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Mapping time: chronometry on top of the world

At dawn on the 9th of June, 1873, the sturdy Victorian ocean naturalist C. Wyville Thomson swung his elegantly bearded person down from the deck of the British research vessel *Challenger*, berthed in the Bermuda dockyards, and made his way aboard a diminutive steam pinnace for a day trip on the island. After churning around to Mount Langton to pick up the governor, the shore party of collectors and dignitaries (with a 'native fisherman' in tow as guide and a photographer along in the service of posterity) made for Harrington Sound, rowed ashore, and hiked up to the Walsingham Caves for an afternoon of learned spelunking in the deep and winding limestone caverns. The cool reaches of this geological attraction would provide welcome respite from the midday tropical sun, to be sure, but Wyville Thomson had more than comfort on his mind: the belly of Bermuda, he believed, secreted a rare device – a kind of earth clock, an hourglass for planetary time.

For it happened that more than fifty years earlier, the commanding officer of the North American and West Indian station, Sir David Milne, had spent several days in Walsingham indulging his petrological curiosity by carefully severing an eleven-foot stalagmite from its moorings on the cave floor, and arranging for it to be returned to the British Isles – yet another strange fruit plucked from the colonial periphery to be enjoyed in metropolitan institutions of philosophical cultivation. This calcareous obelisk had thus found its way to a new, cool, dark cave across the Atlantic – the Museum of the University of Edinburgh, where Thomson (the Regius Professor of Natural History) would later ponder its bulk and consider the manner and pace of its formation. Between 1819 and 1873 such ponderings had grown urgent, since the age of the earth had burst into one of the most contested questions in science. Genesis, evolution, Darwin, even thermodynamics lay in the balance. So it is perhaps less strange to learn that in 1863, four years after the publication of Darwin's *Origin of Species*, the Walsingham Caves saw the visit of another

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pith-helmeted colonial administrator, Sir Alexander Milne, who, acceding nepotistically to his father's post in the West Indies, made a pilgrimage to his stump as well, the better to follow in his footsteps, and to report on the passage of time. There, on his elbows and knees, pocket watch in hand, Milne junior timed the soft splats falling from the ceiling of the cave and landing on five separate points where the stalagmite had once been. One drip fell at the rate of five drops a minute, he reported, another between three and four, the rest slower still. He identified two new knoblets that had come into being over the intervening forty-four years, along with a little mineral slick to one side – a total of five cubic inches of matter. It was Alexander Milne's brother David, back in Scotland, who did the math, and decided that at this rate their father's three-and-a-half-ton prize represented something like six hundred thousand years of subterranean accumulation.

To this same site, then, came Wyville Thomson and his party the following decade, and they also drew their watches in the lantern light: "The two drops were still falling," Thomson reported, "but apparently somewhat more slowly, one not quite three times in a minute, the other twice." The three other drips continued to feed their little slick deposit, though the party "could not determine that the bulk of the new accumulation was perceptibly greater than when it was measured by Sir Alexander Milne." If this geochronometer was ever to be of real use, what Thomson needed was some more definite record of the current form and magnitude of the lumps. Out came the photographer's equipment, and the blue-white brilliance of burning magnesium made the Walsingham Caves, briefly, brighter than a Bermuda noon. But Thomson despaired: "We were very anxious to carry away with us a permanent record of the present condition of the stump of the stalagmite, and we twice tried to photograph it," but the conditions foiled the photographer, and spoiled his exposures.

Thomson, however, would not be denied: "It then occurred to us that it might be possible to take another slice from the column, showing the amount of reparation during half a century, as an accessory and complement to the Edinburgh specimen." Hammers and chisels again went to work in Walsingham, with the aim of producing yet another crate for the Edinburgh Museum; another crate, containing yet another piece in the jigsaw puzzle of time.[1]

There is something strangely compelling, I think, about this crate. Granted, it would solve none of the pressing chronoscientific questions of the day. It would not help sort out if Lord Kelvin's much reduced timescale for the formation of the earth (grounded in his physics of cooling bodies) was right, and it would not settle heated disputes among geologists and paleontologists about the dating of cave remains. In fact, it is not even clear (to me, anyway) that this crate ever made its way to the museum in Edinburgh; it may have, but it may also have wound up forgotten on the docks in Bermuda, or in the office of the superintendent of the shipyard, Captain Aplin, who arranged for the stonecutting tools and the men to wield them.

But this slice of lost stalagmite merits a moment's thought nevertheless. For here was a specimen chosen for what it might tell about the timeline of the planet's history, the sequential ages of geological time; chosen because it was the

1 The story of the Walsingham stalagmite can be found in C. Wyville Thomson, *Voyage of the 'Challenger,' Volume I: The Atlantic* (London: Macmillan and Co., 1877), 322–328.

frozen stuff of a chthonic water clock dripping in a smooth quartz bowl of middle earth. And yet, this small artifact of the relentless passage of timeline time was something quite different too, since, keystone-like, it served to close a set of looping arches that spanned space and time: falling into place, it promised to close the gaps between geological time and human time, between 1819 and 1873, between Milne *père* and Milne *fils*, between now and then, Edinburgh and Bermuda, here and there, metropolis and colony. The scientific investigation of linear time cut a divot in the floor of the Walsingham cave, but the redoubled scar in the stone powerfully symbolizes how the workings of human memory continuously tangle that timeline time into a knotty skein – producing folds, juxtapositions, curious singularities.

