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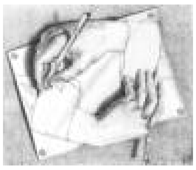
QUEST OF TIMES: UNIVERSAL CONCEPT?

Advanced Studies in Social and Cultural Anthropology Research Paper

- supervised by professor **Renaat Devisch** -



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Time is a natural means to prevent everything happening at the same time...

(anonymous graffito, quoted by Richard P. Feynman)

1. INTRODUCTION

TIME tamed by precise atomic clocks and mysterious feared Chronos swallowing his own children, old reliable absolute time and time madly changing its pace with mass and velocity, personal time and time of the universe, time of day and time of dreaming, time of harvest and time of famine, past time and time for sale, time of life and - eternity...

At the beginnings of the modern science time was no special category. It was mysterious, yet simple. Both in physics and in philosophy there was just one concept, symbolised by a straight Euclidean line. Time was infinitely divisible, constant in both speed and direction and absolutely causal. Physical discoveries of our century, however, particularly the impact of the relativistic physics and quantum theories brought about a drastic modification, or rather rebuilding, of the classical edifice of science. Time has appeared to be bound with space as its fourth dimension while space has showed to be just another feature of matter. Time has proved to be able to run faster or slower and even stop depending on amount of mass and speed. At the microphysics level it has become very possible that one can speak about certain units of time and causality is not a concrete law anymore for nuclear physicists.

Nobody in the history of humankind would ever have expected that these so much natural boundaries would once vanish, and maybe that's why the momentum of the classical concept of time still lingers. Perhaps except for cosmologists and physicists, the new concept of time did not penetrate into general awareness as a natural phenomenon and most of the other scientists as well as general public are reluctant to adopt the disappearance of the reliable golden old times.

But is it such a revolutionary approach, anyway? Should we present these findings, in an adequate form, to some non-western cultures, we would very likely encounter less bewilderment. Free from the command of clocks they sure have experienced, in one or another way, different speeds of time. Neither the hypothesis that past, present and future might be one is strange to them: for how many of them have already seen their dead parents in their dreams alive, laughing, talking and even threatening? Do we, perhaps out of some fears, create too many needless categories where there is just one? Is it possible - from an anthropological point of view - to propose a single, universal theory of time, or rather *times* embracing the complete range of intercultural social, economic, psychological, anthropological as well as physical, cosmological and philosophical time questions? And then, how would such an universal concept of times modify other anthropological concepts as change, cause, space, destiny, freedom, the particular vs. the general, a part vs. the whole, etc.? Yes, it is apparent that this article aims more at raising questions (although very physical sometimes, necessarily) than their answering. However, if pithy enough, good questions stimulate intellection and are vital and often the triggering prerequisites for brand new answers. And author hopes that questions contained in his paper are very good indeed. Alas, only *time* will show…

The research is drawn upon author's personal selection of magazine and newspaper articles on this topic, Internet sources, numerous books presenting viewpoints from different branches of science, e.g. anthropology, psychology, philosophy and theology, history, physics and cosmology, etc. and upon some university courses and lectures.

2. DEFINITIONS AND NOTIONS OF TIME

Very generally, we could say that time is *a measured or measurable period, a continuum that lacks spatial dimensions* (well, but time is actually not directly measurable). We could also say, that time is *the continuum of experience in which events pass from the future through the present to the past*, but it implies future experience or events existing in the future, a concept that is upheld by just one group of philosophers. Another definition says time is *the fourth co-ordinate that is required (along with three spatial dimensions) to specify a physical event (synonymous to fourth dimension)*, but it lacks all cultural meanings of time. If we say it is a *duration, considered independently of any system of measurement or any employment of terms which designate limited portions thereof*, we consider solely the ideal time that is barely approximated by clocks and the like. All of these and many other definitions are correct, of course, but none of them really captures all what time means for humans and the whole universe. Moreover, this variety introduces a lot of confusion.

The difficulty of defining time was one of the features that puzzled already the Platonist Augustine, in the 5th century AD, and most of the other philosophers. However, the contemporary philosophy of language sees no mystery in this task. Learning to handle the word *time* involves a multiplicity of verbal skills, including the ability to handle such connected words as *earlier, later, now, second,* and *hour*. These verbal skills have to be picked up in very complex ways, and it is not surprising that the meaning of the word *time* cannot be distilled into a neat verbal definition. See more in Chapter 9 (Time in Languages). [19] [6]

Time appears to be more puzzling than space because it seems to flow or pass, or else people seem to advance through it. But the passage or advance seems to be unintelligible. If we wanted to tell the possible time flow speed changes, then time would have to be compared to something else - to a sort of hypertime. But if this hypertime itself flows, then a hyper-hypertime is required, and so on, ad infinitum. Again, if the world is thought of as spread out in space-time, it might be asked whether human consciousness advances up a time-like direction of this world and, if so, how fast. And whether future events pop into existence as the *now* reaches them or are there all along. Plus, how such changes in space-time can be represented, since time is already within the picture. (Ordinary change can, of course, be represented in a space-time picture: for example, a particle at rest is represented by a straight line and an oscillating particle by a wavy line.)

In the face of these difficulties, philosophers tend to divide into two sorts: the *process philosophers* and the *philosophers of the manifold*. Process philosophers - such as Alfred North Whitehead, an Anglo-American metaphysician who died in 1947 - hold that the flow of time (or human advance through it) is an important metaphysical fact. Like the French intuitionist Henri Bergson, they may hold that this flow can be grasped only by non-rational intuition. Bergson even held that the scientific concept of time as a dimension actually misrepresents reality. The philosophers of the manifold hold that the flow of time, or human advance through time, is an illusion. They argue, for example, that words such as past, future, and now, as well as the tenses of verbs, are indexical expressions that refer to the act of their own utterance. Hence, the alleged change of an event from being future to being past is an illusion. To say that the event is future is to assert that it is later than this utterance; then later yet, when one says that it is in the past, he or she asserts that it is earlier than that other utterance. Past and future are not real predicates of events in this view; and change in respect of them is not a genuine change.

Again, although process philosophers think of the future as somehow open or indeterminate, whereas the past is unchangeable, fixed, determinate, philosophers of the manifold hold that it is as much nonsense to talk of changing the future as it is to talk of changing the past. If a person decides to point left rather than to point right, then pointing left is what the future was. Moreover, this thesis of the *determinateness* of the future, they argue, must not be confused with *determinism*.

