists concerned with its functioning instead of calling themselves astronomers call themselves geologists. The objects of their sciences are contiguous and if the methods that they follow still separate them, one can say that they are sisters. The most remarkable thing about this hourglass is that it preserves the traces of shocks it has received ... can judge that their length is comparable to those of periods measure by the clock we were talking about.... Perhaps one day they could be linked and then the two sciences will help each other. (Beaumont 1832-1843, December 20, 1832: if. 2-3)

Thus astronomy and geology will be seen to meet at the point of regularity, in a contemplation of the regular clockwork mechanism that seemed to govern both the heavens and the earth (all appearances to the contrary in the latter case; though a number of writers of the period also judged that human history was, in its underlying tendency, equally regular e.g., Babbage 1837). At this point, first and second nature converge onto a timeless present and an anisotropic flow of time.

Technology entered into the picture of earth sciences in the 1830s in three ways then. First, the earth itself is a kind of large information storage device not a very efficient one, but no less remarkable for all that. Second, the inefficiencies of the storage device could be mitigated as Beaumont and Lyell both pointed out by redundancies in the recording process; and these redundancies could be perceived through efficient use of the new transport infrastructure: steamboats and trains. Finally, when this work is done, geology would converge with astronomy in calling forth a historical time as regular and perfect as that of the clockwork solar system. If we had technology entering in at just one point of the process, then it could be simple analogy. What is significant is first of all the commitment to describing the archival process -a natural technology; then we get the move from the natural to the ideal archive being mediated by technology, with the ideal archive being marked by clockwork regularity. Beaumont and Lyell together embedded a complex argument on the nature of statistical record keeping, a central technology for a modern state, within their geologies. For both, good record keeping would demonstrate underlying lawlike regularities in the face of current empirical chaos: precisely the same argument being made in the then burgeoning field of government statistics (Porter 1986). The metaphor of the clock and its regularity supported the application of statistical thinking to the geological record; and the geological record thus sorted gave weight to the clock metaphor as organizing principle-each bootstrapped the other.

Through a linguistic metaphor, Lyell endeavored to explain the apparent asymmetry between past and present. This metaphor brings out the peculiar centrality of humanity in Lyell's geology and thus the centrality of human society to his problematic. It revolves around an image sanctioned by long usage in scientific texts: the idea of the Book of Nature. In the natural theology that Lyell opposed, the Book of Nature was taken to be fully complementary to the Book (the Bible). In his alternative development of the theme, the miracle would be if we could read the Book now, since we only know a tenth of the world in the present and so could only know a tenth of it in the past. He wrote playfully:

So if a student of Nature, who, when he first examines the monuments of former change upon our globe, is acquainted only with one-tenth part of the processes now going on upon or far below the surface, or in the depths of the sea, should still find that he comprehends at once the imports of the signs of all, or even half the changes that went on in the same regions some hundred or thousand centuries ago, he might declare without hesitation that the ancient laws of nature had been subverted. (Lyell 1830-1833, 1:462)

The logic of this passage is not, perhaps, immediately clear; not surprisingly, it was dropped from later editions. What Lyell is saying is that at present our knowledge of the Book of Nature is highly restricted (to processes occurring on land, and only to a small proportion of these). He argues that if from our knowledge of these processes we could reconstruct the history of the earth, then the past must have been very different for that would mean that the small proportion of causes that we know about today were once all the causes there were. Whereas the earth kept only a limited and random sample of its own records; here we as humans have access only to a limited and random grammar of the Book of Nature. So the burden of proof lies not with those who with their set of present causes cannot explain the past, but with those who with their set of past causes can.

Lyell's defense of his geological time against appearances to the contrary is, first, that appearances are necessarily deceptive if his system is right; and second, that there is no way at present that geologists could know enough to explain past changes. He argued against any possible connection between religious time and geological time by denying an origin to the earth and buttressed his new geological time against possible counterarguments about the nature of the geological record. When he arrived at this point in his argument, he believed that the basis had been laid for a true science of geology an argument he proposed using the contrast between his own true language of geology and the false language of catastrophists: "These topics we regard as constituting the alphabet and grammar of geology; not that we expect from such studies to obtain a key to the interpretation of all geological phenomena, but because they must form the groundwork from which we must rise to the contemplation of more general questions relating to the complicated results to which, in an indefinite lapse of ages; the existing causes of change may give rise" (Lyell 1830-1833, 3:10).