The crate contained another piece in the jigsaw puzzle of time. But did the piece fit? I imagine the stalagmite-in-exile reunited with this now rootless sliver of its trunk. The fragments do not fit, of course. There is a remainder, a calcareous accretion that holds them apart. Is there a lesson in this? Perhaps. We set out, at great effort, again and again, to put the pieces of time together; but time itself, it seems, forever holds those pieces apart.

This issue of *Dædalus* draws together a shipload of pieces in the puzzle of time. From Heraclitus to Einstein, from Faulkner to fifteenth-century Namibia, from cognitive science to the apocalypse, these ten essays invite reflection on what time is and what it has meant and still means. Does the origin of time lie in language, as J. Hillis Miller suggests in "Time in literature"? Or could we say, with Danielle Allen, that time – a condition of possibility for human justice – is born of the need to put both halter and yoke on anger, the furious beast that strains to trample every social form? And what to make, then, of a physicist like Thomas Gold, who reminds us that without the particular configurations of astrophysics, it is not clear that time would exist at all? Or of a biologist like Michael Rosbash, who points out that if several of our deep biochemical pathways were slightly different, it is not clear we would miss it?

Do these pieces fit? The reader must turn them in the mind to find reflecting facets, to hold them together, to measure the remainder.

Let me add a piece myself. In an interview published in the early 1990s, the French philosopher Michel Serres offered a striking parable for the timescape of modernity, a story about the collective conception of time that shapes our sense of who we are. Gesturing at the history of cartography, Serres recalled the quirky world maps of the medieval period. These geometrical disks strike the modern viewer as wholly fantastical, since they gathered up the known world and arranged it with care around a powerful centering point: Jerusalem. We laugh, Serres pointed out, at this and every other ancient cosmography that tried to place humanity in the heart, middle, and origin of everything. And yet, he went on to argue mischievously, are we not the victims of a comparably narcissistic delusion? If Mercator and Copernicus dramatized that human institutions are not at the center of space, the deep cognitive structures of modernity have offered us a consolation of considerable power: now, at this moment, we are continuously reassured, we stand at the *summit of time*.

The idea of progress makes us this guarantee. As Serres put it, "we conceive of time as an irreversible line, whether interrupted or continuous, of acquisitions and inventions." And therefore, continuously abreast of the past, "it follows that we are always right, for the simple, banal, and naïve reason that we are living in the present moment." From our vantage point at the center of this temporal *mappamundi* we can survey history, secure in the knowledge that we are not only right, but "righter than was ever possible before."[2] Moreover, we are guaranteed always to occupy this enviable seat, since each moment simply lifts us higher over all that has come before. By these lights, if one dreams Serres's strange dream for a moment, our dominant theories of knowledge – our accounts of how we know we are right in politics and in science; our sense that our truths are the best truths – suddenly seem to be dependent on a very particular (even peculiar) cartography of time. Who made time into the hill we are always atop? Will those who come after someday look back at us – secure in our sense of being forever astride our yesterdays – and laugh, just as we are tempted to chuckle at a *mappamundi* with the Old Temple at its navel? It is a puzzling thought.

Who made time into the hill we are always atop? This is a deep and difficult question, and reasonable thinkers have lain the idea of progress on different doorsteps. Anthony Grafton's essay in this volume, "Dating history," takes up this very issue, and reminds us that even as those old TO maps were being replaced by the cartographies of Mercator and Johann Schott, a similarly revolutionary project – technical chronology – was rearranging the temporal framework of the universe in an equally radical way. This story is much more than a forgotten episode in the history of eccentric learning, since it is, in the end, a watershed moment in the creation of history itself, both history as a practice, and history as a product of this practice. As Renaissance chronologers like Scaliger organized antiquity along the axis of time, they were putting the presiding authorities of the classical tradition *in the past*. It was not a simple business, but here, surely, was the hill of time abuilding, and men scrambling to the top, even as they heaped the dirt under their feet.

If it was these early practitioners of a 'science of time' who served as architects, builders, and earliest summiteers of the hill of time, it was the robed claque of professional historians who became its surveyors, custodians, and dedicated gardeners. And in this club the historians of science and technology have long held a special place where the problem of progress is concerned. For theirs was an enterprise, at least in its inception, exactly dedicated to showing just how high the hill had grown, an enterprise that could dramatize temporal progress, stage by stage, in a pageant of new truths overcoming old errors on the way to the present. These historians might have walked down the hill, but they did so in order to show the colorful and treacherous path back up to the Olympian heights of modernity.

If the field of the history of science has changed in the last decades, many of its most satisfying narratives still hail from this era of the mountaineers. One of the very best stories they brought up the slopes was the story of timekeeping itself. This was a story of progress if there ever was one – perhaps the ultimate tale of how humanity had literally 'climbed the hill of time.' And a compelling story it remains: Once upon a time, human beings reasoned the passage of time by

2 The interview was published in English as Michel Serres and Bruno Latour, *Conversations on Science, Culture and Time*, trans. by Roxanne Lapidus (Ann Arbor: The University of Michigan Press, 1995). For the section on modern conceptions of time, see pages 48 – 51.