Determinism is a theory that there are laws whereby later states of the universe may be deduced from earlier states, and vice versa. All events, including moral choices, are completely determined by previously existing causes that preclude free will and the possibility that humans could have acted otherwise. The theory holds that the universe is utterly rational because complete knowledge of any given situation assures that unerring knowledge of its future is also possible. Pierre-Simon, Marquis de Laplace, in the 18th century framed the classical formulation of this thesis. For him, the present state of the universe is the effect of its previous state and the cause of the state that follows it. If a mind, at any given moment, could know all of the forces operating in nature and the respective positions of all its components, it would thereby know with certainty the future and the past of every entity, large or small. The Persian poet Omar Khayyam expressed a similar deterministic view of the world in the concluding half of one of his quatrains: "And the first Morning of Creation wrote / What the Last Dawn of Reckoning shall read." *Indeterminism*, on the other hand, though not denying the influence of behavioural patterns and certain extrinsic forces on human actions, insists on the reality of free choice. Exponents of determinism strive to defend their theory as compatible with moral responsibility by saying, for example, that evil results of certain actions can be foreseen, and this in itself imposes moral responsibility and creates a deterrent external cause that can influence actions. [6]

The philosophy of the manifold is neutral about this issue. Future events may well exist and yet not be connected in a sufficiently law-like way with earlier ones.

3. PRE-SCIENTIFIC CONCEPTIONS OF TIME AND THEIR INFLUENCE

Since the onset of their minds humans have encountered the presence of time. Alternation of day and night, seasons, Moon phases, life cycles of all living creatures, were just some of the many incentives. At the origin of every observed phenomenon, some internal clocks start to measure periods of progress and decline up to destruction. Humans have always been alive to this merciless law, respecting and fearing it. In an effort to explore and master the nature, people have tried to order or even subjugate time as well, by creating time units, calendars and gods. [13]

The most well-known personified symbol of time used to be *Chronos* from the Greek pantheon, usually interchanged for god Kronos (or Saturn, in Latin), who was depicted by symbols of elusiveness - sandglass and scythe. Kronos swallowed his children, thereby symbolising continually originating and expiration of time. In ancient mysterious religions, Kronos, then called Aion, was the primeval god of the universe, progenitor of the world coming out of darkness, that created a silver primeval egg out of the ether. A guardian of time presence is common on many baroque clocks. Elusiveness of the flowing time was figured by his wings, brutal inevitability by scythe (which he used to emasculate primeval god Uranus, according to Hesiod's epic *Theogony*). [21]

3.1 Fundamental Views of Time in the Philosophy of History

The philosophy of time bears powerfully on human emotions. Not only do individuals regret the past, they also fear the future, not least because the alleged flow of time seems to be sweeping them toward their deaths. The irreversibility and inexorability of the passage of time is borne in on human beings by the fact of death. Unlike other living creatures, they know that their lives may be cut short at any moment and that, even if they attain the full expectation of human life, their growth is bound to be followed by eventual decay and, in due time, death.

Although there is no generally accepted evidence that death is not the conclusive end of life, it is a tenet of some religions (e.g., of Zoroastrianism, Judaism, Christianity, and Islam) that death is followed by everlasting life elsewhere - in sheol, hell, or heaven - and that eventually there will be a universal physical resurrection. Others (e.g., Buddhists, Orphics, Pythagorean, and Plato) have held that people are reborn in the time flow of life on Earth and that the notion that a human being has only one life on Earth is the illusion of a lost memory. The Buddha claimed to recollect all of his previous lives. The Greek philosophers Pythagoras and Empedocles, of the 6^{th} and early 5^{th} centuries BC, whose lives probably overlapped that of the Buddha, likewise claimed to recollect some of their previous lives. Such rebirths, they held, would continue to recur unless a person should succeed in breaking the vicious circle (releasing himself from the "sorrowful wheel") by strenuous ascetic performances.

The belief that a person's life in time on Earth is repetitive may have been an inference from the observed repetitiveness of phenomena in the environment. The day-and-night cycle and the annual cycle of the seasons dominated the conduct of human life until the recent harnessing of inanimate physical forces in the Industrial Revolution made it possible for work to be carried on for 24 hours a day throughout the year - under cover, by artificial light, and at a controlled temperature. There is also the generation cycle, which the Industrial Revolution has not suppressed: the generations still replace each other, in spite of the lengthening of life expectancies. In some societies, it has been customary to give a man's son a different name but to give his grandson the same name. To name father and son differently is an admission that generations change; but to name grandfather and grandson the same is perhaps an intimation that the grandson is the grandfather reincarnate. Thus, though every human being has the experience of irreversible change in his own life, he also observes cyclic change in his environment; hence the adherents of some religions and philosophies have inferred that, despite appearances, time flows cyclically for the individual human being, too.

The human experience and observation of time has been variously interpreted. Parmenides, an Italiote Greek (Eleatic) philosopher (6^{th} - 5^{th} century BC) and Zeno, his fellow townsman and disciple, held that change is logically inconceivable and that logic is a surer indicator of reality than experience; thus, despite appearances, reality is unitary and motionless. In this view, time is an illusion. The illusoriness of the world that "flows" in time is also to be found in some Indian philosophy. The Buddha and, among the Greeks, Plato and Plotinus, all held that life in the time flow, though not wholly illusory, is at best a low-grade condition by comparison, respectively, with the Buddhist Nirvana (in which desires are extinguished) and with the Platonic world of Ideas; i.e., of incorporeal timeless exemplars, of which phenomena in the time flow are imperfect and ephemeral copies.

It has been held, however - e.g., by disciples of the Greek philosopher Heracleitus - that the time flow is of the essence of reality. Others have held that life in the time flow, though it may be wretched, is nevertheless momentous; for it is here that a person decides his destiny. In the Buddhist view, a person's conduct in any one of his successive lives on Earth will increase or diminish his prospects of eventually breaking out of the cycle of recurrent births. For those who believe in only one earthly life, however, the momentousness of life in the time flow is still greater because this life will be followed by an everlasting life at a destination decided by conduct in this brief and painful testing time. The view that life in time on Earth is a probation for weal or woe in an everlasting future has often been associated - as it was by the Iranian prophet Zoroaster (c. 600 BC) - with a belief in a general judgement of all who have ever lived to be held on a common judgement day, which will be the end of time. The belief in an immediate individual judgement was also held in pharaonic Egypt. Both of these beliefs have later been adopted by Jews, Christians, and Muslims.

