

[Essay]

The Geological Sublime

Butterflies, deep time, and climate
change

by Lewis Hyde

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It is not inadmissible to think of an epoch . . . not too far distant, when humanity, to ensure its survival, will find itself reduced to desisting from any further “making” of history.

—Mircea Eliade

The earthquake shook us awake at 4:31 in the morning. We hurried into a closet while, for fifteen seconds, it finished its business and the car alarms down on Third and California began their complaint. When we emerged, the night sky greeted us through a crack in the wall and chunks of plaster sat smack on the Apple keyboard. The cat had fled.

Out on the street, the hanging dust of rendered Sheetrock mixed with the scent of potted plants and, for those of us standing in our nightclothes, a dose of adrenaline improved the sense of awe. Suddenly the inhuman forces of the raw earth had struck us, forces that lift mountains and sink cities. And suddenly there was a rip in time, a twenty-heartbeat glimpse into the equally inhuman roll of ages where continents join and break apart.

Thirty miles north of our Santa Monica apartment, Oat Mountain had risen fifteen inches and moved six inches to one side. That mountain sits in southern California’s Transverse Ranges, which began their rise from the sea about 5 million years ago, having first been caught, some 15 million years earlier, between tectonic plates that spun them clockwise so they now sit at right angles to the coast. The geology of the Transverse Ranges consists largely of granite from the

Mesozoic Era—66 to 252 million years ago—with some even earlier Precambrian material, at least 1.6 billion years old.

These are large numbers. They belong to the calculus of deep time as introduced to the world by British scientists in the mid-nineteenth century, namely, the preeminent geologist of the age, Charles Lyell, and Charles Darwin, who borrowed Lyell’s unbounded temporality and used it to underpin his theory of evolution.

Long before he formulated that theory, Darwin himself had witnessed what he called “the forces which slowly and by little starts uplift continents.” The year was 1835 and Darwin was nearing the end of a five-year journey around the world aboard the British surveying ship the HMS *Beagle*. In Chile, he was onshore one February day taking a nap when the ground began to rock. The quake lasted two minutes; its only local effect was to make Darwin “almost giddy.”

Nearly two weeks later, he arrived in Concepción to find a completely ruined city. After offering an inventory of all that was lost, Darwin, ever the student geologist, noted that “the land round the Bay of Concepcion was upraised two or three feet” and that on the nearby island of Santa María they found “mussel-shells *still adhering to the rocks*, ten feet above high-water mark.” Later that month, Darwin climbed high into the Andes, where he found “shells which were once crawling on the bottom of the sea, now standing nearly 14,000 feet above its level.” It had taken about twenty-five million years for those shells to reach that height.

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For several years now, I have been reading these early theorists, thinking that their vision of geological and evolutionary time might give me a context for understanding not just the age of mountains but something more current. It's one thing to hear of the millions of years it took the Andes to rise; it's quite another to hear that, in mere centuries, the oceans may reach levels of acidity not seen in 300 million years, or that the earth is the hottest it has been in the past 125,000 years. These days, geological forces, formerly the stuff of earthquakes and volcanoes, have escaped the confines of deep time to present themselves daily, winter, spring, summer, and fall.

It is on this other end of the scale of time—in seasons rather than eons—that my own interest in natural science began and where today it finds its focus and concern. As a child and to this day, one of my deepest pleasures has come from walking farm fields and alpine meadows, watching for butterflies, a pursuit that takes on a formal touch

THESE DAYS, GEOLOGICAL FORCES, FORMERLY THE STUFF OF EARTHQUAKES AND VOLCANOES, HAVE ESCAPED THE CONFINES OF DEEP TIME TO PRESENT THEMSELVES DAILY

each year when, in early July, I join the annual Concord, Massachusetts, butterfly count. Fifteen or twenty naturalists, most of us amateurs, gather and split into several teams to search a set list of local fields and woods. My group always begins in nearby Sudbury, where there's a colony of Appalachian Browns, not a rare butterfly but one found only in wet woods, swamps, and bottomlands, a habitat I would have done well to read about before my first visit, when I waded into a field of tall sedges and spent the rest of the day in waterlogged shoes.

By the end of last year's hunt, our four teams had seen 353 butterflies belonging to 29 species. Most common was the Pearl Crescent (84), followed by the Common Wood-Nymph (47) and a nineteenth-century immigrant from Europe, the Cabbage White (39). At the bottom of the list lay the Great Spangled Fritillary, the Question Mark, and the American Painted Lady (one each).