He made two further moves in order to defend his time. First, he tried to legislate for the way that geology would develop as a discipline by trying to attach to it the same time that he attached to the history of the earth. Second, he produced arguments to counter the idea that geological time was somehow different since the advent of humanity more peaceful, or transformed by its presence. Just as we would not contribute henceforth as geniuses to the scientific record but as workers in the mines; so humanity did not contribute anything lasting to the earth's archives by virtue of our consciousness. Overall, the appearance of any discontinuity in the past of a science, of the earth was to remain a feature of the imperfect record, not of reality.

For Lyell, just as the past history of geology is concerned with catastrophes, so is the past history of the discipline of geology catastrophic; it is "between new opinions and ancient doctrines, sanctioned by the implicit faith of many generations, and supposed to rest on scriptural authority" (Lyell 1830-1833, 1:72). Lyell does not, however, abandon his patterning for geological time when he turns to geologists. The imperceptibly slow operation of simple causes operates for both the earth and its scientists: "By the consideration of these topics, the mind was slowly and insensibly withdrawn from imaginary pictures of catastrophes and chaotic confusion, such as haunted the imagination of the early cosmogonists" (ibid.). To get some idea of just how long a period of time he has in mind, we can turn to his proto-Jungian assertion that "the superstitions of a savage tribe are transmitted through all the progressive stages of society, till they exert a powerful influence on the mind of the philosopher" (ibid.). Thus the catastrophic history of geology is itself underwritten by slow, insensible change. The two rhythms of time (the catastrophic and the uniformitarian) battle it out within both the history of geological ideas and the history of the earth. Just as our readings of the Book of Nature should become ever more uniformitarian, so should our reading of the history of geology. Lyell signals this change in the nature of the history of geology in a return to the language metaphor. In a lecture to London high society, he referred to the former (catastrophic) state of geology:

While the science was in so fluctuating a state the philosopher who was anxious to discover truth, naturally preferred to enter himself into the field of original investigation, rather than to devote his literary labors; to the comparison and the reduction into order of imperfect observations and a limited collection of facts. One of our poets alluding to the incessant fluctuations of our language after the time of Chaucer complains that:

"We write on sand, the language grows

And like the tide our work o'erflows." (Lyell 1833)

This was in marked contrast to the halcyon future, when, as Lyell (ibid.) opines: "We shall from year to year approach nearer to the time when the new facts which can be added by one generation of men however important will form but a trifling contribution to the stock of knowledge which had previously been acquired and when that period shall arrive they who have no opportunity of traveling themselves or of constantly associating with those who are engaged in actual observation will be more on a par." When the center of calculation is in place, there is no need to move. So static scientists will be able to produce science about an unchanging earth: their records will last forever through archival publications because they will be reading the true records of the earth. Sublunary earth would become a part of the stasis and regular order that exists everywhere but, apparently, here.

We can, then, unify Lyell's pictures of the history of geology and the history of the earth. In the past, knowledge developed catastrophically, and analyses were framed in terms of catastrophes; in the present and future, knowledge develops uniformly and analyses are framed in terms of continual steady change. Lyell encourages us in this formulation when he asserts that "the connexion between the doctrine of successive catastrophes and repeated deteriorations in the moral character of the human race is more intimate and natural than might at first be imagined" (Lyell 1830-1833, 1:10). This is the same move that Buchez made: science would be the agent that converged both human and natural history onto isotropic time. There is, indeed, a powerful moral force in Lyell's geology that derives from just this symmetry between the past of the geological discipline and of the earth. It would be better all round, the reader feels, if the time that has eternally framed nature were to frame human society. It is through records that salvation will be found scientific records (properly kept) tie us in with the (real) records inscribed onto the skin of the earth (Derrida has a nice discussion of the inscription of records onto skins in his case, Freud's penis (Derrida 1995)).

There is a final way in which the new time that Lyell is using to found the discipline of geology is applied in his Principles of Geology. This is in his resolution of the problem of whether the time of the earth is somehow different since the creation of humanity. Unlike all the other objects in Lyell's geology, humanity irrupts into the picture at a very specific moment. Moreover, this moment is six thousand years ago: precisely the moment that biblical fundamentalists picked for the origin of the whole earth (including humanity). Not only did humanity make a singular appearance, however, it also set about creating the appearance of singularity. Thus Lyell (1830-1833) commented on hybrids that displayed extreme variability in their outward form (and thus changed at a pace too fast for his geology) and asserted that no hybrid had ever achieved a permanent niche on earth (ibid., 2:32 and 3: chap. 4). Humanity then, makes time look as if it is irreversible and rapid (even catastrophic), but for Lyell this serves only to highlight the fact that underlying reality is as uniform as can be. In general, not only does humanity have a tendency to read the Book of Nature wrongly, it also has had a tendency to write it wrongly too, making the same mistake in each instance.