The foregoing diverse interpretations of the nature and significance of the individual human being's experience and observation of time differ sharply from each other. They have led to equally sharp differences in views of human history and of ultimate reality and in prescriptions for the conduct, both collective and individual, of human life. Thinkers have been divided between holders of the cyclic view and holders of the one-way view of time and between believers in the different prescriptions for the conduct of life that these differing views have suggested. Variations in the two basic views of time and in the corresponding codes of conduct have been among the salient characteristics distinguishing the principal civilisations and philosophies and higher religions that have appeared in history to date. [6]

3.1.1 Cyclic View of Time

The cyclic theory of time has been held in regard to the three fields of religion, of history (both human and cosmic), and of personal life. That this view arose from the observation of recurrences in the environment is most conspicuously seen in the field of religion. The observation of the generation cycle has been reflected in the cult of ancestors, important in Chinese religion and also in older civilizations and in pre-civilisational societies. The observation of the annual cycle of the seasons and its crucial effect on agriculture is reflected in a ceremony in which the emperor of China used to plow the first furrow of the current year; in the ceremonial opening of a breach in the dike of the Nile to let the annual floodwaters irrigate the land; and in the annual "sacred marriage," performed by a priest and priestess representing a god and goddess, which was deemed to ensure the continuing fertility of Babylonia. A cycle longer than that of the seasons is represented by the recurrent avatars (epiphanies, incarnate, on Earth) of the Hindu god Vishnu (Visnu) and in the corresponding series of buddhas and bodhisattvas (potential buddhas). Although the only historical Buddha was Siddhartha Gautama (6^{th} - 5^{th} century BC), in the mythology of the northern school of Buddhism (the Mahayana), the identity of the historical Buddha has been almost effaced by a long vista of putative buddhas extending through previous and future times.

In contrast to northern Buddhism and to Vaisnava Hinduism, Christianity holds that the incarnation of God in Jesus was a unique event; yet the rite of the Eucharist, in which Christ's self-sacrifice is held by Catholic and Eastern Orthodox Christians to be re-performed, is celebrated every day by thousands of priests, and the nature of this rite has suggested to some scholars that it originated in an annual festival at the culmination of the agricultural year. In this interpretation, the bread that is Christ's body and the wine that is his blood associate him with the annually dying gods Adonis, Osiris, and Attis - the divinities, inherent in the vital and vitalising power of the crops, who die in order that people may eat and drink and live. "Unless a grain of wheat falls into the earth and dies, it remains alone; but, if it dies, it bears much fruit" (John 12:24).

The cyclic view of history, both cosmic and human, has been prevalent among the Hindus and the pre-Christian Greeks, the Chinese, and the Aztecs. More recently, the cyclic view has gained adherents in modern Western society, although this civilisation was originally Christian - that is, was nurtured on a religion that sees time as a one-way flow and not as a cyclic one.

The Chinese, Hindus, and Greeks saw cosmic time as moving in an alternating rhythm, classically expressed in the Chinese concept of the alternation between Yin, the passive female principle, and Yang, the dynamic male principle. When either Yin or Yang goes to extremes, it overlaps the other principle, which is its correlative and complement in consequence of being its opposite. In the philosophy of Empedocles, an early Greek thinker, the equivalents of Yin and Yang were Love and Strife. Empedocles revolted against the denial of the reality of motion and plurality that was made by his Eleatic predecessors on the strength of mere logic. He broke up the Eleatics' motionless, and therefore timeless, unitary reality into a movement of four elements that were alternately harmonised by Love and set at variance by Strife. Empedocles' Love and Strife, like Yin and Yang, each overlapped the other when they had gone to extremes.

Plato translated Empedocles' concept from psychological into theistic terms. At the outset, in his view, the gods guide the cosmos, and they then leave it to its own devices. But when the cosmos, thus left to itself, has brought itself to the brink of disaster, the gods resume control at the 11th hour - and these two phases of its condition alternate with each other endlessly. The recurrence of alternating phases in which, at the darkest hour, catastrophe is averted by divine intervention is similarly an article of Vaisnava Hindu faith. In guessing the lengths of the recurrent aeons (*kalpas*), the Hindus arrived, intuitively, at figures of the magnitude of those reached by modern astronomers through meticulous observations and calculations. Similarly, the Aztecs of Mesoamerica rivalled modern Westerners and the Hindus in the scale on which they envisaged the flow of time, and they kept an astonishingly accurate time count by inventing a set of interlocking cycles of different wavelengths.

Plato and Aristotle took it for granted that human society, as well as the cosmos, has been, and will continue to be, wrecked and rehabilitated any number of times. This rhythm can be discerned, as a matter of historical fact, in the histories of the pharaonic Egyptian and of the Chinese civilizations during the three millennia that elapsed, in each of them, between its first political unification and its final disintegration. The prosperity that had been conferred on a peasant society by political unity and peace turned into adversity when the cost of large-scale administration and defence became too heavy for an unmechanised economy to bear. In each instance, the unified state then broke up - only to be reunited for the starting of another similar cycle. The Muslim historian Ibn Khaldun, writing in the 14th century AD, observed the same cyclic rhythm in the histories of the successive conquests of sedentary populations by pastoral nomads.

In the modern West, an Italian philosopher of history, Giambattista Vico, observed that the phases through which Western civilisation had passed had counterparts in the history of the antecedent Greco-Roman civilisation. Thanks to a subsequent increase in the number of civilizations known to Western students of cultural morphology, Oswald Spengler, a German philosopher of history, was able, in the early 20th century, to make a comparative study of civilizations over a much broader spectrum than that of Vico. The comparison of different civilizations or of successive periods of order and disorder in Chinese or in pharaonic Egyptian history implied, of course, that, in human affairs, recurrence is a reality.

The application of the cyclic view to the life of a human being in the hypothesis of rebirth was mentioned earlier. This hypothesis relaxes the anxiety about being annihilated through death by replacing it with a no less agonising anxiety about being condemned to a potentially endless series of rebirths. The strength of the reincarnationists' anxiety can be gauged by the severity of the self-mortification to which they resort to liberate themselves from the "sorrowful wheel." Among the peoples who have not believed in rebirth, the pharaonic Egyptians have taken the offensive against death and decay with the greatest determination: they embalmed corpses; they built colossal tombs; and, in the Book of the Dead, they provided instructions and spells for ensuring for that portion of the soul that did not hover around the sarcophagus an acquittal in the post-mortem judgement and an entry into a blissful life in another world. No other human society has succeeded in achieving this degree of indestructibility despite the ravages of time. [6]

3.1.2 One-way View of Time

When the flow of time is held to be not recurrent but one-way, it can be conceived of as having a beginning and perhaps an end. Some thinkers have felt that such limits can be imagined only if there is some timeless power that has set time going and intends or is set to stop it. A god who creates and then annihilates time, if he is held to be omnipotent, is often credited with having done this with a benevolent purpose that is being carried out according to plan. The omnipotent god's plan, in this view, governs the time flow and is made manifest to humans in progressive revelations through the prophets - from Abraham, by way of Moses, Isaiah, and Jesus, to the Prophet Muhammad.