It's hard to say what any one year's numbers mean. The weather varies, as do the number of volunteers, their taxonomic skill, and the time spent in the field. Habitats can change, too; should someone drain that Sudbury shrub swamp, the Appalachian Brown would disappear.

But we have kept the count for decades now, and the trend is clear. In thirty-five years, the number of individual butterflies observed has

dropped by more than half. The number of species has fallen by a third. A dozen butterflies are now missing, including the showy Baltimore Checkerspot and the Aphrodite Fritillary, a large orange-and-black butterfly with amber eyes and light-catching silver spots on the underwing. The Aphrodite leaves its chrysalis in June, lays its eggs in late summer, and survives the winter as newly hatched larvae. Statewide, its population has fallen 90 percent in recent decades, most likely because those young larvae are more and more at risk of dying from dehydration now that snow cover is getting thinner and the seasons warmer.

Daily observations need only the context of decades to yield their meaning, but the decades-long decline of the Aphrodite Fritillary needs the context of deep time. In New England, one chapter of the deep-time story was written twenty-two thousand years ago, when a mile of glacial ice covered the land; a second chapter began when the last of that ice melted away and we entered the period we now call the Holocene, the time of recorded human history. As for butterflies, their subgroup within the Lepidoptera goes back more than a hundred million years. Within that subgroup, the greater fritillaries belong to the genus *Speyeria*, and the *Speyeria* in turn belong to a family, the Nymphalidae, that goes back ninety million years. Given that the life span of insect species can exceed a million years, we can reasonably suppose that the now-troubled *Speyeria aphrodite* has been greeting New England summers throughout the Holocene's eleven thousand years.

Eleven thousand years of survival versus a few decades of decline: it may not be clear how we are to reckon with spans of time so utterly out of proportion with one another, but that is now the task at hand as more species decline or go extinct. A "sense of temporal proportion" is what the climate crisis calls for, writes the geologist Marcia Bjornerud, a sense of "the durations of the great chapters in Earth's history, [of] the rates of change during previous intervals of environmental instability," and of each of these in relation to present human time. She's right. To acquire that sense has been one of the goals of my reading over the past few years.

And yet, even if we overcome our temporal illiteracy, we may still feel like that Mexican farmer who, in 1943, went out to tend his cornfield only to find a volcano opening a fissure in his furrows and rising, eventually, to bury his town in lava. How are we, who plant our corn in spring, who live with four-year election cycles and thirty-year mortgages—how are we to position ourselves in relation to the inhuman forces that have been shaping the earth for four and a half billion years and now seem to be accelerating?



How, in short, shall we approach the climate crisis when the needed sense of proportion can be baffled by floods of geological time? As for the early theorists who first opened time's floodgates, my question has been whether they left us tools or stories that might help guide the present, urgent work. How did Lyell and Darwin imagine and engage with deep time, and how might this be of service today?

The first thing to say is that they were not unaware of the difficulty. Having dispensed with the common belief that the earth was six thousand years old, both men nonetheless often found themselves perplexed as to how to speak of the vaster reaches of time they envisioned. In his primary work, the three-volume *Principles of Geology*, Lyell is regularly vague, speaking of "an indefinite lapse of ages," "very remote eras," or "time incalculably remote." Sometimes he speaks of "millions," as when he's arguing against geologists who calculate using thousands of years when "the language of Nature signified millions." How many millions he rarely says, although his numbers can reach dizzying heights. Truly primordial matters must be figured not just in millions but in "millions of ages," spans of time wherein all the

epochs of geology taken together would "constitute a mere moment of the past, a mere infinitesimal portion of eternity."

Darwin's vision of deep time came almost entirely from Lyell. In 1831, at the start of that five-year journey around the world, he carried with him the first volume of *Principles* and immediately applied its ideas to all he saw. Decades later, in *On the Origin of Species*, he tells his readers that any who have read Lyell and yet do "not admit how incomprehensibly vast have been the past periods of time, may at once close this volume." In a typical passage in *The Voyage of the Beagle*, he writes that "the mind is stupefied" when trying to think on the "lapse of years" needed to produce a two-hundred-mile-wide bed of porphyry pebbles, or that "it makes the head almost giddy" to think of the years required for ocean tides to wear away three hundred feet of solid rock. Such a case, he confesses elsewhere, "impresses my mind almost in the same manner as does the vain endeavour to grapple with the idea of eternity."