Lyell has two strategies for playing down humanity's influence: accreting it to the natural, and assigning it to another plane of existence. In the former, Lyell stresses that changes wrought by humanity are for all that natural changes. Humanity does its work of sowing seeds far afield, but these seeds would have been sown regardless: by the wind or through the agency of a migrating bird. Nature keeps a check on the whole process by organizing flora and fauna into "nations": nothing can survive long outside its nation. This "natural" side of humanity is totally divorced from its civilized side. Thus Lyell (1830-1833, 3: chap. 5) argues that if humanity were cataclysmically reduced to a few specimens in some far-off land, it would once again spread out and fill the earth because that is our natural fate whether or not we are civilized. Both the spread of humanity and its ability to act as dispersive agent are, then, fully natural and under nature's control.

There is, however, another aspect to humanity: its ability to transform landscapes and species temporarily. To account for this aspect, Lyell develops his second strategy for playing down humanity's influence: he posits a complete divorce between civilized humanity and nature. The changes humanity has wrought are

not of a physical but of a moral nature ... it will scarcely be disputed that we have no right to anticipate any modification in the results of existing causes in times to come, which are not conformable to analogy, unless they be produced by the progressive development of human power, or perhaps from some other new relations between the moral and material worlds. In the same manner we must concede, that when we speculate on the vicissitudes of the animate and inanimate creation in former ages, we have no ground for expecting any anomalous results, unless where man has interfered, or unless clear indications appear of some other moral form of temporary derangement. (Lyell 1830-1833, 1:164)

The two arguments about human time can be summarized thus: insofar as humanity interacts with geological time, it is the bestial part of humanity fitting into the economy of nature (a phrase much used by Lyell), whereas civilized humanity operates in a different dimension to nature and creates the temporary appearance of an anomaly in Nature's Book. We humans do not contribute to the "real record." So the earth creates a false record by being a bad archivist; and the humans create false records through smudging the earth's annals with mules, hybrids, and monsters. But the geologist can read between the lines to the true record of stasis. There is a similar consideration of humanity's effects in some contemporary environmental literature where humanity's influence is seen as ultimately outside of the natural system. In both cases, this allows the two "morals" of Lyell (state of morality and scientific theory earlier; human action and state of the earth here) to converge and hence intercommunicate along a Mobius strip).

In general, Lyell's foundation work on the creation of geological time operates a series of divorces. The time of the origin is given to religion, the rest of time (effectively all of time) is given to the geologist. Catastrophic change is given to the history of the earth sciences before the foundation of geology by Lyell; the new discipline of geology will be uniformitarian. Humanity's "moral" influence is seen as outside geological time and fully reversible; its "physical" influence is fully within geological time. Thus a single time is created for the history of the earth, for the development of earth sciences and for human time and it is the time of the good record keeper.

Creating a Memory for Geology

A series of tracts on natural theology were published in England during the 1830s, tracts called the Bridgewater Treatises. These formed a major series of books written by leading scientists of all disciplines. They had been commissioned in a bequest made by the dissolute ninth Earl of Bridgewater. The earl made his fortune in building canals in the industrial north of England, but he squandered most of his money with sybarites and sycophants. In his will he made provision for the publication of a series of pious works, as a gauge against his entry into Paradise. The President of the Royal Society, with the help of the Bishop of London and the Archbishop of Canterbury, chose eight leading men of science, who were instructed to shed light on "the power, wisdom and goodness of God, manifested in his Creation, illustrating the proof with all reasonable arguments." Charles Babbage, who invented an ancestor of the computer, wrote a ninth "renegade," uncommissioned treatise. The sort of reasoning proposed over the set of treatises was that the existence of God was proven by the fact that all of Creation formed a perfectly ordered whole, with even indeed especially the anomalies appearing as the expression of intelligent design. Thus water is paradoxically heavier as a liquid at 4 degrees Centigrade than as a solid, so that ice floats on water and fish can survive in lakes through winter (Prout 1834, 251). Though they were supposed to consider all the sciences, most of them contain long chapters devoted to geology. The Bridgewater Treatise by the Reverend William Buckland was devoted to geology; it provides a model of the religious causality that Lyell was fighting. Babbage's work is devoted to the subject of physical causality. For both Buckland and Babbage, the argument that Lyell made that the archive is jussive and sequential is central.