the loose organic cycles of the years, the seasons, the moons, and the days. Time was the passage of the sun in the sky: a sweep each day, a seesaw procession each year. The invention of timekeeping devices – hourglasses, water clocks, graduated tapers – made it possible for early civilized people to begin to control and standardize the units of time, and in doing so to coordinate their lives. But the great step came sometime around the turn to the fourteenth century – say, between 1270 and 1330 – when someone (we can't say who!) somewhere (in Europe, we think, but we can't say where!) hit upon the ticking heart of a true mechanical clock. This heart, called an 'escapement,' consists of a clever arrangement of swinging paddles set beside a toothed wheel shaped like a crown. The wheel would like to spin free, driven by a falling weight, but the weight cannot fall free (and the wheel cannot simply spin) because those deftly balanced paddles kick the wheel's teeth, stopping it for a moment, before letting it go – but just for a moment, only to stop it again: block, unblock, and block again; block, unblock, block. Instead of the weight dropping to the floor in a whir, it lowers itself by tiny steps: tick, tock, tick, tock; and the wheel turns, slow as the plodding of the seconds.

Not that those seconds were all exactly alike, at least not at first. The earliest mechanical clocks swung those precious paddles with a certain erratic charm, since the paddles were affixed to the axis of a T-shaped bar called a *verge and foliot.* The name itself suggests that the device could not be made to behave with perfect regularity: etymologies offered for the term 'foliot' have suggested that it hails from the root word for 'lunatic' or 'madwoman' (as in, "the thing swings back and forth like a nut"), or perhaps from the word for 'leaf' (as in, "it trembles like a leaf"). Suffice it to say that the swinging arms of the foliot beat no natural pulse.

But the basic structure of the mechanical clockwork had been defined, and medieval towns vied for glory in the erection of public clocks, the better sort of which showed the paths of the planets on their dials and sounded the hours on giant bells. The very gaudiest set those bells ringing with the hammer strike of well oiled jack-work automatons, which creaked into action in elaborate mechanical masques. Many of these clocks survive, jacks intact, but few retain their original escapements, since those were upgraded long ago: in the seventeenth century, thanks to the work of Galileo (and Christian Huygens), the verge and foliot met its demise; and those same paddles that kicked the slowly turning wheel of time into a regular beat found their way onto the shaft of a *pendulum*, whose swings gave a new rhythm to the mechanical timekeeper. Within a few years, the error of the best mechanical timekeepers went from something like twenty minutes a day, to something closer to twenty seconds.

The effect was profound, since these new devices were precise enough to reveal in detail curious irregularities in the natural cycles of earthly and celestial time. Take the 'day,' for instance. One might think that the period of time from noon to noon marks an unchanging unit; more light in the summer, more dark in the winter, but always in sum the same period. An astronomer will tell you different. By the seventeenth century this and other quirks of the natural order could be measured and plotted with considerable accuracy.

A remarkable thing had happened. A device that had started out as a mechanical model of day and night, and hence of the relationship between the earth and the sun (for this is what the hands of a clock really are – a model of the dynamics of earth and sun), had gradually outstripped its original: new sundials had to be equipped with correction tables, allowing the user to convert shadow time to clock time, this newly abstract and unworldly ticking. It is no exaggeration to say that human beings suddenly found themselves correcting the sun – a small correction to be sure (never more than a few minutes), but one with large implications. For ticking there on the wall was a product of human ingenuity that had, in a sense, surpassed the heavens. It is as if the shadows on the wall of Plato's cave reached back to nudge the source of light and truth back into place; as if Phaëthon took up the reins and drove the chariot better than Apollo. The relationship between the celestial realm and mechanical art, between heaven and earth, would never be the same.

A clock that could be used in these ways was a scientific instrument, an essential tool of the cosmos-encompassing astronomical researches of the seventeenth and eighteenth centuries. Indoor types tinkered with the mathematics that described such fine devices and their workings: if in the mid-sixteenth-century clock craftsmen had worked out the curve representing the force of an unwinding spring, they did so not with graph paper or numbers, but rather with files and wooden blocks, as they shaped the cone-shaped cog (called a *fusée*) that compensated for the uneven driving power of the earliest spring clocks. That cog was nothing less than the reification of a sophisticated dynamical analysis. But by the seventeenth century, as the historian of mathematics Michael Mahoney has shown, clockmaking mathematicians were actually doing that analysis on paper, and discovering whole new areas of geometry (and physics) by watching those same springs, swings, and cogs.[3] Head and hand met in the backrooms of the clockmaker's shop, at the bench and the forge.

Meanwhile, outdoor types made their own use of these powerful new devices. Carefully cased and padded, such 'regulators' made their way around the world with the naturalist voyagers of Enlightenment learning, revealing strange things as they went. For instance, even the best clocks seemed to run at slightly different speeds in different places on the planet. These worrying observations would lead natural philosophers to revise their understanding of the shape of the earth, and the forces that gave it form.

Nor was that all. As David Landes points out in his essay in this collection, "Clocks and the wealth of nations," a new type of highly resilient (and breathtakingly accurate) timekeeper – the true 'chronometer,' developed in the late eighteenth century – would up the ante of mechanical magic even as it provided a handy solution to the oldest problem in navigation and cartography: the longitude.[4] These newly compact instruments could ride out a six-week voyage slopping on the high seas while maintaining time to within a second or two a day: accuracies of 99.999 percent and better. They were, in their day, the most otherworldly devices ever made by the hand of man. Otherworldly in a very real sense: each was its own little autono-

3 See, for example, Michael Mahoney, "Huygens and the Pendulum: From Device to Mathematical Relation," in E. Grosholz and H. Breger, eds., *The Growth of Mathematical Knowledge* (Dordrecht: Kluwer Academic Publishers, 2000), 17–39.

