

# CHAPTER 1

## A VERY BRIEF HISTORY OF TIME

Time is at the heart of all that is important to human beings.

BERNARD D'ESPAGNAT

### WHOSE TIME IS IT ANYWAY?

*Time must never be thought of as pre-existing in any sense; it is a manufactured quantity.*

HERMANN BONDI

In a dingy laboratory in Bonn lies a submarine-shaped metal cylinder. It is about three meters long, and rests comfortably in a steel frame surrounded by wires, pipes and dials. At first glance, the entire contraption looks like the inside of a giant car engine. In fact, it is a clock—or, rather, *the* clock. The Bonn device, and a network of similar instruments across the world, together constitute “the standard clock.” The individual instruments, of which the German model is currently the most accurate, are cesium-beam atomic clocks. They are continually monitored, compared, tweaked and refined via radio signals from satellites and television stations, to cajole them into near-perfect step. At the International Bureau of Weights and Measures at Sèvres, not far from Paris, the data are collected, analyzed and broadcast to a time-obsessed world. Thus originates the famous pips, the radio time signals by which we set our watches.

So, as we go about our daily toil, the Bonn cesium-beam clock keeps the time. It is, so to speak, a custodian of Earth time. The trouble is, the Earth itself doesn't always keep good time. Occasionally our clocks, all supposedly linked to the master system in France like a retinue of obedient slaves, must be adjusted by a second to track changes in the Earth's rotation rate. The last such "leap second" was added on 30 June 1994. The planet's spin, accurate enough to serve as a perfectly suitable clock for a thousand generations, is now defunct as a reliable chronometer. In this age of high-precision timekeeping, poor old Earth doesn't make the grade. Only an atomic clock, man-made and mysterious, serves to deliver those all-important tick-tocks with the precision demanded by navigators, astronomers and airline pilots. One second is no longer defined to be  $\frac{1}{86,400}$  of a day: it is 9,192,631,770 beats of a cesium atom.

But whose time is the Bonn clock telling anyway? Your time? My time? God's time? Are the scientists in that cluttered laboratory monitoring the pulse of the universe, fastidiously tracking some abstract cosmic time with atomic fidelity? Might there be another clock, perhaps on another planet somewhere, faithfully ticking out another time altogether, to the joy of its makers?

We know clocks need not agree: the Earth clock gets out of sync with the Bonn clock. So which one is *right*? Well, presumably the Bonn clock, because it's more accurate. But accurate relative to *what*? To *us*? After all, clocks were invented to tell the time for entirely human purposes. Are all humans "on" the same time, however? The patient in the dentist's chair and the audience listening to a Beethoven symphony experience the same atomically tagged duration in quite different ways.

So much of what we believe about time is a result of cultural conditioning. I once met a mystic in Bombay who claimed he could alter his state of consciousness through meditation and so suspend the flow of time altogether; he was unimpressed with talk of atomic clocks. In a lecture in London some years ago, I found myself sharing the platform improbably with the Dalai Lama. Our task was to compare and contrast time as it enters into Western scientific thinking and Eastern philosophy. The Lama spoke with quiet assurance, but unfortunately in Tibetan. Though I tried to follow the translation for enlightenment, I didn't receive much, regrettably. Culture clash, I suppose.

After my lecture, we had a tea break, and the Dalai Lama took my hand as we walked out of the building into the sunshine. Someone dropped to his knees and presented His Holiness with a daffodil, which he graciously accepted. I had the overwhelming impression of a gentle and intelligent man with insights of value to us all, but prevented by the trappings of his office from effectively communicating them to the assembled Western scientists. I came away from the occasion with a deep sense of missed opportunity.