Buckland's geology represented the opinion of High Church religious authorities (as against those of the fundamentalists; many in the Low Church, even later in the century, cleaved to a literal reading of the Bible). We will see that clergymen were prepared to follow Lyell to a certain point but without going far enough to raise the question of the infallibility of the Bible or the Book of Nature. Buckland made frequent allusions to the work of Lyell and admitted the principle of the earth as having persisted through an indefinite number of ages. He had two methods of squaring Lyell with the Book of Genesis. The first, which has survived to this day, is to say that while a rose is but a rose, a day can be any number of things extending to hundreds of thousands of years if God saw fit. (Le comte Charles de Perron ([1835] 1840, 13), pointed out that we sought to impose our ideas of time on God because He existed outside of time and so had no such conception.) The second was that he found a loophole in time in Genesis in the undefined interval following the first verse so that in this period fossil evidence and so forth could accumulate, and it was only with the third verse that the current sequence started the requisite six thousand years before. Genesis, then, is literally right, and so is Lyell ... about the age of the earth. The records in the Book of Nature thus reconciled with the Book itself (Buckland 1836). Whereas for Lyell nature is profoundly and perhaps irretrievably unknowable, for Buckland it is all in essence already known. Buckland's infallible Book of Nature contains the sure traces of God's design, which provides the true link for geological events; Lyell's fallible book obscures these very traces.

Indeed, Lyell was angry at his friend Babbage's use of Laplacean determinism, with its entirely knowable past and futures precipitated onto the moment of calculation of the scientist in the present (or God whenever, depending on your preference). Laplace (1814) had written the following: 'An intelligence who at some given moment knew all the forces that animate nature, and the respective situation of the beings that compose it, if it were further sufficiently vast to submit these data to analysis, could embrace within a single formula, the movements of the largest bodies of the universe and those of the lightest atom: nothing would be uncertain for it, and the future, like the past, would be present to its eyes" (2-3). Babbage's ninth Bridgewater Treatise made much of this kind of determinism, which mimicked the operation of his calculating engines, which could even be programmed to contain the numerical equivalent of miracles, if the algorithm were complex enough. The Difference Engine could perform the same action without change for 100,000 years, and then produce an anomalous result (a "miracle") and immediately return to normal. The fact of the anomaly was not enough to deny the regularity of the machine. This determinism not only applied to the future, but could also in theory be used to learn about the past. He wrote that "the air itself is one vast library" (Babbage 1837, 113) because when we speak "the waves of air thus raised, perambulate the earth and the ocean's surface, and in less than twenty hours every atom of its atmosphere takes up the altered movement due to that infinitesimal portion of the primitive motion which has been conveyed to it through countless channels, and which must continue to influence its path throughout its future existence" (ibid., 110). He believed that if we knew the original position of every atom in the atmosphere, we could trace its complete future. Every murderer bore a record of his crime, "some movement derived from that very muscular effort, by which the crime itself was perpetrated" (ibid., 117). One great dimension of the past was the destructive nature of a totalizing social or natural memory (remembering murders, brutality, and missteps) and indeed his proffered punishment for some crimes was hearing the past repeated (see Liu, forthcoming, for a very suggestive analysis of a negative memory passage) (ibid., 164). Thus he shows how even minute phase differences of tide in a spheroidal world with two great tides would have a large effect over hundreds of years (ibid., 248). He is in horror of these irregularities. The incalculable, irrational past seems to him full of noise and cacophony irregularity, just as for Lyell the past of geology was cacophonous. A good enough ear could hear the Sermon on the Mount, without making Monty Python's error of believing that the Greeks would inherit the earth. But the use of such an instrument would basically be torture; a future punishment would be the connecting of the soul of a dead man to a "very sensitive bodily organ of hearing." Suddenly "all the accumulated words pronounced from the creation of mankind will fall at once upon that ear." This repeated image of past noise is complemented by a drear statement that for most "oblivion would be the greatest boon" (ibid., 165) and a look forward into a well-ordered future: "if that Being who assigned to us those faculties, should turn their application from survey of the past, the inquiry into the present and to the search into the future, the most enduring happiness will arise from the most inexhaustible source" (ibid., 166).

This contrasted with the memory ensconced in books (filtered memory; rational memory; part of the archive with its very clear point of origin in printing) that freed us from instinct and brutality. Thus Babbage (1837) wrote that, until the invention of printing, "the mass of mankind were in many respects almost the creatures of instinct" (59). Now, the great are encouraged to write, knowing that "they may accelerate the approaching dawn of that day which shall pour a flood of light over the darkened intellects of their thankless countrymen" (ibid., 55), seeking "that higher homage, alike independent of space and time, which their memory shall for ever receive from the good and the gifted of all countries and all ages" (ibid., 54). Since printing, the rate of progress of humanity has "vastly accelerated" (ibid., 55); over the past three or four centuries, "man, considered as a species, has commenced the development of his intellectual faculties" (ibid., 56). In order for this the new space and time, he needs the regular working of the machines of nature and the world. The act of making information such a key variable tied directly into operations on social and natural space and time: for Babbage, the regularization of time and the distribution of tasks. In both cases, the mythological operation succeeded because of infrastructural work: for Babbage the development of computing and other machinery and the imposition of the principle of the division of labor.