4 For a brief description of how a clock makes it possible to measure longitude, see page 45 in this issue.

mous world, a universe to itself. This fact was not lost on the English mechanical genius John Harrison, who first pushed chronometrical precision into this ethereal realm. For decades he labored to produce a clockwork that would be impervious to the vicissitudes of the swirling world of dirt and change: his devices would continuously compensate for every perturbation in the conditions of this fallen, messy planet – swings in temperature, in pressure, in orientation. Regarding his creation, after enumerating its fine balances and countless defenses, he was moved to declare: "In short, it is a little world of itself, independent of the difference of gravity, heat, or cold of this our Globe."[5]

A world of itself. It is a tempting idea. An idea consistent with that powerful narrative in the historiography of time science: the story of how time 'left the earth' in the march to modernity. Once upon a time, sun and season, heat and cold were not obstacles to time-telling, they were *exactly the way that people reasoned what the time was*. The medieval peasant watched for hoarfrost and night herons; but Captain Cook, aboard the *Resolution*, peered into a gimbaled box, which, inured to heat and cold, place and position, simply told the time, a world unto itself.

But of course, in another sense, such devices could never leave the world; on the contrary, they stayed right here among us, and transformed it. Their austere and independent workings were inscribed with human significance at every tick. Not least aboard the *Resolution*: it became immortal legend that when Cook fell dead in the Hawaiian surf on February 14, 1779, his faithful chronometer, K1 – back on board the ship – stopped ticking forever, in a mystical manifestation of mechanical sympathy.

Such a braiding of machines and men, meaning and mensuration, should not surprise us. For even as timekeeping precision climbed the curve of progress to an asymptotic plateau beyond the soil, sun, and stars, the devices that performed these feats remained potent worldly objects. After all, as Peter Galison reminds us in this volume, there is eternally a propinquity between things and thoughts, and the clock was a perennial philosophical machine, a machine to *think*, as much as it was a machine to use. Those verge and foliot medieval clocks did more than tell the time of vespers in the village or merely toll the working hours out into the fields; they provided a new way to think about what nature was and how it worked. If that elaborate tower clock could coordinate the swinging motions of the planets and stars on its baroque dials, what made us sure that a similar clockwork was not behind the swinging of the originals, out there, moving against the black sky? Newton wondered as much. And what about that mechanical jack, hammering the bell? If it walked like a duck and talked like a duck, what made it not a duck? Or what made a duck something other than a particularly intricate jackwork? Viscount Bolingbroke may have doubted – wryly, with patrician comfort – that his villagers would ever confuse the parish clock with the town bull, but Descartes, listening to his cat squeak like a wagon wheel, was not so sure.

Such musings touched the heavens. Was God, in the end, perhaps the finest watchmaker of all? A clockwork nature called for a clockwork natural theology, a notion still vigorous (and contested) in the nineteenth century, when the celebrated Anglican divine William Paley

5 Quoted on page 217 of William J. H. Andrewes, "Even Newton Could be Wrong," in Andrewes, ed., *The Quest for Longitude* (Cambridge, Mass.: Collection of Historical Scientific Instruments, Harvard University, 1996).

opened his treatise on God and Man with a clockwork encounter: He asked his readers to imagine a sojourner upon a heath who, walking through the emptiness, stubs his toe on a pocket watch. From this encounter, Paley assures us, our solitary walker could be sure of one thing: a man – a thinking being – has been this way. And yet, Paley went on to suggest, we stub our toes on rocks, twigs, and turtles in any field. Can we not, looking at these, be absolutely certain that some fine intelligence passed this way before us? Otherwise, who made these 'works'? Moreover, does the turtle not surpass the watch (in complexity and craftsmanship) by precisely that measure that the Divine Artificer surpasses man?

In these ways and many more, the clock – the concrete referent in the dominant metaphor of a 'clockwork universe' – served as a potent conceptual tool for thinking about the workings of nature, even as it was also a powerful practical tool for investigating those same workings. And none of this was static. As the actual clocks changed through time (gaining new parts and new capabilities) the elaborations and implications of the clockwork metaphor changed in step: new bits of clocks, like the compensator or the precision-enhancing *remontoir*, offered new dimensions for thinking about the (clockwork) universe, in much the same way that in our own day – as Jennifer Groh and Michael Gazzaniga show in their essay here – new developments in computing have implications for how we think about our (computer-like?) brains.

To see this dynamic at work, take, for instance, the nineteenth-century earth science of the American naval astronomer and hydrographic innovator Matthew Fontaine Maury. Hailing from the fallen-on-hard-times branch of a large and distinguished Virginia family, Maury decided as a boy to cast his meager bread upon the waters, joining the nascent U.S. Navy in 1825, at the age of nineteen. Largely an autodidact, Maury rose to be the first superintendent of the U.S. Naval Observatory, and is often remembered now as the 'founder of oceanography.' As a midshipman and navigator plying the seas in naval and merchant vessels in the first decades of the nineteenth century, Maury had much contact with the new technologies of timekeeping at sea. Later, in the midcentury, as he put his hand to the defense of a new kind of sea science, he reached for the chronometer as a way to make sense of the oceans. And his visionary "Physical Geography of the Sea" needed chronometers as both practical and conceptual tools. Practically, Maury's sea science depended on an extended network of global informants, continuously making and reporting observations about the physical conditions of wind and water throughout the world's oceans. As the century unfolded, chronometrical navigation would make such a system viable, since it enabled observers reliably to correlate their data with specific sites on the trackless wastes of the sea. Plotted to their chronometer-derived coordinates, these data would make the earliest large-scale oceanographic models possible. Standard histories of oceanography seldom fail to acknowledge the field's debt to the chronometer.