## THE QUEST FOR ETERNITY

*Eternity! thou pleasing, dreadful thought!*

JOSEPH ADDISON

In the madcap world of modern Western society, where time is money, railways, airline schedules, television programs, even cooking are subject to the tyranny of the clock. Our hectic lives are firmly bolted to the treadmill of time. We are slaves of our past and hostages to the future. But was it always thus? Running like a common thread through the history of human thought, East and West, North and South, is a belief that the entire paradigm of human temporality is rooted in some sort of monstrous illusion; it is but an elaborate product of the human mind:

*And likewise time cannot itself exist,  
But from the flight of things we get a sense of time. . . .  
No man, we must confess, feels time itself,  
But only knows of time from flight or rest of things.<sup>1</sup>*

Thus wrote the Roman poet-philosopher Lucretius in his first-century epic *De Rerum Natura*. From such unsettling ideas it is but a small step to believe that the passage of time can be controlled or even suspended by mental power, as we discover in the following haunting words of the sixteenth-century mystical poet Angelus Silesius:

*Time is of your own making,  
its clock ticks in your head.  
The moment you stop thought  
time too stops dead.<sup>2</sup>*

For such temporal relativists, true reality is vested in a realm that transcends time: the Land Beyond Time. Europeans call it “eternity,” Hindus refer to it as “moksha” and Buddhists as “nirvana.” For the Australian aborigines it is the Dream Time. Angelus Silesius again:

*Do not compute eternity  
as light-year after year  
One step across  
that line called Time  
Eternity is here.<sup>3</sup>*

In our struggle to come to terms with mental and physical reality, nothing vexes us more than the nature of time. The paradoxical conjunc-

tion of temporality and eternity has troubled Man through the ages. Plato concluded that the fleeting world of daily experience is only half real, an ephemeral reflection of a timeless domain of pure and perfect Forms, which occupy the realm of eternity. Time itself is but an imperfect “moving image of Eternity which remains forever at one,” but which we human beings incorrigibly reify: “The past and future are created species of time, which we unconsciously but wrongly transfer to the eternal essence.”<sup>4</sup>

The abiding tension between the temporal and the eternal pervades the world’s great religions, and has led to generations of heated and sometimes violent theological debate. Is God inside or outside of time? Temporal or eternal? Process or Being? According to Plotinus, a third-century pagan, to exist in time is to exist imperfectly. Pure Being (i.e., God) must therefore be characterized by the utter absence of any relation to time. For Plotinus, time represents a prison for human beings, separating us from the divine realm—the true and absolute reality.

Belief that God lies outside of time altogether also became the established doctrine among many early Christian thinkers, such as Augustine, Boethius and Anselm, starting a tradition that continues to the present day. Like Plato and Plotinus before him, Augustine places God in the realm of eternity, “supreme above time because it is a never-ending present.” In this existence, time does not pass; rather, God perceives all times at once:

Your years are completely present to you all at one because they are at a permanent standstill. They do not move on, forced to give way before the advance of others, because they never pass at all. . . . Your today is eternity.<sup>5</sup>

Thus, the God of classical Christianity not only exists outside of time, but also knows the future as well as the past and present. These far-reaching ideas have been subjected to detailed analysis and received some sharp criticism by the medieval church, as well as by modern theologians and philosophers. The core of the debate is the daunting problem of how to build a bridge between God’s presumed eternity on the one hand and the manifest temporality of the physical universe on the other. Can a god who is completely atemporal logically relate in any way at all to a changing world, to human time? Surely it is impossible for God to exist *both* within and outside of time? After centuries of bitter debate, there is still no consensus among theologians about the solution to this profound conundrum. These tangled issues are reviewed in greater depth in my book *The Mind of God*, for those readers who are interested.

## ESCAPE FROM TIME

*The great thing about time is that it goes on.*

ARTHUR EDDINGTON

Although theologians and philosophers wrangle over the technicalities of the logical relationship between time and eternity, many religious people believe that the most powerful insights into the subject are provided, not by academic debate, but by direct revelation:

I remember that I was going to bathe from a stretch of shingle to which the few people who stayed in the village seldom went. Suddenly the noise of the insects was hushed. Time seemed to stop. A sense of infinite power and peace came upon me. I can best liken the combination of timelessness with amazing fullness of existence to the feeling one gets in watching the rim of a great silent fly-wheel or the unmoving surface of a deep, strongly-flowing river. Nothing happened; yet existence was completely full. All was clear.<sup>6</sup>

This personal story, recounted by the physicist and Anglican bishop Ernest Barnes in his 1929 Gifford Lectures, eloquently captures the combination of timelessness and clarity so often said to be associated with mystical or religious experiences. Can a human being really escape time and glimpse eternity? In Barnes's case, as happens so often in reports from Westerners, the experience came totally out of the blue. But Eastern mystics have perfected special techniques that allegedly can induce such timeless rapture. The Tibetan monk Lama Govinda describes his own experiences thus:

The temporal sequence is converted into a simultaneous co-existence, the side-by-side existence of things into a state of mutual interpenetration . . . a living continuum in which time and space are integrated.<sup>7</sup>

Many similar descriptions have been published of deep meditation, or even drug-induced mental states, in which human consciousness apparently escapes the confines of time, and reality appears as a timeless continuum.