Lyell, on receiving a first manuscript of this book from Babbage, fired off a series of criticisms of these passages. Basically these consisted, as in his criticism of design, of stressing over and over the fallibility of the Book of Nature. Thus he wrote to his friend:

if it be true that all sounds remain in the air, which I cannot help doubting, something should be said for the benefit of the ignorant ... Can the air be said to be the historian when it is only a mute depositary unread by any one and unheard? Do not the circles on the water cease at last, an ordinary reader (for whom you write) will feel annoyed at not being told how it is that in a resisting medium undulations are not at length destroyed, how it is that they do not combine with others so as to produce new sounds and notes and words? (Babbage 1830-1840, May 1837, f.187)

In general, he considered the book in bad taste, and recommended against publication.

Babbage's is certainly an extreme expression of the theme of complete determinism, but the trope was common at the time. Buckland and Babbage proffered two arguments for the complete knowability of the Book of Nature: one threatening to subsume geology into theology, and the second threatened to subsume it into physics. The Word, lodged in the Ark of the Covenant; or the World, lodged in the Archives of the Exact Sciences, were equally corrosive of Lyell's archive; the geologist needs to read the smudged archives of the earth.

Lyell created a picture of the work of geologists that allowed him to know nature without being a theologian or a physicist. He created a "Mnemonick Deep" that anchors us in an eternal now For Lyell, the role of the interpreter of nature is central: God and Nature are both profoundly unknowable, and it is only through an epiphanic moment of profound insight that the scientist can hope to grasp their mysteries. Lyell (1830-1833) referred to this moment in a citation from Niebuhr: "'he who calls what was vanished back again into being, enjoys a bliss like that of creation"' (1:73). Any human attempt, religiously motivated or not, to offer some more direct way of reading or writing the Book of Nature deserved utter scorn. Along with the Romantic poets (e.g., Keats in his "Ode on a Grecian Urn" or Byron in "Childe Harolde"), Lyell found reverence and sublimity in the capture of the tension between the fleeting instant and eternal ages; thus anyone who saw "the summit of Etna often breaking through the clouds for a moment with its dazzling snows, and being then as suddenly withdrawn" must "form the most exalted conception of the antiquity of the mountain" (ibid., 3:370). For some, size matters; for others, it is age and beauty.

The Profession of Geologist

The agents of the convergence of human and earth time onto a stateless present were readers of the archives of the earth, the geologists workers in the leading science of the time. Not so surprising, perhaps. If one looks at the role of information and database theory in genomics, a core science of our day, one sees a great deal of continuity over the past few hundred years. The archive is central both to thinking about the objects being studied (the annals of the earth; the code in our genes) and to our writing these studies (archival publications; databases as scientific publications).

Links between the information explosion of the early nineteenth century and the new ways of describing the past of the earth were forged (if that is a good word) explicitly in the jottings of Leonce Elie de Beaumont. His notes for an introductory lecture on geology at the College de France in 1839 include the following:

today, now that we start to be able to go to St. Petersburg in 5 days, to Constantinople in 8 to 10 and to New York in 14, given that today with the electric telegraph people talk to each other by signs at several hundred leagues distance; we are at the start of a new era when the locality of each person will be much bigger than it has been up to now because the ability to move around will have been much increased and the inconvenience of being away from home will be greatly diminished. We are approaching a time when the locality of each geologist will be the terrestrial globe. It is then that a philosopher will be really able to call himself citizen of the universe. (Beaumont 1832-1843, 1st lesson, December 7, 1834: f 11)

Buffon ended the heroic age of geology wherein everyone constructed complete systems it was impossible to go further without making geology the province of a large number of people and as a consequence a profession having its own rules ... it is after him and not though him that geology took its place among the academic sciences, which grow gradually through the successive works of a collection of individuals, it is the application of the principle of the division of labour. (ibid., ff:14, 15)

Lyell himself made much of the need for travel as being central to the occupation of the geologist; indeed, in his autobiography he proclaimed that: "We must preach up traveling as the first, second, and third requisites for a modern geologist" (Lyell 1881, 273).