But Maury needed the chronometer as more than an instrument. A true sea science demanded a sea that had an inner order that could be revealed – a sea of patterns and workings, a rational sea, not a sea of unformed chaos and opaque looming. A real sea science therefore called for nothing less than a conceptual reinvention of the sea itself, traditionally a brooding brew of mystery, moodiness, and fearsome unpredictability. Against these notions Maury repeatedly invoked a "clockwork ocean," whose inner workings were as regular and reliable as those of a great blue chronometer. Waves and cycles of salinity were, as he put it, "balance-wheels" in the mechanism, as was the equatorial cloud ring, which "like the balance-wheel of a well-constructed chronometer, affords the grand atmospherical machine the most exquisitely arranged self-compensation"; the Antarctic served as a "regulator" in the thermodynamics of oceanic currents; and, expanding the clockwork analogy, he argued that the Gulf Stream "acts like a pendulum, slowly propelled by heat on the one side, and repelled by cold on the other." "In this view," he continued, "it becomes a chronograph for the sea, keeping time for its inhabitants, and marking the seasons for the great whales; and there it has been for all time vibrating to and fro, once every year, a great self-regulating, self-compensating liquid pendulum." Pushing beyond the waters, Maury went so far as to suggest that the sea was itself nothing less than the main driver in the whole geophysical clockwork of sea, land, and air. For those who took up this new study, Maury promised, "the sea, with its physical geography, becomes as the main-spring of a watch; its waters, and its currents, and its salts, and its inhabitants, with their adaptations, as balance-wheels, cogs, and pinions, and jewels in the terrestrial mechanism." Maury's rich language, his meticulous elaboration of the metaphor, suggests how, in the nineteenth century, new clocks facilitated new thinking as well as new doing.[6]

But there may be a deeper point here as well. The chronometrical sea was, above all and crucially, a *rational* sea. Human efforts to conceive the workings of the sky – the original 'rational' phenomena presented by nature – yielded the earliest clocks, and in time refined clocks made it possible to reconceive the sea – long invoked as the consummately 'irrational' face of nature – as a sky-like place: a formal system that would yield to metrical and mathematical analysis. A sea that behaved like a clock was a sea amenable to science. A chronometrical sea was a rational sea, a sea of ratios, a sea ready to come under a *mathesis universalis*. Here Maury's chronometrical sea science intimates the degree to which the chronometer had come, in the Victorian age, to embody nothing less than rationality itself.

Was the chronometer a Victorian 'theory machine'? A way to think about thinking and being in the nineteenth century? The argument can be made. In January of 1841 another hard-luck young man of good breeding took passage to the Pacific to try a life at sea. By the time the youthful Herman Melville signed on for a sperm-whale cruise aboard the *Acushnet*, Maury had given up life on the decks for life at the desk, but the two men had more in common than youthful wanderlust: Melville's cousin Thomas had been Maury's shipmate aboard the *U.S.S. Vincennes* in 1827 – 1830, on a voyage across the Pacific that stopped in the Marquesas and included a junket on wild and seductive Nukuhiva Island, where Herman would later jump ship. Maury's older brother, John, as it happened, had lived for almost two years as a beachcomber on Nukuhiva all the way back in 1812. On his visit there in 1829,

6 Matthew Fontaine Maury, *The Physical Geography of the Sea*, ed. John Leighly (Cambridge, Mass.: Harvard University Press, 1963 [1861]). In order, I refer to pages 212, 224, 423, 260, 403, 347, and 70; for a lengthy discussion of compensators in the "clock-work of the ocean" see also page 240.

young Maury was searching for evidence of his brother's stay; Thomas could not know then that his cousin Herman would give the island literary immortality in the novel *Typee* less than twenty years later.

Like Maury, then, Melville spent his youth in the chronometrical world of global navigation, and, strikingly, he too would place this new clockwork system at the heart of his later writing. Book XIV of his sprawling, cloying, and finally maddening *Pierre, or The Ambiguities* contains a half dozen of the most remarkable pages ever written on timekeeping, in the form of a fragmentary pamphlet that falls into the hands of the novel's eponymous hero. "Chronometricals and Horologicals," authored by the shadowy sage "Plotinus Plinlimmon," offers a worldly sermon on time, space, and the soul – a sermon that uses the chronometer as an instrument for nothing less than the transvaluation of all values. At the heart of this strange embedded narrative lies a cumbrous allegory. As Plinlimmon puts it:

> It seems to me, in my visions, that there is a certain most rare order of human souls, which if carefully carried in the body will almost always and everywhere give Heaven's own truth, with some small grains of variance. For peculiarly coming from God, the sole source of that heavenly truth, and the great Greenwich hill and tower from which the universal meridians are far out into infinity reckoned; such souls seem as London sea-chronometers (*Greek*, time-namers) which as the London ship floats past Greenwich down the Thames, are accurately adjusted by Greenwich time, and if heedfully kept, will still give that same time, even though carried to the Azores.