This belief in salvational history has been derived by Islam and Christianity from Judaism and Zoroastrianism. Late in the 12th century, the Christian seer Joachim of Fiore saw this divinely ordained spiritual progress in the time flow as unfolding in a series of three ages - those of the Father, the Son, and the Spirit. Karl Jaspers, a 20th century Western philosopher, has discerned an "axis age" - i.e., a turning point in human history - in the 6th century BC, when Confucius, the Buddha, Zoroaster, Deutero-Isaiah, and Pythagoras were alive contemporaneously. If the "axis age" is extended backward in time to the original Isaiah's generation and forward to Muhammad's, it may perhaps be recognised as the age in which humans first sought to make direct contact with the ultimate spiritual reality behind phenomena instead of making such communication only indirectly through their non-human and social environments.

The belief in an omnipotent creator god, however, has been challenged. The creation of time, or of anything else, out of nothing is difficult to imagine; and, if God is not a creator but is merely a shaper, his power is limited by the intractability of the independent material with which he has had to work. Plato, in the Timaeus, conceived of God as being a non-omnipotent shaper and thus accounted for the manifest element of evil in phenomena. Marcion, a 2nd-century Christian heretic, inferred from the evil in phenomena that the creator was bad and held that a "stranger god" had come to redeem the bad creator's work at the benevolent stranger's cost. Zoroaster saw the phenomenal world as a battlefield between a bad god and a good one and saw time as the duration of this battle. Though he held that the good god was destined to be the victor, a god who needs to fight and win is not omnipotent. In an attenuated form, this evil adversary appears in the three Judaic religions as Satan.

Observation of historical phenomena suggests that, in spite of the manifestness of evil, there has been progress in the history of life on this planet, culminating in the emergence of humans who know themselves to be sinners yet feel themselves to be something better than inanimate matter. Charles Darwin, in his theory of the selection of mutations by the environment, sought to vindicate apparent progress in the organic realm without recourse to an extraneous god. In the history of Greek thought, the counterpart of such mutations was the swerving of atoms. After Empedocles had broken up the indivisible, motionless, and timeless reality of Parmenides and Zeno into four elements played upon alternately by Love and Strife, it was a short step for the Atomists of the 5th century BC, Leucippus and Democritus, to break up reality still further into an innumerable host of minute atoms moving in time through a vacuum. Granting that one single atom had once made a single slight swerve, the build-up of observed phenomena could be accounted for on Darwinian lines. Democritus' account of evolution survives in the fifth book of *De rerum natura*, written by a 1st-century-BC Roman poet, Lucretius. The credibility of both Democritus' and Darwin's accounts of evolution depends on the assumption that time is real and that its flow has been extraordinarily long.

Heracleitus had seen in phenomena a harmony of opposites in tension with each other and had concluded that War (i.e., Empedocles' Strife and the Chinese Yang) "is father of all and king of all." This vision of Strife as being the dominant and creative force is grimmer than that of Strife alternating on equal terms with Love and Yang with Yin. In the 19th-century West, Heracleitus' vision has been revived in the view of G. W. F. Hegel, a German Idealist, that progress occurs through a synthesis resulting from an encounter between a thesis and an antithesis. In political terms, Heracleitus' vision has reappeared in Karl Marx's concept of an encounter between the bourgeoisie and the proletariat and the emergence of a classless society without a government.

In the Zoroastrian and Jewish-Christian-Islamic vision of the time flow, time is destined to be consummated - as depicted luridly in the Revelation to John - in a terrifying climax. It has become apparent that history has been accelerating, and accumulated knowledge of the past has revealed, in retrospect, that the acceleration began about 30,000 years ago, with the transition from the Lower to the Upper Palaeolithic Period, and that it has taken successive "great leaps forward" with the invention of agriculture, with the dawn of civilisation, and with the progressive harnessing - within the last two centuries - of the titanic physical forces of inanimate nature. The approach of the climax foreseen intuitively by the prophets is being felt, and feared, as a coming event. Its imminence is, today, not an article of faith but a datum of observation and experience. [6]

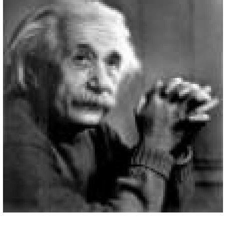
4. EARLY MODERN PHILOSOPHIES OF TIME

Isaac Newton distinguished absolute time from "relative, apparent, and common time" as measured by the apparent motions of the fixed stars, as well as by terrestrial clocks. His absolute time was an ideal scale of time that made the laws of mechanics simpler, and its discrepancy with apparent time was attributed to such things as irregularities in the motion of the Earth. Insofar as these motions were explained by Newton's mechanics (or at least could not be shown to be inexplicable), the procedure was vindicated. Similarly, in his notion of absolute space, Newton was really getting at the concept of an inertial system. Nevertheless, the notion of space and time as absolute metaphysical entities was encouraged by Newton's views and formed an important part of the philosophy of Immanuel Kant, a German critical philosopher, for whom space and time were "phenomenally real" (part of the world as described by science) but "noumenally unreal" (not a part of the unknowable world of things in themselves). (*Noumenon* = a posited object or event as it appears in itself independent of perception by the senses.) Kant argued for the noumenal unreality of space and time on the basis of certain antinomies that he claimed to find in these notions - that the universe had a beginning, for example, and yet (by another argument) could not have had a beginning. In a letter dated 1798, he wrote that the antinomies had been instrumental in arousing him from his "dogmatic slumber" (pre-critical philosophy). Modern advances in logic and mathematics, however, have convinced most philosophers that the antinomies contain fallacies.

Newtonian mechanics, as studied in the 18th century, was mostly concerned with periodic systems that, on a large scale, remain constant throughout time. Particularly notable was the proof of the stability of the solar system that was formulated by Pierre-Simon, marquis de Laplace, a mathematical astronomer. Interest in systems that develop through time came about in the 19th century as a result of the theories of the British geologist Sir Charles Lyell, and others, and the Darwinian theory of evolution. These theories led to a number of biologically inspired metaphysical systems, which were often - as with Henri Bergson and Alfred North Whitehead - rather romantic and contrary to the essentially mechanistic spirit of Darwin himself (and also of present-day molecular biology). [6]

5. TIME IN MODERN PHILOSOPHY OF PHYSICS

5.1 Time in the Theories of Relativity



Since the classic interpretation of Einstein's *special theory of relativity* by Hermann Minkowski, a Lithuanian-German mathematician, it has been clear that physics has to do not with two entities, space and time, taken separately, but with a unitary entity space-time, in which, however, time-like and space-like directions can be distinguished. The Lorentz transformations, which in special relativity define shifts in velocity perspectives, were shown by Minkowski to be simply rotations of space-time axes. The Lorentz contraction of moving rods and the time dilatation of moving clocks turns out to be analogous to the fact that different-sized slices of a sausage are obtained by altering the direction of the slice: just as there is still the objective (absolute) sausage, so also Minkowski restores the absolute to relativity in the form of the invariant four-dimensional object, and the invariance (under the Lorentz transformation) of the space-time interval and of certain fundamental physical quantities such as action (which has the dimensions of energy times time, even though neither energy nor time is separately invariant).