The Indian philosopher Ruth Reyna believes the Vedic sages "had cosmic insights which modern man lacks. . . . Theirs was the vision not of the present, but of the past, present, future, simultaneity, and No-Time."<sup>8</sup> Sankara, the eighth-century exponent of Advaita Vedanta,

taught that Brahma—the Absolute—is perfect and eternal in the sense of *absolute timelessness*, and thus the temporal, though real within the world of human experience, has no ultimate reality. By following the path of Self-Realization through Advaita, a truly timeless reality may be attained: “timeless not in the sense of endless duration, but in the sense of completeness, requiring neither a before nor an after,” according to Reyna. “It is this astounding truth that time evaporates into unreality and Timelessness may be envisioned as the Real . . . that spells the uniqueness of Advaita.”<sup>9</sup>

The yearning for an escape from time need not involve refined meditative practices. In many cultures it is merely a pervasive yet subconscious influence—a “terror of history,” as anthropologist Mircea Eliade expresses it—which manifests itself as a compulsive search for the Land Beyond Time. Indeed, this search is *the* founding myth of almost all human cultures. The deep human need to account for the origin of things draws us irresistibly back to a time before time, a mythical realm of timeless temporality, a Garden of Eden, a primordial paradise, its potent creativity springing from its very temporal contradictions. Whether it is Athena leaping from the head of Zeus or Mithras slaying the Bull, we encounter the same heady symbolism of a lost, timeless, perfect realm that somehow—paradoxically, timelessly—stands in creative relation to the immediate world of the temporal and the mortal.

This paradoxical conjunction is captured in its most developed form in the “Dreaming” concept of the Australian aborigines, sometimes referred to as the Eternal Dream Time. According to the anthropologist W. E. H. Stanner:

A central meaning of The Dreaming *is* that of a sacred, heroic time long, long ago when man and nature came to be as they are; but neither “time” nor “history” as we understand them is involved in this meaning. I have never been able to discover any aboriginal word for *time* as an abstract concept. And the sense of “history” is wholly alien here. We shall not understand The Dreaming fully except as a complex of meanings.<sup>10</sup>

Although the Dream Time carries connotations of a heroic past age, it is wrong to think of that age as now over. “One cannot ‘fix’ The Dreaming in time,” observes Stanner. “It was, and is, everywhen.” Thus the Dreaming retains a relevance in contemporary aboriginal affairs, because it is part of the present reality; the “creator beings” are still active today. What Europeans call “the past” is, for many aboriginal people, *both* past and present. Stories of creation are often cast in what Europeans would call the recent past, even as recent as the era of white settlement. No incongruity is felt, because, for the Australian aborigine, events are more important than dates. This subtlety is lost on most European

minds; we have become obsessed with rationalizing and measuring time in our everyday lives. Stanner quotes an old Australian black man who expressed this cultural gulf lyrically:

*White man got no dreaming.  
Him go 'nother way.  
White man, him go different,  
Him got road belong himself.*

The concept of “white man’s time” as a “road” down which he marches single-mindedly is an especially apt description, I think, of Western linear time. It is a road that may perhaps lead to progress, but the psychological price we pay for embarking upon it is a heavy one. Fear of death lies at the root of so much we do and think, and with it the desperate desire to optimize the precious duration we have been allotted, to lead life to the full and accomplish something of enduring value. Modern man, wrote J. B. Priestley,

. . . feels himself fastened to a hawser that is pulling him inexorably toward the silence and darkness of the grave. . . . But no idea of an “eternal dream time,” where gods and heroes (from whom he is not separated for ever) have their being, comes shining through to make modern man forget his calendars and clocks, the sands of his time running out.