Describing the actual process by which world shipping was regulated – merchant and navy vessels embarking on global voyages would set their chronometers by the daily fall of the 'time-ball' atop the Greenwich Observatory, which presided over the lower reach of the Thames docklands – Plinlimmon reimagines the divine *soul* (not merely the body) as a clockwork device. Thus regulated to keep 'God's time,' virtuous spirits can make their way through the world and remain 'true' to a distant and divine standard. They may require, as any chronometer would, periodic adjustments, and – playing out the allegory in technical detail – Plinlimmon suggests they ought to be 'rated' so their particular behaviors can be continuously corrected. But still, such souls can, with attention, emulate Christ, who "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."

Moreover, like Christ, all 'chronometrical' souls will find themselves in the same worldly bind:

> Now in an artificial world like ours, the soul of man is further removed from its God and Heavenly Truth, than the chronometer carried to China, is from Greenwich. And, as that chronometer, if at all accurate, will pronounce it to be 12 o'clock high-noon, when the China local watches say, perhaps, it is 12 o'clock midnight; so the chronometrical soul, if in this world true to its great Greenwich in the other, will always, in its so-called institutions of right and wrong, be contradicting the mere local standards and watch-maker's brains of this earth.

To work from one's chronometer is thus to be out of sync – usually ridiculously so – with the 'horologicals,' to be out of sync with local norms and ways of life. Only on the fine line of the prime meridian, on that "great Greenwich hill and tower" of the celestial seat, will chronometrical time be the 'right time.' Elsewhere, living by Greenwich time will make a chronometrical soul "guilty of all manner of absurdities: – going to bed at noon, say, when his neighbors would be sitting down to dinner."

At stake, finally, is nothing less than the very existence of absolute principles in moral life. Melville the beachcomber – that amphibious sailor who had by this time already made his way inland on notorious Nukuhiva, and who, confronting the terrifying 'Typee,' wondered how to reset his ethical ticker to a 'savage' local time – lets Plinlimmon play out the dark meaning of the lecture:

> In short, this Chronometrical and Horological conceit, in sum, seems to teach this: – That in things terrestrial (horological) a man must not be governed by ideas celestial (chronometrical).... A virtuous expediency, then, seems the highest desirable or attainable earthly excellence for the mass of men, and is the only earthly excellence that their Creator intended for them. When they go to heaven, it will be quite another thing. There, they can freely turn the left cheek, because there the right cheek will never be smitten. There they can freely give all to the poor, for *there* there will be no poor to give to. A due appreciation of this matter will do good to a man.

Here are the clocks and maps not of a physical relativity (that will come later with Einstein and Poincaré), but of an equally radical ethical relativism.

If not something more extreme – since it cannot have been lost on an educated salt like Melville that every nation set its chronometers to its own prime meridian: the French to Paris, the Spanish to San Fernando, the Americans to Washington. Even the *absolutes* of those chronological souls, by these lights, were perfectly arbitrary. Plinlimmon would seem to be offering a kind of antinomian horology at worst, at best an unctuous pragmatism of local mores.

And yet, there is a suggestive promise that the conceit, if rightly understood, offers something more, perhaps something less bleak. As Plinlimmon hints, "And yet it follows not from this, that God's truth is one thing and man's truth another; but – as above hinted, and as will be further elucidated in subsequent lectures – by their very contradictions they are made to correspond."

"By their very contradictions they are made to correspond." What can this gnomic conundrum possibly mean? Since the text in question is a fragment, the reader of *Pierre* shuffles in vain for an account of this reconciliation of oppositions, this transcendental deduction. Still, the vehicle of the allegory may carry us to a solution: for to anyone familiar with the actual operations of mid-nineteenth-century navigation, it is a simple matter of geometry to make horological and chronometrical contradictions 'correspond.' That is to say, the difference between Greenwich time and local time is a way of *orienting oneself in space*, of knowing where one is, and how one is heading. Does Melville want us to think of moral principles in this way? As a means to find our way home? Is this, ultimately, the function of the chronometrical soul?[7]

From the natural theology of Paley's wanderer and his watch, to the meanderings of Melville's chronometrical spirit, adrift on the high seas, the technologies of timekeeping ticked away in the heart of Victorian metaphysics and theology, even as they ticked in earnest

7 In the Northwestern-Newberry edition of *Pierre*, "Chronometricals and Horologicals" runs from pages 210 – 215. See Herman Melville, *Pierre, or The Ambiguities*, ed. Harrison Hayford, Hershel Parker, and G. Thomas Tanselle (Ev-

in the church towers of Victorian Britain. And as if in syncopated echo of Plinlimmon's tale, even those steeple clocks did not tick together. As the railways extended London time throughout England in the 1850s, a real chronometrical schism split the isle: high church bells still rang local hours; the nonconformist places of worship switched to Greenwich time. Chronometricals and Horologicals indeed.