Process philosophers charge the Minkowski universe with being a static one. The philosopher of the manifold denies this charge, saying that a static universe would be one in which all temporal cross sections were exactly similar to one another and in which all particles (considered as four-dimensional objects) lay along parallel lines. The actual universe is not like this, and that it is not static is shown in the Minkowski picture by the dissimilarity of temporal cross sections and the non-parallelism of the world lines of particles. The process philosopher may say that change, as thus portrayed in the Minkowski picture (e.g., with the world lines of particles at varying distances from one another), is not true Bergsonian change, so that something has been left out. But if time advances up the manifold, this would seem to be an advance with respect to a hypertime, perhaps a new time direction orthogonal to the old one. Perhaps it could be a fifth dimension, as has been used in describing the de Sitter universe as a four-dimensional hyper-surface in a five-dimensional space. The question may be asked, however, what advantage such a hypertime could have for the process philosopher and whether there is process through hypertime. If there is, one would seem to need a hyper-hypertime, and so on to infinity. (The infinity of hypertimes was indeed postulated by John William Dunne, a British inventor and philosopher, but the remedy seems to be a desperate one.) And if no such regress into hypertimes is postulated, it may be asked whether the process philosopher would not find the five-dimensional universe as static as the four-dimensional one. The process philosopher may therefore adopt the expedient of Henri Bergson, saying that temporal process (the extra something that makes the difference between a static and a dynamic universe) just cannot be pictured spatially (whether one supposes four, five, or more dimensions). According to Bergson, it is something that just has to be intuited and cannot be grasped by discursive reason. The philosopher of the manifold will find this unintelligible and will in any case deny that anything dynamic has been left out of his world picture. This sort of impasse between process philosophers and philosophers of the manifold seems to be characteristic of the present-day state of philosophy.

The theory of relativity implies that simultaneity is relative to a frame of axes. If one frame of axes is moving relative to another, then events that are simultaneous relative to the first are not simultaneous relative to the second, and vice versa. This paradox leads to another difficulty for process philosophy over and above those noted earlier. Those who think that there is a continual coming into existence of events (as the present rushes onward into the future) can be asked: *Which present?* It therefore seems difficult to make a distinction between a real present (and perhaps past) as against an as-yet-unreal future. Philosophers of the manifold also urge that to talk of events becoming (coming into existence) is not easily intelligible. Enduring things and processes, in this view, can come into existence; but this simply means that as four-dimensional solids they have an earliest temporal cross section or time slice.

When talking in the fashion of Minkowski, it is advisable, according to philosophers of the manifold, to use tenseless verbs (such as the "equals" in "2 + 2 equals 4"). One can say that all parts of the four-dimensional world exist (in this tenseless sense). This is not, therefore, to say that they all exist now, nor does it mean that Minkowski events are "timeless." The tenseless verb merely refrains from dating events in relation to its own utterance. The power of the Minkowski representation is illustrated by its manner in dealing with the so-called clock paradox, which deals with two twins, Peter and Paul. Peter remains on Earth (regarded as at rest in an inertial system) while Paul is shot off in a rocket at half the velocity of light, rapidly decelerated at Alpha Centauri (about four light-years away), and shot back to Earth again at the same speed. Assuming that the period of turnabout is negligible compared with those of uniform velocity, Paul, as a four-dimensional object, lies along the sides AC and CB of a space-time triangle, in which A and B are the points of his departure and return and C that of his turnaround. Peter, as a four-dimensional object, lies along AB. Now, special relativity implies that on his return Paul will be rather more than two years younger than Peter. This is a matter of two sides of a triangle not being equal to the third side: AC + CB < AB. The "less than" - symbolised < - arises from the semi-Euclidean character of Minkowski space-time, which calls for minus signs in its metric (or expression for the interval between two events, which is $ds = c^2dt^2 - dx^2 - dy^2 - dz^2$). The paradox has been held to result from the fact that, from Paul's point of view, it is Peter who has gone off and returned; and so the situation is symmetrical, and Peter and Paul should each be younger than the other - which is impossible. This is to forget, however, the asymmetry reflected in the fact that Peter has been in only one inertial system throughout, and Paul has not; Paul lies along a bent line, Peter along a straight one.

In the *general theory of relativity*, which, though less firmly established than the special theory, is intended to explain gravitational phenomena, a more complicated metric of variable curvature is employed, which approximates to the Minkowski metric in empty space far from material bodies. Cosmologists who have based their theories on general relativity have sometimes postulated a finite but unbounded space-time (analogous, in four dimensions, to the surface of a sphere) as far as space-like directions are concerned, but practically all cosmologists have assumed that space-time is infinite in its time-like directions. Kurt Gödel, a contemporary mathematical logician, however, has proposed solutions to the equations of general relativity whereby time-like world lines can bend back on themselves. Unless one accepts a process philosophy and thinks of the flow of time as going around and around such closed time-like world lines, it is not necessary to think that Gödel's idea implies eternal recurrence. Events can be arranged in a circle and still occur only once.

The general theory of relativity predicts a time dilatation in a gravitational field, so that, relative to someone outside of the field, clocks (or atomic processes) go slowly. This retardation is a consequence of the curvature of space-time with which the theory identifies the gravitational field. As a very rough analogy, a road may be considered that, after crossing a plain, goes over a mountain. Clearly, one mile as measured on the humpbacked surface of the mountain is less than one mile as measured horizontally. Similarly - if "less" is replaced by "more" because of the negative signs in the expression for the metric of space-time - one second as measured in the curved region of space-time is more than one second as measured in a flat region. Strange things can happen if the gravitational field is very intense. It has been deduced that so-called black holes in space may occur in places where extraordinarily massive or dense aggregates of matter exist, as in the gravitational collapse of a star. Nothing, not even radiation, can emerge from such a black hole. A critical point is the so-called Schwarzschild radius measured outward from the centre of the collapsed star - a distance, perhaps, of the order of 10 kilometres. Something falling into the hole would take an infinite time to reach this critical radius, according to the space-time frame of reference of a distant observer, but only a finite time in the frame of reference of the falling body itself. From the outside standpoint the fall has become frozen. But from the point of view of the frame of the falling object, the fall continues to zero radius in a very short time indeed - of the order of only 10 or 100 microseconds. Within the black hole space-like and time-like directions change over, so that to escape again from the black hole is impossible for reasons analogous to those that, in ordinary space-time, make it impossible to travel faster than light. (To travel faster than light a body would have to lie - as a four-dimensional object - in a space-like direction instead of a time-like one.)