Beaumont promoted the principle of the division of labor in modern geology. This ties in in several ways to the idea of specific geological time found in Lyell's Principles of Geology. Concentrating for a minute on what is common to both authors, we find that they both make exactly the same points about the development of geology. Now is the end of the "heroic age," of individual systems that are thrown up and hurled down in cataclysmic succession. For both, the present is the time of slow, piecemeal development by a large group of workers, no one of whom will dominate the field, and both authors in their work laid quasi-mathematical foundations for this field: Beaumont with his theory of orogeny, and Lyell with his balance sheet for the static earth. Lyell spent large sections of his Principles of Geology inveighing against what could be called the "heroic" system of geological change. There was no time when things were different: "The minute investigations ... of the relics of the animate creation of former ages, had a powerful effect in dispelling the illusion which had long prevailed concerning the absence of analogy between the ancient and modem state of our planet" (Lyell 1830-1833, 1:72).

Why this division of labor, within geology as a discipline, and in society and nature? Both Lyell and Beaumont stress that, with current social and economic change, they were seeing a form of information explosion. If we look at Lyell's geology as a system for the classification of this information, then we can gain another insight into the articulation of his time. At its most abstract, Lyell is proposing a change from seeing geology as a litany of an enormous number of singular events (like a huge epic poem) to seeing it as the systematization of a small number of kinds of event. Thus, instead of seeing a particular mountain as a sign of a massive upthrust at some given date in the past, he sees it as a typical example of a kind of change that is occurring today. There are no privileged moments. His geology is a kind of bookkeeping device that allows the storage of vast amounts of information by sorting them into a kind of filing cabinet of different kinds of event. This reading of Lyell brings out why it was easy and natural for Lyell to find the metaphor of the statistical commissioners-after all, his geology is undertaking a version of their task. Further, it demonstrates how large-scale social change is reflected directly in the writing of geology through the intermediary of the organization of the foundling discipline of geology (the principle of the division of labor) and the handling of the information explosion that all sciences and professions were undergoing (uniformitarian time).

Indeed, Lyell's Principles of Geology reads like nothing other than a doubleentry ledger-book: the sum of creative and destructive forces (credit and debit) is always precisely zero. Lyell carries this principle well beyond the bounds of the available evidence in his four rules of the disposition of land and sea, which we cited previously in this chapter. To recapitulate, these were that the proportion of dry land to sea is always constant, that the volume of land rising above the sea is constant, that the mean and extreme depth of the sea are equal at every epoch, and that "the grouping together of the land in great continents is a necessary part of the economy of nature." These rules are frankly absurd unless they are read in the context of Lyell's accounting method. A further justification for the reading lies in Lyell's constant reference to the economy of nature, the plan of nature. Thus it helps us interpret the following enigmatic opinion about the idea some philosophers had that only a few laws produced the "endless diversity of effects": "Whether we coincide or not in this doctrine, we must admit that the gradual progress of opinion concerning the succession of phenomena in remote eras, resembles in a singular manner that which accompanies the growing intelligence of every people in regard to the economy of nature in modern times" (Lyell 1830-1833, 1:76). The metaphor of the economy of nature is second in his work only to the Book of Nature. Lyell introduces a principle of the division of labor into the profession of geology and into the economy of nature, and such that both will generate cumulative reports in a stateless present. The earth is an open book if the principle of the balance of forces is accepted: it returns a calculus of regularity out of apparent chaos and old time.

Lyell in his Principles of Geology (1830-1833), as we have seen in Beaumont's work, drew a close connection between the work of the geologists and the work of the astronomer:

However convinced a geologist may be that the earth had a beginning he has no right to assume a priori that in tracing back the history of the globe he should find the records of that beginning, no more than we have a right to assume in regard to any particular nation that we shall be able to trace back their history to its true origin.... When Descartes removed the boundaries of universe and speculate on indefinite space as filled with worlds, no one had a right to impute to him that there was no termination to the space. (August 7, 1811, E6)

Just as the astronomers had reduced the solar system to a clock, then so could geology reduce the earth to an hourglass. This is precisely what Lyell (1830-1833) did in his articulation of time: every physical operation is made as regular and smooth as clockwork; it was just a case of finding the right periods. Thus he recognized one difficulty with his system: "It is clear that if the agency of inorganic causes be uniform as we have supposed, they must operate very irregularly on the state of organic beings, so that the rate according to which these will change in particular regions will not be equal in equal periods of time; nor do we doubt that if very considerable periods of equal duration could be taken into our consideration and compared one with another, the rate of change in the living as well as in the inorganic world, would be nearly uniform" (ibid., 2:160). The solar system was hymned as an accurate clock, the clock dominated industry, and between the two the synthesizing geologist Lyell turned the earth itself into a clock: ticking away regularly and faithfully once we understand its workings. Lyell's articulation of the connection between geological and human time can be interpreted in this light. Humanity and geology may have developed raggedly in the past, but with the triumph of industrial society (which was the natural form of association because it ran like clockwork) the two could approximate to the industrial time written into his geology. Thus two basic methods of factory production the division of labor and the parceling up of time into regular units are both written into the time that Lyell created for the new discipline of geology; and we have seen that he used factory production methods precisely because he saw these as best suited to the fruitful exercise of the profession he sought to create. Through this approach, social time could converge with natural time; astronomical time with geological time.