One reading of "Chronometricals and Horologicals" sees the tale as a parable of nineteenth-century theosophical chronometry. And this cannot be wrong. And yet, it is not clear that this reading is enough. For one could begin again, at the beginning, and survey the world from the top of time – from atop Melville's "great Greenwich hill and tower." From here we can watch the sails open for the east, for China, Java, Africa, and India, places that are out there beyond the sea, yes, but even more importantly, places that are *not in our time*: not in our time chronometrically speaking, to be sure, as Melville reminds us; but not in our time in a deeper way too, since in the colonial imagination the 'out there' was almost always a 'back then.' In this sense London marked the prime meridian in a cultural cartography too – a global chronocultural geography. If there was a metaphysics of the chronometer in the age of empire, might we not be obliged to acknowledge that there was a geopolitics as well?

This observation extends beyond the straightforward fact that the clocks of the nineteenth century were tools for the creation of the maps of empire, though they were emphatically that: Darwin's ship the *Beagle* carried no fewer than twenty-two chronometers aboard as it fulfilled its admiralty duty, charting the South American coasts for the improvement of British shipping, while showing the Union Jack from Bahia to Valparaiso and beyond. The *Beagle* and its countless sister ships were chronometrical souls, and they kept Greenwich time (and paraded Greenwich mores) in the horological Chinas and Nukuhivas of the expanding European empires.

But the geopolitics of timekeeping meant more than this. For even as those brass Frodsham and Arnold chronometers helped bully colonial explorers keep track of where they were on sea and on land (as they made their maps and used them), these same ticking devices helped such men keep track of where they were in the history of civilization: they came from atop the hill of time, and could show this to the feathered and benighted people of the horological realms by opening a gimbaled mahogany box.

Such scenes were the stock-in-trade of Victorian exploration. The French gorilla-hunting swashbuckler Paul du Chaillu would write of how awed Africans contemplated his timekeeper in wonder and amazement and decided that it must be his "guardian spirit." If his onlookers actually asserted something like this, they were, of course, not far off. And such tales were legion. After showing his watch and other instrumental accoutrements to the native people he met, the British explorer Lovett Cameron quoted (ventriloquized?) their ejaculations of Anglophilia: "Oh these white men! They make all these wonderful things and know how to use them! Surely men who know so much ought never to die!"[8]

Indeed, so they all hoped. And if they did not die under the tropical sun, they

anston and Chicago: Northwestern University Press and The Newberry Library, 1971).

8 Both stories are told in Michael Adas, *Machines as the Measure of Men* (Ithaca, N.Y.: Cornell University Press, 1989), 159.

packed up and went back to the future, whence they were increasingly sure they had come. They left the past behind, in Africa, the Amazon, and elsewhere – primeval places, filled with primeval peoples at different stages in the evolution of civilization.

These scenes of chronometrical encounter were by no means new to the nineteenth century. Mechanical timekeepers had served European voyagers as a way to put themselves on the map culturally, long before such devices were adequate to put them on the map geodetically. Nowhere was this sort of timekeeping more important than in the early-seventeenth-century encounters between the China of the Ming dynasty and the Jesuit missionaries who set out for Peking to convert the middle kingdom. As Father Ricci liked to tell the story, it was the promise of receiving a gift of 'self-ringing bells' that finally seduced the reclusive emperor and gave the brethren a way around the meddling eunuchs of the imperial palace. The results entered the providential hagiography of the order: the emperor, instantly besotted with this fine new toy, obliged his supercilious mathematicians to sit at the feet of these clever foreigners and to learn the regulation and maintenance of this remarkable device. Soon thereafter, he insisted upon having a clock with him at all times, and within a year a section of the Forbidden City was being remodeled to accommodate a large tower clock. By 1730, a French missionary to the court would report that "The Imperial Palace is stuffed with clocks...watches, carillons, repeaters, organs, spheres and astronomical clocks of all kind and description – there are more than four thousand pieces from the best masters of Paris and London."[9]

Recently, after presenting a lecture on science and colonialism, I was approached by a distinguished senior gentleman who wanted me to explain why the Chinese never had a scientific revolution. This question – often known as the Needham Problem, after the great Cambridge sinologist and Marxist historian of science, Joseph Needham – has long been the sixty-four-thousand-dollar question for the historian of science. If in recent years developments in the historiography of the European 'scientific revolution' have somewhat put the question aside (we are no longer so sure we know exactly what that revolution was, so it makes it tough to ask why the Chinese didn't have one), it remains a hard problem on which much distinguished work has been done. I began to offer my questioner a sense of how one might go about answering his question, but he cut me off briskly. As it happened, he already knew the answer, and wanted to tell me: "The Chinese emperor," he explained, "had this huge, locked closet where he kept all the clocks of the kingdom, and he wouldn't let anyone else see them or study them. He hoarded them because he was afraid of what the people would do if they got any science."

Now this isn't right. By the early eighteenth century there was a proper trade in European timepieces through Canton, and by the 1820s a whole international European subindustry had arisen, linking London and Geneva, wholly for the purpose of supplying a distinctive kind of watch to the burgeoning China trade.[10] But my interlocutor was not to

9 Quoted in Carlo Cipolla, *Clocks and Culture 1300 – 1700* (New York: Collins, 1967), 86. There is a rich and detailed literature on timekeeping and European encounters with China. For an introduction see Chun-chieh Huang and Erik Zürcher, eds., *Time and Space in Chinese Culture* (Leiden: E. J. Brill, 1995).

10 This industry is discussed by David Landes, *Revolution in Time* (Cambridge, Mass.: Harvard

be budged: authoritarian tyranny and technophobia had, as far as he was concerned, consigned China to the dustbin of history. For him, they got stuck in the Middle Ages.