As a rough analogy two country roads may be considered, both of which go at first in a northerly direction. But road A bends round asymptotically toward the east; i.e., it approaches ever closer to a line of latitude. Soon road B crosses this latitude and is thus to the north of all parts of road A. Disregarding the Earth's curvature, it takes infinite space for road A to get as far north as that latitude on road B; i.e., near that latitude an infinite number of "road A northerly units" (say, miles) correspond to a finite number of road B units. Soon road B gets "beyond infinity" in road A units, though it need be only a finite road. Rather similarly, if a body should fall into a black hole, it would fall for only a finite time, even though it were "beyond infinite" time by external standards. This analogy does not do justice, however, to the real situation in the black hole - the fact that the curvature becomes infinite as the star collapses toward a point. It should, however, help to alleviate the mystery of how a finite time in one reference frame can go "beyond infinity" in another frame.

Most cosmological theories imply that the universe is expanding, with the galaxies receding from one another (as is made plausible by observations of the red shifts of their spectra), and that the universe as it is known originated in a primeval explosion at a date of the order of 15 x 10^9 years ago. Though this date is often loosely called "the creation of the universe," there is no reason to deny that the universe (in the philosophical sense of "everything that there is") existed at an earlier time, even though it may be impossible to know anything of what happened then. (There have been cosmologies, however, that suggest an oscillating universe, with explosion, expansion, contraction, explosion, etc., ad infinitum.) And a fortiori, there is no need to say - as Augustine did in his Confessions as early as the 5th century AD - that time itself was created along with the creation of the universe, though it should not too hastily be assumed that this would lead to absurdity, because common sense could well be misleading at this point.

A British cosmologist, E. A. Milne, however, proposed a theory according to which time in a sense could not extend backward beyond the creation time. According to him there are two scales of time, "t time" and "t time." The former is a time scale within which the laws of mechanics and gravitation are invariant, and the latter is a scale within which those of electromagnetic and atomic phenomena are invariant. According to Milne t is proportional to the logarithm of t (taking the zero of t to be the creation time); thus, by t time the creation is infinitely far in the past. The logarithmic relationship implies that the constant of gravitation G would increase throughout cosmic history. (This increase might have been expected to show up in certain geological data, but apparently the evidence is against it.) [6]

5.2 Time in Microphysics

The behaviour of matter and radiation on the atomic scale often seems peculiar, and the consequences of quantum theory are accordingly difficult to understand and to believe. Its concepts frequently conflict with common-sense notions derived from observations of the everyday world. There is no reason, however, why the behaviour of the atomic world should conform to that of the familiar, large-scale world. It is important to realise that quantum mechanics is a branch of physics and that the business of physics is to describe and account for the way the world - on both the large and the small scale - actually is and not how one imagines it or would like it to be. In quantum mechanics and in particle interactions, there also arise very special problems related to time.

In quantum mechanics, it is usual to represent measurable quantities by operators in an abstract many-dimensional (often infinite-dimensional) so-called Hilbert space. Nevertheless, this space is an abstract mathematical tool for calculating the evolution in time of the energy levels of systems - and this evolution occurs in ordinary space-time. There may be something unusual, however, about the concept of the time at which quantum-mechanical events occur, because according to the Copenhagen interpretation of quantum mechanics the state of a microsystem is relative to an experimental arrangement. Thus energy and time are conjugate: no experimental arrangement can determine both simultaneously, for the energy is relative to one experimental arrangement, and the time is relative to another. (Thus, a more relational sense of time is suggested.) The states of the experimental arrangement cannot be merely relative to other experimental arrangements, on pain of infinite regress; and so these have to be described by classical physics. (This parasitism on classical physics is a possible weakness in quantum mechanics over which there is much controversy.)

The relation between time uncertainty and energy uncertainty, has led to estimates of the theoretical minimum measurable span of time, which comes to something of the order of 10^{-24} second and hence to speculations that time may be made up of discrete intervals (chronons). These suggestions are open to a very serious objection, viz., that the mathematics of quantum mechanics makes use of continuous space and time (for example, it contains differential equations). It is not easy to see how it could possibly be recast so as to postulate only a discrete space-time (or even a merely dense one). For a set of instants to be dense, there must be an instant between any two instants. For it to be a continuum, however, something more is required, viz., that every set of instants earlier (later) than any given one should have an upper (lower) bound. It is continuity that enables modern mathematics to surmount the paradox of extension framed by the Pre-Socratic Eleatic Zeno - a paradox comprising the question of how a finite interval can be made up of dimensionless points or instants. [6]

5.3 Time in Molar Physics

Until recently it was thought that the fundamental laws of nature are time symmetrical. It is true that the second law of thermodynamics, according to which randomness always increases, is time asymmetrical; but this law is not strictly true (for example, the phenomenon of Brownian motion contravenes it), and it is now regarded as a statistical derivative of the fundamental laws together with certain boundary conditions. The fundamental laws of physics were long thought also to be charge symmetrical (for example, an antiproton together with a positron behave like a proton and electron) and to be symmetrical with respect to parity (reflection in space, as in a mirror). The experimental evidence now suggests that all three symmetries are not quite exact but that the laws of nature are symmetrical if all three reflections are combined: charge, parity, and time reflections forming what can be called (after the initials of the three parameters) a CPT mirror. The time asymmetry was shown in certain abstruse experiments concerning the decay of K mesons that have a short time decay into two pions and a long time decay into three pions.

These violations of temporal symmetry in the fundamental laws of nature are such out-of-the-way ones, however, that it seems unlikely that they are responsible for the gross violations of temporal symmetry that are apparent in the visible world. An obvious asymmetry is that there are traces of the past (footprints, fossils, tape recordings, memories) and not of the future. There are mixing processes but no comparable unmixing process: milk and tea easily combine to give a whitish brown liquid, but it requires ingenuity and energy and complicated apparatus to separate the two liquids. A cold saucepan of water on a hot brick will soon become a tepid saucepan on a tepid brick; but the heat energy of the tepid saucepan never goes into the tepid brick to produce a cold saucepan and a hot brick. Even though the laws of nature are assumed to be time symmetrical, it is possible to explain these asymmetries by means of suitable assumptions about boundary conditions. Much discussion of this problem has stemmed from the work of Ludwig Boltzmann, an Austrian physicist, who showed that the concept of the thermodynamic quantity entropy could be reduced to that of randomness or disorder. Among 20th-century philosophers in this tradition may be mentioned Hans Reichenbach, a German-U.S. Positivist, Adolf Grünbaum, a U.S. philosopher, and Olivier Costa de Beauregard, a French philosopher-physicist. There have also been many relevant papers of high mathematical sophistication scattered through the literature of mathematical physics. Reichenbach (and Grünbaum, who improved on Reichenbach in some respects) explained a trace as being a branch system; i.e., a relatively isolated system, the entropy of which is less than would be expected if one compared it with that of the surrounding region. For example, a footprint on the beach has sand particles compressed together below a volume containing air only, instead of being quite evenly (randomly) spread over the volume occupied by the compressed and empty parts.