This is a long way from the picture of Lyell as the heroic scientist who rolled back the years of the earth's origin. Keeping to this one canonic result, there would be no way to situate his work within the Industrial Revolution or to see its link with the Romantic movement sweeping Europe at this time. In particular, the thrust of what he says about the nature of time his stress on the periods of equal duration that govern industry, the solar system, and the world; and his belief in an epiphanic moment wherein all of time is grasped would have been missed.

The jussive work of Lyell's archive, which had him expelling the priests from the temple of science by redefining geological time has become clear. In fact, two sorts of religious time are excluded from geology by Lyell. The first is the pagan representation of a time of great heroes bestriding the field of geology like colossi; or of great geological events earthquakes, floods, storms dwarfing today's minimal, tranquil variations on the theme of repose. The second is the Christian author of the Book of Nature being denied the right to interpret His works: it is the moment of creation enjoyed by the geologist as the new priest of nature that constitutes the definitive, correct reading of the flawed Book. Whereas God had been the only being capable of standing outside time and space and able to oversee the whole, now the geologist could join and effectively supplant Him. The foundation myth is thus shorthand for a much more complex reality that sees modern science, despite its secular selfimage, forming itself into the new religion of our times.

So does our hero, Charles Lyell, wield enormous power? Armed only with his incisive intellect, he singlehandedly engineered the split of Church and State so as to found the profession of geology? Of course, this vision is totally improbable. The arrow of historical causation in this case is not from towering intellect to society through the mediation of ideas, but from society to intellect mediated by the day-to-day exercise of the profession of geology. The problem of the division of labor and the organization of time in factories and in geology was precisely the same problem. Through the mediation of the creation of the profession of geologist in the image of the middle management of a thriving business, Lyell inscribed the same time scientifically onto the history of the earth as others inscribed socially onto industrial society. He produced in his Principles of Geology a reading of geological history and of the earth that revolved around an understanding of archives. It is scarcely surprising that Lyell uses the metaphors he does and Beaumont makes the connections he does: both were being better historians than an intellectual historian who asserts that all Lyell did was increase the age of the earth.

Conclusion

Synchrony and Synchronization

We have had three "second natures" in this chapter. One was from the past, and two are analytic constructs from the extended present. Ajasson and Grandsagne had industry as second nature; Sohn-Rethel had smooth, isotropic space and time in that position; and Cronon had the imposition of a Cartesian grid on the grand prairies of the Midwest. We also encountered 1\'Lichelet's "second world," "constructed ... through industry and trial." All are speaking of the moment of the penetration of the industrial economy into the modern world over the span of several centuries.

One way of understanding this "second nature" is that before it, things were lumpy, confused, wayward. True science, Lyellian geology, stood on the leeward side of a chaos characterized by vast systems erupting into the world of discourse and then disappearing abruptly; vast causes acting punctually in the history of the earth and then disappearing. Humanity for Babbage had created a new human nature on the leeward side of a chaos characterized by an irregular past and a totalizing memory. On this side lay the orderly production of the scientific archive remembering for us only what needed to be remembered and consigning chaos to oblivion. One could guarantee against chaos and old time on two fronts: by keeping better records (Babbage, Lyell) and by better reading the earth's records beneath their chaotic inscription on the face of the earth. Our moral duty as humans was to recognize the stasis at the heart of disorder (apperceive synchrony in the midst of diachrony) and to bring social and natural time into a unified form (synchronization) through the production and storage of records.

The trick that Michelet and Lyell and de Beaumont deployed to make the earth's, humanity's, and geology's records more regular was to spatialize time. For the earth, every cause that has ever acted could be found acting somewhere in the world now; every story that appeared wayward and secular could become part of a metronomic story if due attention were paid to the earth's record keeping and if the true story were garnered from the set of imperfect traces scattered across the face of the earth. For humanity, going out in space (to India, to the Orient, or within France to Brittany or the Pyrennees) was going backward in time. The mapping process allowed the regularization of the earth's history. For geology, the past was catastrophic, but progress would become regular as the set of geologists across the face of the globe replaced the individual genius irrupting on the scene toting a completely new theory.