Neither Lyell nor Darwin ever disposed of time's incomprehensibility. Commendably, both men filled their work with regular professions of their own ignorance. "Our capacities are finite,

while the scheme of the universe may be infinite," notes Lyell at one point. "The greater the circle of light, the greater the boundary of darkness by which it is surrounded." As for Darwin, his arguments in the *Origin* often end with a bow to "our profound ignorance"; in the book's final chapter, he concludes by saying that serious objections to his theory remain, but that they "relate to questions on which we are confessedly ignorant; nor do we know how ignorant we are." Toward the beginning of *Principles*, Lyell recalls how his first encounter with the work of his predecessor James Hutton awakened in him a sense of the sublime, of awe mixed "with a painful sense of our incapacity to conceive a plan of such infinite extent."

As I tracked how Lyell wrestles with "times incalculably remote," the first thing that surprised me was his attraction to an ancient idea

IN THE FULLNESS OF TIME, A WIDE PEBBLE
BEACH REPLACES THE CLIFF, AND A PIGEON WITH
ASTOUNDING FANTAILS REPLACES ITS ANCESTOR

that the planet's history could be told in terms of recurrent eras, in which millennia of summer warmth and millennia of winter chill follow endlessly, one after the other, in what used to be called an *annus magnus* or Great Year. For Lyell the scientist, geology itself seemed to offer confirmation: the fossil record proved that in earlier ages much of the Northern Hemisphere had been tropical and then, for ages since, it hadn't. How did that come to be? Could it happen again?

Lyell answers by proposing that large climatic changes arise when volcanoes and earthquakes alter the distribution of land and sea. The winter of the Great Year might descend upon Europe and the open seas turn icy if, he says, the hills of Italy were to sink, while at the same time an equivalent extent of land were to rise from the Arctic Ocean north of Siberia. As for the geological Great Summer, "all signs of frost should disappear from the earth" if land were to rise in "the torrid zone" and waters flood the North Pole. Then prehistoric creatures now extinct might once again roam the earth: "The huge iguanodon might reappear in the woods, and the ichthyosaur in the sea, while the pterodactyle might flit again through umbrageous groves of tree-ferns."

If this matter of the Great Year was the first surprise when I began to read Lyell, a second came when he moves from the first volume of *Principles*, in which he shows how small geological changes, repeated constantly over vast

periods of time, can produce huge results, to the second volume, where he focuses on the organic realm. Are not species, he asks, similarly "capable, as some naturalists pretend, of being indefinitely modified in the course of a long series of generations"? Jean-Baptiste Lamarck was the pretending naturalist he had in mind, having already famously argued for the inheritance of acquired characteristics. Lyell did not agree. No new species comes into being by transmutation from another, he argued; each is stable, "endowed, at the time of its creation" with all the features "by which it is now distinguished."

And yet the fossil record gave clear evidence that species do not last forever, stable as they may be. As for how, if that's the case, new species arise to replace the lost, nowhere in his geology does Lyell offer an explanation. In his private letters, however, there is an answer: under "the Presiding Mind," a "succession of extinction of species, and creation of new ones, [is] going on perpetually."

Lyell calls that idea "the grandest which [he] had ever conceived," and indeed it was because it allowed him to harmonize his geology with his religion. Among the beetle-collecting country parsons of his day, it was often assumed that the world had been created six thousand years ago and that many geological anomalies could be explained by Noah's Flood. Lyell was a scientist, however, not a parson, and he had found that floods of time offered greater insight than floods of water. At the same time, he was a believing Christian, and even as he willingly dispensed with Noah and Genesis 6–9 he held firm to the special creation of humankind as figured in Genesis 1.

Mircea Eliade's *The Myth of the Eternal Return* has helped me understand Lyell's reluctance to extend to organic life the incremental temporality that gives his geology such explanatory power. Eliade's book is built around the contrast between time as figured in the myth of his title and time as history. "History" in this context is a series of unforeseeable and irreversible events, while in eternal return, events proceed like the phases of the moon, ceaselessly and predictably manifesting what came before and will come again. Those who hold to such a myth, Eliade writes, may be aware of history but will strive to ignore it, attending instead to "the beginning of things, to the 'Great Time.'" Out of that refusal of profane time in favor of transhistorical events comes a certain "valorization" of human existence." Our lives and ideals matter because they belong to things eternal.