Another striking temporal asymmetry on the macro level, viz., that spherical waves are often observed being emitted from a source but never contracting to a sink, has been stressed by Sir Karl Popper, a 20th-century Austrian and British philosopher of science. By considering radiation as having a particle aspect (i.e., as consisting of photons), Costa de Beauregard has argued that this "principle of retarded waves" can be reduced to the statistical Boltzmann principle of increasing entropy and so is not really different from the previously discussed asymmetry. These considerations also provide some justification for the common-sense idea that the cause-effect relation is a temporally unidirectional one, even though the laws of nature themselves allow for retrodiction no less than for prediction.

A third striking asymmetry on the macro level is that of the apparent mutual recession of the galaxies, which can plausibly be deduced from the red shifts observed in their spectra. It is still not clear whether or how far this asymmetry can be reduced to the two asymmetries already discussed, though interesting suggestions have been made.

The statistical considerations that explain temporal asymmetry apply only to large assemblages of particles. Hence, any device that records time intervals will have to be macroscopic and to make use somewhere of statistically irreversible processes. Even if one were to count the swings of a frictionless pendulum, this counting would require memory traces in the brain, which would function as a temporally irreversible recording device. [6]

6. TIME MEASUREMENT: SCALES, CLOCKS & DEVIATIONS

Accuracy in specifying time is vital for civil, industrial, and scientific purposes. Although defining time presents difficulties, measuring it does not. Actually, it is the most accurately measured physical quantity. A time measurement assigns a unique number to either an epoch, which specifies the moment when an instantaneous event occurs, in the sense of time of day, or a time interval, which is the duration of a continued event. The progress of any phenomenon that undergoes regular changes may be used to measure time. Such phenomena make up much of the subject matter of astronomy, physics, chemistry, geology, and biology. The following sections of this chapter treat time measurements based on manifestations of gravitation, electromagnetism, rotational inertia, and radioactivity. Although reading some of the paragraphs might tempt us to believe that precise and universal time are terms that are understandable only to a few scientists, the modern Guardians of Time or Chronoses, they are irreplaceable in the current discussion and search for unified times, and in justifying the claim mentioned in the conclusive chapter, that today's everyday world is ruled by a time concept devised from natural phenomena, not by an obscurant Middle Age papal root concept.

Series of events can be referred to a time scale, which is an ordered set of times derived from observations of some phenomenon. Two independent, fundamental time scales are those called *dynamical* (evolved from *rotational time*) - based on the regularity of the motions of celestial bodies fixed in their orbits by gravitation - and *atomic* - based on the characteristic frequency of electromagnetic radiation emitted or absorbed in quantum transitions between internal energy states of atoms or molecules. Two time scales that have no relative secular acceleration are called equivalent. That is, a clock displaying the time according to one of these scales would not - over an extended interval - show a change in its rate relative to that of a clock displaying time according to the other scale. It is not certain whether the dynamical and atomic scales are equivalent, but present definitions treat them as being so.

The decay of radioactive elements is a random, rather than a repetitive, process, but the statistical reliability of the time required for the disappearance of any given fraction of a particular element can be used for measuring long time intervals (r*adiometric time*). [6]

6.1 Rotational Time

The Earth's daily rotation about its own axis provides a time scale, but one that is not equivalent to the fundamental scales because tidal friction inexorably decreases the Earth's rotational speed (symbolised by the Greek letter omega, ?). There are also other sources of variation. *Rotational time* is needed for civil purposes, celestial navigation, and tracking of space vehicles.

The Earth's rotation causes the stars and the Sun to appear to rise each day in the east and set in the west. The *apparent solar day* is measured by the interval of time between two successive passages of the Sun across the observer's celestial meridian, the visible half of the great circle that passes through the zenith and the celestial poles. One *sidereal day* (very nearly) is measured by the interval of time between two similar passages of a star. The plane in which the Earth revolves about the Sun is called the ecliptic. As seen from the Earth, the Sun moves eastward on the ecliptic 360 per year, almost one degree per day. As a result, an apparent solar day is nearly four minutes longer, on the average, than a sidereal day. The difference varies, however, from 3 minutes 35 seconds to 4 minutes 26 seconds during the year because of the ellipticity of the Earth's orbit, in which at different times of the year it moves at slightly different rates, and because of the 23 1/2 inclination of the ecliptic to the Equator. In consequence, apparent solar time is non-uniform with respect to dynamical time. A sundial indicates apparent solar time. The introduction of clocks and watches during the 17^{th} century made apparent solar time unsuitable for civil use. Therefore, *mean solar time* was introduced; it is defined below. The difference between apparent solar time and mean solar time, called the equation of time, varies from zero to about 16 minutes. The measures of sidereal, apparent solar, and mean solar time are defined by the hour angles of certain points, real or fictitious, in the sky. Hour angle is the angle, taken to be positive to the west, measured along the celestial equator between an observer's meridian and the hour circle (a great circle passing through the poles) on which some celestial point or object lies. Hour angles are measured from zero through 24 hours.

Local mean solar time depends upon longitude; it is advanced by four minutes per degree eastward. *Time zones* were adopted by U.S. and Canadian railroads in 1883. In October 1884 an international conference held in Washington, D.C., adopted the meridian of the transit instrument at the Royal Observatory, Greenwich, as the prime, or zero, meridian. This led to the adoption of 24 standard time zones; the boundaries are determined by local authorities and in many places deviate considerably from the 15º intervals of longitude implicit in the original idea. The times in different zones differ by an integral number of hours; minutes and seconds are the same. The International Date Line is a zigzag line in the mid-Pacific Ocean near 180º longitude. When one travels across it westward a calendar day is added; one day is dropped in passing eastward. During World War I, *daylight-saving time* was adopted in various countries; clocks were advanced one hour to save fuel by reducing the need for artificial light in evening hours. During World War II, all clocks in the United States were kept one hour ahead of standard time for the interval Feb. 9, 1942-Sept. 30, 1945, with no changes made in summer. Beginning in 1967, by act of Congress, the United States has observed daylight-saving time in summer, though state legislatures retain the power to pass exempting laws, and a few have done so. The day begins at midnight and runs through 24 hours. In the *24-hour system* of reckoning, used in Europe and by military agencies of the United States, the hours and minutes are given as a four-digit number. Thus 0028 means 28 minutes past midnight, and 1240 means 40 minutes past noon. Also, 2400 of May 15 is the same as 0000 of May 16. This system allows no uncertainty as to the epoch designated. In the 12-hour system there are two sets of 12 hours; those from midnight to noon are designated AM (ante meridiem, "before noon"), and those from noon to midnight are designated PM (post meridiem, "after noon"). The use of AM and PM to designate either noon or midnight can cause ambiguity. To designate noon, either the word noon or 1200 or 12 M should be used. To designate midnight without causing ambiguity, the two dates between which it falls should be given unless the 24-hour notation is used. Thus, midnight may be written: May 15-16 or 2400 May 15 or 0000 May 16.