But even those of us who are trapped within Western culture, for whom a magical, mystical escape route from time is unavailable, can still discern the powerful ancient symbols at work in art and literature, reverberating down the ages. From *Paradise Lost* to *Narnia*, from King Arthur’s Avalon to that distant galaxy far away and long ago where the *Star Wars* were fought and won, the realm of eternity has never been very far from the surface. The evocative emblems of eternity now lay shadowy and indistinct in our culture, serving merely as a seductive distraction from the commonsense “reality” of ruthless, passing time. Yet, Priestley assures us, they live on:

Among the ideas that haunt us—ideas we may laugh at but that will not leave us, ideas that often promise a mysterious happiness when all else seems to fail us—is this one of the Great Time, the mythological dream time, that is behind and above and altogether qualitatively different from ordinary time. We no longer create any grand central system out of it. We do not let it shape and guide our lives. It has dwindled and now looks small and shabby, rather laughable; but it cannot be laughed out of existence, it refuses to go away.<sup>11</sup>

## CYCLIC WORLDS AND THE ETERNAL RETURN

*All things from eternity are of like forms and come round in a circle.*

MARCUS AURELIUS ANTONINUS

In ancient cultures, contact with eternity was kept alive by introducing cyclicity in the world. In his classic text *The Myth of the Eternal Return*, Mircea Eliade describes how traditional societies habitually rebel against the historical notion of time, and yearn instead “for a periodical return to the mythical time of the beginning of things, to the ‘Great Time.’”<sup>12</sup> He maintains that the symbols and rituals of ancient cultures represent an attempt to escape from historical, linear, “profane” time, to a mythical or sacred epoch, believing that the suspension of profane time “answers to a profound need on the part of primitive man.”<sup>13</sup> Walter Ong, an expert on temporal symbolism, also finds evidence in mythology and folklore for a longing to throw off the trappings of time:

Time poses many problems for man, not the least of which is that of irresistibility and irreversibility: man in time is moved willy-nilly and cannot recover a moment of the past. He is caught, carried on despite himself, and hence not a little terrified. Resort to mythologies, which associate temporal events with the atemporal, in effect disarms time, affording relief from its threat. This mythological flight from the ravages of time may at a later date be rationalized by various cyclic theories, which have haunted man’s philosophizing from antiquity to the present.<sup>14</sup>

Release from historical time may be sought by religious rites, such as the ritual repetition of phrases or gestures that symbolically re-create the original events. Contact with sacred time is often identified with regeneration and renewal. The ancient Festival of New Year, common to both traditional and modern cultures, symbolizes the periodic regeneration or rebirth of nature. In some instances, it represents a repetition of the creation event itself—the mythical transition from chaos to cosmos.

The symbolism underlying these widespread folk practices stems from the ancient belief in temporal cyclicity. Many annual rituals in the Western world have pagan origins that predate Christianity, yet they have been tolerated for centuries by the church. Indeed, cyclic rituals play an important role in the church too, in spite of Christianity’s implacable opposition to cyclic time.

Western art, poetry and literature, despite being strongly influenced by the dominance of linear time, nevertheless betrays much hidden and



occasionally overt cyclicality. The deep preoccupation with the natural cycle of the seasons, the use of repetitious style, and the liberal employment by writers of a nothing-new-under-the-sun philosophy suggest a fantasized retreat from time's relentless arrow. In some extreme examples, the text itself is structured in a temporally distorting manner, as in James Joyce's *Finnegans Wake*, where the last words of the book run onto the opening passage, or Martin Amis's *The Arrow of Time*, where the entire narrative runs backwards.

Cyclicity retains a deep appeal for some people, yet is abhorrent to others. As we shall see, there is a modern variant of Einstein's cosmology that suggests a cyclic universe, and whenever I give public lectures on cosmology and fail to mention it, somebody inevitably asks me about it. Perhaps the attraction of the model is the prospect of resurrection in subsequent cycles. There is a world of difference, however, between a general sort of cosmic regeneration, and a universe that endlessly repeats itself in precise detail. Plato's assertion of cosmic cyclicality exercised a strong influence on Greek, and later Roman thought. It was taken to the logical extreme by the Stoics, who believed in the concept of *palingenesis*—the literal reappearance of the same people and events in cycle after cycle, an idea that strikes most people today as utterly sterile and repugnant.