For Lyell, the material and the organic worlds belong to categorically distinct temporal orders. For mountains and rivers, time is history, sequential and irreversible; for species, it isn't. Lyell joins the ancients in mapping peri-

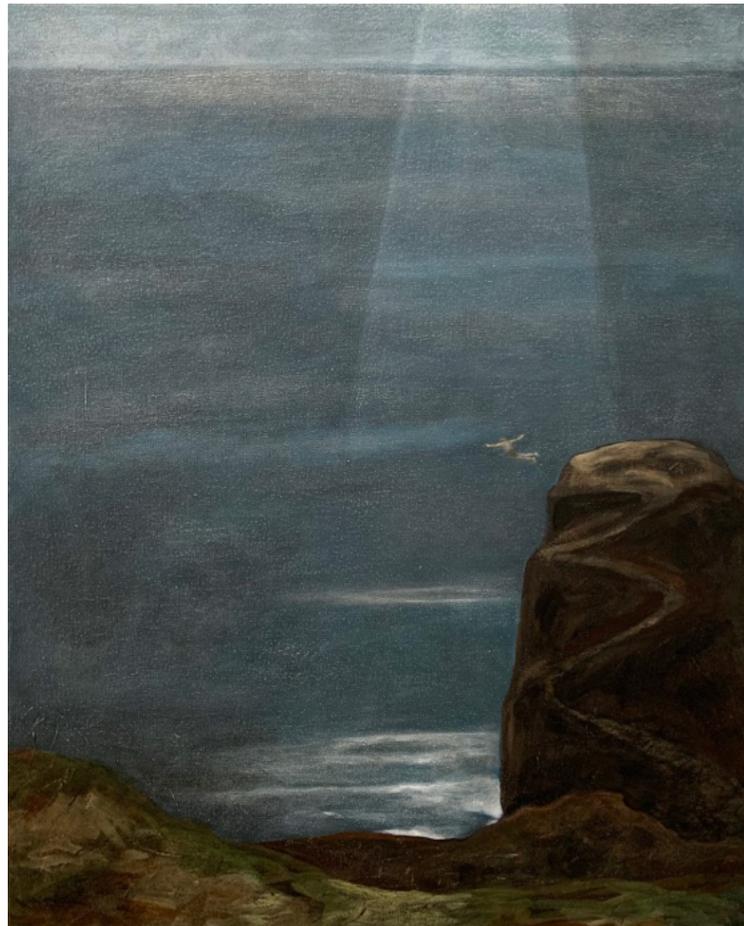
ods of creation and destruction onto the Great Year, leaving open the possibility that the pterodactyl might even one day fly again. Some cultures, Eliade shows, preserve their eternals by simply denying the force of history; in Lyell's case, the culture at hand was Christianity, and the ideal was the unique status of humankind. To the end of his days, Lyell resisted any natural history that implied that human beings might have descended from "one of the inferior animals." Eventually, Lyell abandoned the hope that prehistoric megafauna would reappear and, by the 1860s, he finally assented to the gist of Darwin's theory ("an indispensable hypothesis"), while continuing to assert the sovereignty of "the Divine mind."

Charles Darwin had no trouble discarding Adam and Eve, but that did not dispose of a problem he shared with Lyell: how to build a theory when a key element—the apparent infinity of time—defies comprehension. By my reading, several strategies arose. The first was to split infinity into tiny pieces, spans of time short enough to understand and work with. That is to say, Lyell and Darwin invented a kind of integral calculus, a method of adding together a series of infinitesimals, of minute changes that can, over "the lapse of ages," produce huge consequences. Minute after minute, little waves hit a granite cliff, or year after year, the wings of pigeons vary slightly. Then, in the fullness of time, a wide pebble beach replaces the cliff, and a pigeon with astounding fantails replaces its ancestor—or even, after an "accumulation of infinitesimally small inherited modifications" over "an almost infinite number of generations," a bird appears that is not a pigeon at all but an entirely new species.