This view, which glosses over both the history of timekeeping in China and a complex story of cross-cultural exchange, nevertheless has a long scholarly pedigree, one that can be traced right back to some of those very eighteenth-century Jesuits who attended at court in Beijing. Put aside its merits. Most striking is the way this view places the chronopolitics of modernity in high relief. For what does it mean to say that other people, manifestly our contemporaries, are best understood as living in our past?

In an influential essay published in 1983, *Time and the Other*, the Dutch anthropologist Johannes Fabian undertook a sweeping critique of precisely this temporal cartography, which he called 'allochrony.' If Serres's parable probed how moderns came to think of themselves as perennially atop some abstract mountain of time, Fabian would ask us to see that this mountain was quite literally mapped onto the globe in the age of European overseas adventuring. London, Paris, Berlin – these metropolitan centers were atop that hill, which is to say that they were in the present, but the farther one went from downtown, the farther back in time one could venture. From the 'serfs' of neighboring Ireland all the way to the 'natural men' and (even better) 'natural women' of Tahiti. Out in space meant back in time. Reading movement in space was the job of a navigator or geographer, but reading this subtle movement back through the ages of humanity, this was the task of that paradigmatic figure of Enlightenment learning: the philosophical traveler.

For Fabian, then, modernity was born when the timeline time of Grafton's chronologers was spatialized into a vast, globe-encompassing geochronocultural tableau, a concentric secular cosmology that gathered the peoples of the world into a new *mappamundi* with the great cities of Europe cast as the new Jerusalem, the origin and apex of civilization, the only part of the planet that was actually *modern*. Here was a powerful new way to make sense of the flood of discontinuous, fragmentary, and destabilizing evidence about human origins and human habits that was pouring into the learned societies of those cities. Here, for Fabian, was the birth of the human sciences, particularly anthropology, which grounded itself in this new cosmology of modernity, grounded itself in the original sin of hegemonic ambitions, the "denial of coevalness."[11]

That a map of time enabled travelers to orient themselves and plot others throughout the age of empire – this, I think, cannot be denied. Whether, as Fabian suggests, allochrony remains a "vast entrenched political cosmology" such that contemporary geopolitics has its ideological foundation in, as he would have it, a "flawed chronopolitics" – this remains a contentious thesis, but not an absurd one. Talk with some undergraduates about the non-Western world and use a stopwatch to time how long it takes before they invoke allochrony as a way to make sense of others. Or, perhaps more tellingly, listen to the evening news.

University Press, 1983), 268. See also Catherine Pagani, *Eastern Magnificence and European Ingenuity: Clocks of Late Imperial China* (Ann Arbor: University of Michigan Press, 2001).

11 Johannes Fabian, *Time and the Other* (New York: Columbia University Press, 1983). He takes the eighteenth century to mark the installation of this idea; but the roots run deep.

Fabian considered his analysis an intervention in what he called "the scandal of domination and exploitation." He believed that he was revealing the ideology of time that had undergirded, and finally authorized, the attitudes and practices that led Europeans and their Creole descendents to claim, by the opening of the twentieth century, territorial sovereignty over some 85 percent of the terrestrial globe.

But does his observation add anything to the history of time's science? That story of progressive precision, of fine clockwork? That story that takes us from the rough-and-ready judicial water clock in Athens to atomic clocks so fantastically precise that they can reveal changes in the speed of the spinning earth when the winds blow, and when the spring sap rises in the trees?

Perhaps. For a long while (as Needham's Problem suggests), scholars in the history of science and technology have been interested in the problem of European exceptionalism. They have asked, for instance, why the Chinese did not immediately take up the larger astronomical and cosmological significance of precision clockwork. What impedimentary aspect of their culture or character could be held responsible for the way that they held these devices in the realm of baubles and playthings? But perhaps we would do well to reconsider this question and others like it in light of Fabian's chronopolitics: if clocks went into the world, at least in part, to show non-Europeans that they were in the past, then these tickers were not simply useful tools, scientific instruments, or symbols of the clockwork universe – they were also agonistic instruments. Little boxes that measured not merely time, but men; and which were always wound up to do battle on foreign shores. And one might build large closets for such troublesome devices.

Deep in the Walsingham cave, in Bermuda, watch in hand, as the native guide looked on, C. Wyville Thomson and his party tried to get to the bottom of time. Pickaxes poised, they were ready to dig, if necessary, to get there. All the while, though, they knew exactly where they stood in history: they were men of science, from Victorian England; they had set their chronometers at Greenwich, that towering hill. Getting to the bottom of time would only tell them what they already knew: they stood at the leading edge of knowledge, they were astride the past.

Who made time the hill we are always atop? And who sold plots on the terraced slopes to the people of the Caribbean, to the Pacific Islanders, to the whole 'family of man'? At what cost?

I have sketched two stories in this essay: one, the story of how, with clocks and rocks, human beings tried to get to the bottom of time – to grasp, hold, and show what it really was; the other, the story of how, with maps and memory, human beings managed to get to the top of time – to mound up the hill of the past and summit it. Do these two stories fit?

Between them comes something else. An accretion, a flow, the sand that slips through the skylight of the hourglass, and makes that little hill, from its base to its ever-sliding tip. Between the bottom of time and the top comes the remainder. Time itself. Which we have not caught. Which does not fit.

What would it be like to let this sand fall into our hands, and neither to dig nor to climb? I do not know.