## NEWTON'S TIME AND THE CLOCKWORK UNIVERSE

*I cannot believe that medieval man ever felt trapped in some vast machinery of time.*

J. B. PRIESTLEY

The association of time with the mystical, the mental and the organic, fascinating and compelling though it may be, undoubtedly served to hinder a proper scientific study of time for many centuries. Whereas the Greek philosophers developed systematic geometry, and elevated it to a philosophical world view, time remained for them something vague and mysterious, a matter for mythology rather than mathematics. In most ancient cultures, the notion of *timekeeping* cropped up in just a few contexts: in music, in the rhythmic pattern of the seasons and the motions of the heavenly bodies, and in the menstrual cycle. All these topics were overlaid with deep mystical and occult qualities in a way that properties like mass, speed and volume were not.

Aristotle's study of the motion of bodies led him to appreciate the fundamental importance of time, yet he fell short of introducing the notion of time as an abstract mathematical parameter. For Aristotle,

time *was* motion. This is hardly revolutionary: we perceive time through motion, whether the movement of the sun across the sky or the hands around a clock face. The concept of time as an independently existing *thing*, an entity in its own right, did not emerge until the European medieval age. The existence of an order in nature has been recognized by all cultures, but it was only with the rise of modern science that a precise and objective meaning could be given to that order. In this quantification, the role of time turned out to be crucial.

On 8 July 1714, the government of Queen Anne determined “That a Reward be settled by Parliament upon such Person or Persons as shall discover a more certain and practicable Method of Ascertaining Longitude than any yet in practice.”<sup>15</sup> The prize on offer was the princely sum of £20,000, to be awarded for the construction of a chronometer that was capable of determining longitude at sea to within thirty miles after a six-week voyage. No event better symbolizes the transition from the organic, rhythmic time of traditional folklore to the modern notion of time as a functional parameter with economic and scientific value.

The challenge was taken up by a Yorkshireman named John Harrison, who designed several clocks capable of working at sea. Harrison’s fourth instrument, which incorporated a refinement that compensated for temperature changes, was completed in 1759 and submitted for trial two years later. It was conveyed on the ship *Deptford* to Jamaica, where, some two months later, it was found to have accumulated an error of just five seconds. The Admiralty was a bit sticky coming up with the prize money, and by 1765 Harrison had collected only half his reward. He eventually appealed to the King and Parliament, but had turned eighty before he received the balance. Even in the eighteenth century, research funding was tight.

History records that it was Galileo who was foremost in establishing time as a fundamental measurable quantity in the lawlike activity of the cosmos. By measuring the swing of a lamp against the pulse of his wrist while sitting in church, he discovered the basic law of the pendulum—that its period is independent of the amplitude of the swing. Soon the era of precision clockwork was to sweep through Europe, with craftsmen designing ever more accurate timepieces. The push for greater precision in measuring time was not motivated by lofty philosophical or scientific considerations, but by the very practical matter of navigation and trade: sailors need to know the time accurately to be able to compute their longitude from the positions of the stars; the discovery of America, necessitating several weeks of east–west travel, spurred the development of shipborne chronometers.

The crucial position that time occupies in the laws of the universe was not made fully manifest until the work of Newton, in the late seventeenth century. Newton prefaced his presentation with a famous definition of

“absolute, true and mathematical time, [which] of itself, and from its own nature, flows equably without relation to anything external.”<sup>16</sup> Central to Newton’s entire scheme was the hypothesis that material bodies move through space along *predictable* paths, subject to forces which accelerate them, in accordance with strict mathematical laws. Having discovered what these laws were, Newton was able to calculate the motion of the moon and planets, as well as the paths of projectiles and other earthly bodies. This represented a giant advance in human understanding of the physical world, and the beginning of scientific theory as we now understand it.

So successful did Newton’s laws of mechanics prove to be that many people assumed they would apply to literally every physical process in the universe. From this belief emerged the picture of the cosmos as a gigantic clockwork mechanism, predictable in its every detail. The clockwork universe enshrined time as a fundamental parameter in the workings of the physical world. This universal, absolute and completely dependable time was the time that entered into the laws of mechanics, and was faithfully kept by the cosmic clockwork. It encapsulated the rule of cause and effect, and epitomized the very rationality of the cosmos. And it gave the world the powerful image of God the Watchmaker.