In the process of spatializing time, humanity would be increasingly written out of the story of our planet. For the earth, this meant that our impact on the surface was anomolous, moral, and short term. For humanity, the surface's impact on us was progressively less the closer we got to Paris so that in the City of Light, weather and topography were irrelevent. For geology, the individual, named scientist would be replaced by the faceless scientist working in a vast and effective machine. Engineering this removal of humanity from the face of the earth was the Industrial Revolution. For our understanding of the earth, it was our ability to travel by steamboat and train that allowed us to bring the sister sciences of astronomy and geology into synch. For the history of humanity, it was the ability of industrial artifacts to shelter us from external influence. This paradoxical removal of humanity from the face of the earth just as we were achieving an apogee of impact has had a long history through to the present the concept of "ecosystem," so influential in ecology, was largely undergirded by the idea that we humans were not part of natural systems (O'Neill 2001; cf chapter 5).

Memory Modalities

New memory practices, of the sort we have explored in this chapter, lie at the heart of our ways of knowing both ourselves and the world. They skew our available ontological space. From one point of view, our contemporary memory regime seems to be a highly prosaic affair involved with the growth of computers and their associated bureaucratic structures. From another perspective, and often from the same writer within the same paragraph, it seems to be a revolution dense with meaning that will unlock the secrets of life and the universe. Beniger's The Control Revolution is a prime example of this double trend. Thus he writes very prosaically: "The rapid development of rationalization and bureaucracy in the middle and late nineteenth century led to a succession of dramatic new information-processing and communication technologies. These innovations served to contain the control crisis of industrial society in what can be treated as three distinct areas of economic activity: production, distribution, and consumption of goods and services" (Beninger 1986, 16). At the same time, on the same page, he can pose a question like "Why has information of all commodities come to dominate the economies of at least a half-dozen advanced industrial nations?" (ibid., 58). He answers this and like questions with the following: "Ultimate answers to these questions, we have found, lie at the heart of physical existence. In order to oppose entropy and put off for a time the inevitable heat death, every living system must maintain its organization by processing matter and energy. Information processing and programmed decision are the means by which such material processing is controlled in living systems, from macromolecules of DNA to the global economy" (ibid., 58-59). The nature of existence and the new technology are resonant one with the other.

Or again, Herbert Simon tells us in the space of a paragraph: "From an economic standpoint, the modern computer is simply the most recent of a long line of new technologies that increase productivity and cause a gradual shift from manufacturing to service employment.... Perhaps the greatest significance of the computer lies in its impact on Man's view of himself. No longer accepting the geocentric view of the universe, he now begins to learn that mind, too, is a phenomenon of nature, explainable in terms of simple mechanisms" (qtd. in Forester 1980, 434). This last point, echoing Wiener's sketch of the history of science (humanity being no longer spatially then temporally then intellectually central), places the information revolution on an eschatological base at the same time as the first point puts it on an economic base (Wiener 1951). The Oxford Dictionary of Computing (Illingworth 1983) ranges widely in two consecutive sentences: "In principle any conceivable material structure or energy flow could be used to carry information. The scale of our use of information is one of the most important distinctions between the human species and all others, and the importance of information as an economic commodity is one of the most important characteristics of the 'postindustrial' civilization, which we are often said now to be entering" (see under "Information"). From the nature of the universe to the nature of humanity to the organization of the economy in three easy steps. These three steps were mediated in the nineteenth century, in the dominant science of the time, by a meditation on record keeping.

Perhaps the most surprising thing about these conjunctions is that they do not surprise. We are used to the mythological dimension of new memory practices. Business history gets regularly articulated with the meaning of life in a nonproblematic way. One possible treatment of this articulation is to dismiss it as hyperbole. For its detractors, this is the simplest and perhaps the most common treatment, but it is also one that denies the complexity of this historical phenomenon. There is a compelling connection between the information revolution as an economic fact and as a statement about the nature of the universe. This information mythology stems from a set of work practices whose constitution illustrates an important dimension of the relationship between information, knowledge and society one that drives to the heart of our political economy: the interface between the social and natural worlds.

In information mythology, "information" can travel anywhere and be made up of anything. Sequences in a gene, energy levels in an atom, zeroes and ones in a machine, and signals from a satellite are all "information," subject to the same laws. If everything is information, then a general statement about the nature of information is a general statement about the nature of the universe. The new memory modality was at root an economic process of ordering social and natural space and time so that "objective" information can circulate freely. The global statement that "everything is information" is not a preordained fact about the world, it becomes a fact as and when we make it so. Lyell and Babbage in the nineteenth century, and Simon and Beniger in the twentieth, package the world for us and makes it deterministic. The unpacking of their information mythology make the world and its information historical again and richer for it.