A second strategy begins with the obvious fact that the geological record has distinct periods. A cliff by the seashore reveals layers of limestone, sandstone, and cobbles, each presumably a distinct chapter in the history of the earth. If the years it took to write each chapter could be determined, then it would be easier to speak of those otherwise "very remote eras." It was not until the twentieth century that tools sufficient to the task were developed. A key advance came in 1905, when Ernest Rutherford showed that radioactivity decays exponentially and therefore that uranium-bearing rocks can be used as natural clocks. (That and a score of other insights mean that we can now say with some confidence, for example, that the Cambrian began 538.8 million years ago.) As for steps that could be taken in the nineteenth century,

Lyell managed to invent a cunning way to determine the relative age of geological strata. Counting fossilized mollusks, he compared the number matching still-living species with the number now extinct; the larger the proportion of extinct species, the older that stratum. It was an ingenious way of ordering geological periods, but it left the duration of each one still undefined.

In the *Origin*, Darwin took his own stab at trading in time "incomprehensibly vast" for actual numbers. Near his home in Kent there were two prominent ridges, the North and South Downs; between them lay an expanse of woodlands and heathlands known as the Weald. The Downs are what now remain of a prehistoric dome of chalk, sandstone, and clay, the top of which has eroded away. How long did that erosion take? Darwin notes that the Weald Basin is about a thousand feet deep and twenty-two miles wide. Assuming, among other things, that all the stone and sand that once filled it had been carried away at a rate of one inch per century, he concludes that "the denudation of the Weald must have required 306,662,400 years; or say three hundred million years."



Geologists say that the chalk dome began to form thirty million years ago, making Darwin's number at least ten times too big. But even if that is a better estimate than three hundred, I don't believe that more precise periodization will ever dispense with the mystery of deep time. Saying that the Andes took twenty-five million years to rise or that the granite in California's Transverse Ranges is more than sixty-six million years old implies that we've got a handle on time, that we've domesticated it, so to speak, brought it into the house of science and made it familiar rather than strange.

But neither a chart of geology's eons, eras, and periods, nor a calculus of infinitesimals, can eliminate a sense of awe in the face of geological time. Darwin, as far as I can see, never lost his. In the *Origin*, it's just before his analysis of the Weald that he says that all such geological wonders impress his mind "as does the vain endeavour to grapple with the idea of eternity," and when he's finished with his experiment in

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periodization he immediately returns to his sense of wonder: "What an infinite number of generations, which the mind cannot grasp, must have succeeded each other in the long roll of years!"

Some of that geological awe has now been added to my childhood delight in butterflies. For there are fossil Lepidoptera. In Colorado, the Green River Formation has yielded at least four specimens from forty-eight million years ago, during the Eocene, and the nearby Florissant Formation a dozen species, thirteen million years later. Such clearly dated periodization may be easier to grasp than "the idea of eternity," but even so, it should leave untouched the initial wonder that butterflies exist and survive, proof of what nature can do with life when offered a chance to play with flowering plants, sunlight, and air.

One of New Hampshire's most curious butterflies may be called a living fossil, a surviving relic of the Ice Age. By nature an Arctic species, *Oeneis melissa*, or the Melissa Arctic, was widespread during the wintry centuries that followed the retreat of the last glaciers. About ten thousand years ago, however, as the world warmed toward modern temperatures, the spe-

cies retreated to high mountains and to far-northern latitudes. One group took refuge in the alpine meadows of the White Mountains, where they have been isolated ever since (so long, in fact, that they've evolved into a subspecies, *Oeneis melissa semidea*).

I have seen this butterfly only once. It was a June day, and I drove the Mount Washington toll road from Pinkham Notch up four thousand feet to a spot where I was able to hike on level ground across the Alpine Garden Trail. The spring flowers, not the butterflies, were the meadow's first revelation, trailing mats of pink azalea, fields of yellow mountain avens, and colonies of tiny, white-flowered sandwort, another Ice Age refugee. Distracted at first by the flower show, I snapped to attention only when something small and dark flew past, dropped to the ground, and disappeared, as if swallowed up by the scattered stones.

The field guides describe this butterfly, not very helpfully, as "smoky" or "feebly marked." Long ago, the dean of nineteenth-century lepidopterists, Samuel Scudder, took a stab at a fuller description, but the result was more muddled than clear (wings marbled with a "grayish ochraceous" and a "grayish white," though both can be obscured by a "blackish brown"). Suffice it to say that this butterfly has evolved cryptic coloration so as to hide among the equally cryptic surfaces of the alpine landscape. The stones of Mount Washington admittedly have a bit more color than the Melissa Arctic, but they have the same mottled patterning, their weathered skins a maze of blackish-brown and grayish-green lichens and moss, touched occasionally with ocher highlights, the whole nicely broken up by webs of tiny fractures where the summer sun has dried things out.