The great French mathematical physicist Pierre de Laplace, the man who told Napoleon that he “had no need of this hypothesis” when discussing God’s action in the Newtonian universe, realized that, if all motion is mathematically determined, then the present state of motion of the universe suffices to fix its future (and past) for all time. In this case, time becomes virtually redundant, for the future is already contained in the present, in the sense that all the information needed to create the future states of the universe resides in the present state. As the Belgian chemist Ilya Prigogine once poetically remarked, God the Watchmaker is reduced to a mere archivist turning the pages of a cosmic history book that is already written.<sup>17</sup> Whereas most ancient cultures viewed the cosmos as a capricious living organism, subject to subtle cycles and rhythms, Newton gave us rigid determinism, a world of inert particles and forces locked in the embrace of infinitely precise lawlike principles.

Newtonian time is in its very essence mathematical. Indeed, starting with the idea of a universal flux of time, Newton developed his “theory of fluxions”—a branch of mathematics better known as the calculus. Our preoccupation with precision timekeeping can be traced to the Newtonian concept of a mathematically precise, continuous flux of time. After Newton, the passage of time became more than merely our stream of consciousness; it began to play a fundamental role in our description of the physical world, something that could be analyzed with unlimited accuracy. Newton did for time what the Greek geometers did for space: idealized it into an exactly measurable dimension. No longer could it be

convincingly argued that time is an illusion, a mental construct created by mortal beings from their failure to grasp eternity, because time enters deeply into the very laws of the cosmos, the bedrock of physical reality.

## EINSTEIN'S TIME

It was into this world of rigid temporality that Albert Einstein was born. Newton's time had endured for two centuries and was scarcely questioned by Westerners, though it has always rested uneasily alongside Eastern thought, and is alien to the minds of indigenous peoples in America, Africa and Australia. Yet Newton's time is the time of "common sense" (Western style). It is also easy to understand. For Newton, there is but one all-embracing universal time. It is simply *there*. Time cannot be affected by anything; it just goes on flowing at a uniform rate. Any impression of a variation in the rate of time is treated as misperception. Wherever and whenever you are, however you are moving, whatever you are doing, time just marches on reliably at the same pace for everybody, unerringly marking out the successive moments of reality throughout the cosmos.

Among other things, Newton's concept of time invites us to chop it up into past, present and future in an absolute and universal manner. Because the whole universe shares a common time and a common "now," then every observer everywhere, including any little green men on Mars or beyond, would concur with what is deemed to have passed, and what is yet to be. This tidy image of time as defining a succession of universal present moments has important implications for the nature of reality, for in the Newtonian world view only that which happens *now* can be said to be truly real. This is indeed how many nonscientists unquestioningly perceive reality. The future is regarded as "not yet in existence," and perhaps not even decided, while the past has slipped away into a shadowy state of half-reality, possibly remembered but forever lost. "Act, act in the living present!" wrote Longfellow, for it is only the physical state of the world *now* that seems to be concretely real.

But this simple view of time as rigid and absolute—powerful and commonsensical though it may be—is fundamentally flawed. Around the turn of the twentieth century, the Newtonian concept of universal time began yielding absurd or paradoxical conclusions concerning the behavior of light signals and the motion of material bodies. Within a few short years, the Newtonian world view had spectacularly collapsed, taking with it the commonsense notion of time. This profound and far-reaching transformation was primarily due to the work of Einstein.

Einstein's theory of relativity introduced into physics a notion of time that is intrinsically flexible. Although it did not quite restore the ancient

mystical ideas of time as essentially personal and subjective, it did tie the experience of time firmly to the individual observer. No longer could one talk of *the* time—only my time and your time, depending on how we are moving. To use the catch phrase: *time is relative*.

Although Einstein's time remained subject to the strictures of physical law and mathematical regulation, the psychological effect of abolishing a universal time was dramatic. In the decades that followed Einstein's original work, scientists probed deeper and deeper into time's mysteries. Might different sorts of clocks measure different sorts of time? Is there a natural clock, or a measure of time, for the universe as a whole? Was there a beginning of time, and will there be an end? What is it that imprints on time a distinct directionality, a lopsidedness between past and future? What is the origin of our sense of the flux of time? Is time travel possible, and if so, how can the paradoxes associated with travel into the past be resolved? Remarkably, in spite of nearly a century of investigation, many of these questions have yet to be satisfactorily answered: the revolution started by Einstein remains unfinished. We still await a complete understanding of the nature of time.