The butterfly I saw that day had a habit, when it landed, of letting the wind tip it over so that the underwings lay flat against the stone, a mottled creature taking refuge in the mottled world, and I began to feel that this animal was teaching me not just to see it, but to see the stones. It was a schooling in discernment, in the art of recognition.

I once asked a friend why he was so dedicated to watching birds, and he replied, simply, "Darshan." In Indian religions, "darshan" refers to the auspicious sight of a divinity or great teacher. More widely it has come to mean any glimpse of the marvelous or awe-inspiring: the ocean in storm, the cougar watching the hiker, the invisible butterfly suddenly in focus. "Darshan means getting a view," said Gary Snyder. "If the clouds blow away, as they did once for me, and you get a view of the Himalayas from the foothills, an Indian person would say, 'Ah, the Himalayas are

giving you their darshan'; they're letting you have their view." So it was that June day, when the Melissa Arctic gave me a view of things both singular and collective: butterfly and stone, moss and lichen, spring flowers and the mountain rising above us.

At the end of the nineteenth century, Scudder reported that the Melissa Arctic was "exceedingly abundant": "During the entire month of July the butterflies swarm over the rocks and sedgy plateaus of the upper summits." These days, the butterfly is found in only three or four of the White Mountain meadows, the population estimated at 1,500 individuals in each yearly brood. Annual temperatures in New England are now predicted to rise between five and ten degrees Fahrenheit by century's end, a change greater than any in the past ten thousand years. When that happens, all the high-meadow remnants of the Ice Age will be pushed off the top of the mountain and disappear.

The ship that carried Charles Darwin around the world in the 1830s housed more than twenty chronometers in their own special cabin. These were used, along with astronomical observation, to determine the ship's location and thus to draw an accurate map of the voyage—or, as Darwin more boldly puts it, "to complete the chronometrical measurement of the world."

Marine chronometers are set to faithfully indicate the solar time at the Royal Observatory in Greenwich, London. Their uses are not like those of the common kitchen clock because they are built to travel. The kitchen clock and the chronometer circling the globe offer two kinds of temporal awareness, one fitted to the body, the other to the mind. At home we watch the sun move and, when it hangs directly overhead, are pleased to hear the clock strike the bell for lunch.

Chronometrical time, however, applies Greenwich time to the globe as a whole, and any harmony between time and the body is lost. At home, the sun sets once a day; in a chronometrical world, the sun never sets—and never stops rising, either. Time in that empire is disembodied, a thing more imagined than felt.

Neither Lyell nor Darwin measured time on a human scale. It didn't take days, months, or even calendar years for Mount Etna to rise or for the animals of the Galápagos to become unique species. These things now have their daily and seasonal rhythms, but the temporality of their arising belongs to another order, one that the nineteenth century was just beginning to chart. Once solar time in Greenwich had been carried, night and day, around the spinning globe,

time became highly abstracted, cut away from its animal home so as to be more easily figured both geologically and evolutionarily.

Darwin regularly distinguishes what our senses directly tell us from what our reason abstractly knows. In 1836, the HMS *Beagle* arrived at the Cocos Islands, where a low atoll of coral encircled a miles-wide lagoon. Why did these islands stand in a ring? Because, Darwin argues, the coral had grown around the slopes of a slowly sinking volcano. We may be astounded, he writes, by the monumental works of humankind, "but how utterly insignificant are the greatest of these, when compared to these mountains of stone accumulated by the agency of various minute and tender animals!" As if to offer a gloss on his exclamation point, Darwin then divides his awareness into two parts: "This is a wonder which does not at first strike the eye of the body, but, after reflection, the eye of reason."

The eye of reason can travel far beyond the bounds of present time and space. If we look at a

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barrier reef and imagine seeing a mountain rise, a mountain sink, and coral slowly grow,

We may thus, like unto a geologist who had lived his ten thousand years and kept a record of the passing changes, gain some insight into the great system by which the surface of this globe has been broken up, and land and water interchanged.

A ten-thousand-year-old geologist! We are at one of those points where scientific explanation finds it useful to partner with mythology: the eye of the mortal body can see a slow-growing coral reef, but only the fantastic eye of reason can apprehend the vast reaches of time that are its maker. Its maker? To imply some agency at work may be an odd way of speaking, but it's one that Darwin's language suggests in both the *Voyage* and the *Origin*, where time begins to appear as a thing with its own powers, a creator of some sort, one that cannot be comprehended by the human mind except, perhaps, by beginning with its very incomprehensibility.

There's a moment in the final pages of the *Voyage* when Darwin implies that his apprehension of the magnitude of time comes to him through a kind of *via negativa*, that Desert Fathers practice of seeking God by stripping away all that is comprehensible and then watching to

see what remains. A desert sufficient to that purpose Darwin found in southernmost South America:

The plains of Patagonia ... can be described only by negative characters; without habitations, without water, without trees, without mountains, they support merely a few dwarf plants. Why, then ... have these arid wastes taken so firm a hold on my memory?... It must be partly owing to the free scope given to the imagination. The plains of Patagonia are boundless ... and hence unknown: they bear the stamp of having lasted, as they are now, for ages, and there appears no limit to their duration through future time.

It was the sense of awe in the face of the temporal sublime and passages like this one that had



me thinking that time—or, rather, Time—in Darwin sometimes appears as a kind of divinity. Not a God like the one Charles Lyell knew from his Bible; more like those he would have known from his reading of Sanskrit and Greek: the Hindu Trimurti, for example, a three-faced triad of Brahma, Vishnu, and Shiva bound into a single figure of creation and destruction, or the Greek Cronus, last born of the Titans, who in antiquity became a god of time and “brought the animal creation into order.”

We should approach such powers with caution. There is a classic Greek concept, *aidos*, often translated as “shame” but in fact carrying an instructively wide range of meanings. In terms of self-restraint, *aidos* can mean modesty and regard for others. It can also mean reverence and awe.

When you enter the grove of a god, or meet a true poet or prophet, these several feelings should arise as one: awe, reverence, and the kind of inhibitory shame that keeps you from doing or saying anything profane or sacrilegious. The person who has no inborn sense of *aidos*, who can neither sense nor respect the force fields surrounding the great powers, is in danger.

In the case at hand, they who shamelessly toy with the Titan of Time may well be destroyed. The feminist philosophers Donna Haraway and Isabelle Stengers argue that, when it comes to the current geological period, we should focus not on what humankind has done to the earth but on what the earth is doing in response. The earth in this context is Gaia, a complex and synergistic being, and the present era in which Gaia is intruding upon human activity should be called the Chthulucene, not the Anthropocene.

“Chthulucene” derives from the Greek *khthon*, “earth,” and chthonic powers are those associated with volcanoes, earthquakes, caves, and all that lies in the depths below. Greek myths feature dozens of chthonic divinities and forces. Aeacus, a judge of the dead, and Thanatos, winged daemon of death, are chthonic. Hermes in his office as guide of souls is Hermes Chthonios; Persephone in her winter phase is Persephone Chthonia. As for the chthonic powers who might intrude upon us, the worst must be the Titans, primeval offspring of Gaia and Uranus, Earth and Sky. In the Greek succession myth, the Titans overthrew their father, Uranus, and Zeus in turn overthrew the Titans, confining them to the bronze-walled prison of Tartarus, that black and stormy pit that lies lower even than the depths of Hades.

To describe our era as the Chthulucene is to recognize that Gaia is responding to our having released such titanic forces from their confinement. One-hundred-year floods, forest fires the size of nations, record-breaking heat waves: chthonic forces now mess with our affairs as they haven’t since the glaciers last descended from the poles. Surely among the most threatening sources of such powers are the fossil fuels now released from the depths. In her book on George Orwell, Rebecca Solnit ends a chapter touching on coal mining with a citation from a 1930 primer on the first Soviet five-year plan: “The remains of the swamp grass, the ferns, the horsetails rotted under the layers of sand and clay, became black, and turned into coal,” it reads, declaring that “to this cemetery we intend to go, drag the dead out of their tombs, and force them to work for us.”

The era when those dead were alive—the Carboniferous—spanned sixty million years. Today, the coalfields of the Industrial Revolution contain sixty million years of plant-captured sunlight, infinitesimal drops of energy gathered day by day and then petrified over near-infinities of time.

To burn them over the course of a few centuries amounts to treating human time to a blast of geological time, an earthquake of time.

It was 1836 when Darwin wrote of the eye of reason, having been immersed in *Principles of Geology* for more than four years, and learning to see the world through Lyell's eyes. "I feel as if my books . . . came half out of Sir Charles Lyell's brain," he would later remark. "The great merit of the *Principles* was that it altered the whole tone of one's mind and, therefore, that when seeing a thing never seen by Lyell, one yet saw it partially through his eyes." Darwin's ideas about coral islands are his own, but it was what he borrowed from the genius of Lyell's eye of reason that made them possible.

One thing that I myself have borrowed from Lyell, somewhat to my own surprise, is his Great Year and its myth of eternal return, a remnant of which I find worth saving if it could be cut to a more modest size. As the earth's wobbling axis rotates through the signs of the zodiac, the Age of Aquarius will end, but it's comforting to know that, in the fullness of time, it will return. It would be more comforting still were the time involved not so utterly inhuman.

As for human time, I look to the five or six thousand years since human civilization arose. Compared with earlier chapters in the history of the earth, ours have been millennia with a relatively stable climate. It has varied, to be sure, but never as punishingly as during the Ice Age and, because a stable climate slows the hand of evolution, animal and plant species have been relatively stable as well, eternally returning, generation upon generation.

Eternally? Yes, for there are many eternities once "eternity" is understood to be a category of human thought. Viewed from the brevity of human life, there is little difference between the 3,600 years since the Shang dynasty arose, the 11,700 years since the glaciers melted, and the hundred million years since the first butterflies took wing. All are equally eternal. And the animal phyla that have been with us, essentially unchanged, for all those years—the birds and mammals, clams and snails, spiders and insects—these are, to me, surviving embodiments of eternal return.

Defending his belief in the fixity of species in *Principles*, Lyell turned to the recent discovery that "the priests of Egypt [had] bequeathed to us, in their cemeteries . . . embalmed bodies of consecrated animals": bulls, cats, dogs, apes, crocodiles, and more. The cats especially interested Lyell since, during the three thousand years that followed their entombment, their progeny had been dispersed "over the whole earth" and yet had not "undergone any perceptible mutation." The cat "is still the same animal which was held sacred by the Egyptians."

In later years, Lyell acknowledged that he had been wrong about how long it would take to evolve a new species ("thirty or forty centuries" are "insignificant"), but he was right about the stability of cats in the time since the Egyptians built their pyramids. In human time, if history means the irreversible and unforeseen, then the species *Felis catus* hardly belongs to history. To this day, the meanest alley cat in London testifies to the eternal return of cat life.

As for butterflies, consider the Red Admiral—bright orange-red bands across dark wings, touches of blue and white—a common species with an ancient and stable lineage: it not only appears faithfully rendered in four-hundred-year-old Dutch paintings, but ancestors of its genus lie well preserved in the Eocene fossil beds of Colorado. To this day, they fly in Concord, five of them during last year's count, testifying to the eternal return of butterfly life.

I take Lyell's interest in the Great Year to be an illustration of Eliade's point that some cultures protect their eternal ideals by simply resisting history. In Lyell's case, the ideal was humanity's spark of the divine, and the history to be resisted was the "natural history" now called evolution. In my case, the eternals I wish to defend are the species with which we've shared the planet since before the Egyptians wrapped their mummies. As for history, the point is not so much to resist it as to understand that we choose whether or not to make it. Let us not forget our ignorance, nor the limits of our foresight. There is no stopping the arrow of time when it comes to earthquakes and glaciers, but in human affairs it is we who string the bow that lets the arrow fly.

As for what stays with me after having seen the world through Darwin's eyes, I think of a time when, while first reading the *Origin*, I took a break and stood in our garden watching the bees nuzzle the peonies. It was late in May, their legs were yellow-pouched with pollen, and for the first time it occurred to me that I was seeing the fruits of deep time, not just the bees and the flowers, but their mutualism, and the peony leaves feeding on sunlight and the earthworms aerating the soil beneath.

For a long time after, everything I saw seemed to be made of time, or by time, or in time. And not just the cheery pollinators but the red-tailed hawk rendering the stringy meat of its kill and the COVID virus that settled in my throat, Christmas 2021, late variant of some ancestor virus, an embodiment of the time it takes to work up such a cunning art of massive replication. As for the amber stream pouring into my gas tank as I stand at the self-service pump on my way to Walden, I now take it and all the other plant-based fossil fuels to be an infinity of petrified sunlight, best understood through the compound lens of the Lyell-Darwin eye. ■