Until 1928 the standard time of the zero meridian was called *Greenwich Mean Time* (GMT), and in accord with astronomical tradition the epoch 0000 GMT occurred at noon. In 1925 the numbering system was changed so that the day began at midnight, as does the civil day. To alleviate the resulting confusion, in 1928 the International Astronomical Union (IAU) adopted the term *Universal Time* (UT). In 1955 the IAU defined several kinds of UT. The initial values of Universal Time obtained at various observatories, denoted UT0, differ slightly because of polar motion. A correction is added for each observatory to convert UT0 into UT1. An empirical correction to take account of annual changes in the speed of rotation is then added to convert UT1 to UT2. UT2 has since been superseded by atomic time. Precise values of UT1, which give the Earth's rotational position in space, are derived by the Bureau International de l'Heure (BIH) from values determined at about 75 observatories.

The Earth does not rotate with perfect uniformity, and the variations have been classified as (1) secular, resulting from tidal friction, (2) irregular, ascribed to motions of the Earth's core, and (3) periodic, caused by seasonal meteorological phenomena. Separating the first two categories is very difficult. Observations made since 1621, after the introduction of the telescope, show irregular fluctuations about a decade in duration and a long one that began about 1650 and is not yet complete. The large amplitude of this effect makes it impossible to determine the secular variation from data accumulated during an interval of only about four centuries. The record is supplemented, however, by reports - not always reliable - of eclipses that occurred tens of centuries ago. From this extended set of information it is found that, relative to dynamical time, the length of the mean solar day increases secularly about 1.6 milliseconds per century, the rate of the Earth's rotation decreases about one part per million in 5,000 years, and rotational time loses about 30 seconds per century squared. The annual seasonal term, nearly periodic, has a coefficient of about 25 milliseconds.

The time and frequency broadcasts of the United Kingdom and the United States were co-ordinated (synchronised) in 1960. As required, adjustments were made in frequency, relative to atomic time, and in epoch to keep the broadcast signals close to the UT scale. This program expanded in 1964 under the auspices of the IAU into a world-wide system called *Coordinated Universal Time* (UTC). Since Jan. 1, 1972, the UTC frequency has been the TAI frequency, the difference between TAI and UTC has been kept at some integral number of seconds (as of 1 January 1999, for example, TAI was ahead of UTC by 32 seconds [28]), and the difference between UT1 and UTC has been kept within 0.9 second by inserting a leap second into UTC as needed. Synchronisation is achieved by making the last minute of June or December contain 61 (or, possibly, 59) seconds. About one leap second per year has been inserted since 1972. Estimates of the loss per year of UT1 relative to TAI owing to tidal friction range from 0.7 second in 1900 to 1.3 seconds in 2000. Irregular fluctuations cause unpredictable gains or losses; these have not exceeded 0.3 second per year. [6]

6.2 Dynamical Time

Dynamical time is defined descriptively as the independent variable, T, in the differential equations of motion of celestial bodies. The gravitational ephemeris of a planet tabulates its orbital position for values of T. Observation of the position of the planet makes it possible to consult the ephemeris and find the corresponding dynamical time.

A large fluctuation in the Earth's rotational speed, ?, began about 1896, and its effects on the apparent motions of both the Moon and Mercury were described by the Scottish-born astronomer Robert T. A. Innes in 1925. Innes proposed a time scale based on the motion of the Moon, and his scale of ?t from 1677 to 1924, based on observations of Mercury, was the first true dynamical scale, later called *Ephemeris Time*. Further studies by the Dutch astronomer Willem de Sitter in 1927 and by Harold Spencer Jones (later Sir Harold, Astronomer Royal of England) in 1939 confirmed that ? had secular and irregular variations. Using their results, the U.S. astronomer Gerald M. Clemence in 1948 derived the equations needed to define a dynamical scale numerically and to convert measurements of the Moon's position into time values. The fundamental definition was based on the Earth's orbital motion as given by Newcomb's tables of the Sun of 1898. The IAU adopted the dynamical scale in 1952 and called it Ephemeris Time (ET). Clemence's equations were used to revise the lunar ephemeris published in 1919 by the American mathematician Ernest W. Brown to form the *Improved Lunar Ephemeris* (ILE) of 1954.

The IAU in 1958 defined the *second of Ephemeris Time* as 1/31,556,925.9747 of the tropical year that began at the instant specified, in astronomers' terms, as 1900 January 0d 12h, "the instant, near the beginning of the calendar year AD 1900, when the geocentric mean longitude of the Sun was 279 41' 48.04 " - that is, Greenwich noon on Dec. 31, 1899. In 1960 the General Conference of Weights and Measures (CGPM) adopted the same definition for the *SI second*. Since, however, 1900 was past, this definition could not be used to obtain the ET or SI second. It was obtained in practice from lunar observations and the ILE and was the basis of the redefinition, in 1967, of the SI second on the atomic time scale. The present SI second thus depends directly on the ILE. The ET second defined by the ILE is based in a complex manner on observations made up to 1938 of the Sun, the Moon, Mercury, and Venus, referred to the variable, mean solar time. Observations show that the ET second equals the average mean solar second from 1750 to 1903.

In 1976 the IAU defined two scales for dynamical theories and ephemerides to be used in almanacs beginning in 1984. *Barycentric Dynamical Time* (TDB) is the independent variable in the equations, including terms for relativity, of motion of the celestial bodies. The solution of these equations gives the rectangular co-ordinates of those bodies relative to the barycentre (centre of mass) of the solar system. (The barycentre does not coincide with the centre of the Sun but is displaced to a point near its surface in the direction of Jupiter.) Which theory of general relativity to use was not specified, so a family of TDB scales could be formed, but the differences in co-ordinates would be small. Terrestrial Dynamical Time (TDT) is an auxiliary scale defined by the equation TDT = TAI + 32.184 s. Its unit is the SI second. The constant difference between TDT and TAI makes TDT continuous with ET for periods before TAI was defined (mid-1955). TDT is the time entry in apparent geocentric ephemerides. The definitions adopted require that TDT = TDB - R, where R is the sum of the periodic, relativistic terms not included in TAI. Both the above equations for TDT can be valid only if dynamical and atomic times are equivalent. For use in almanacs the barycentric co-ordinates of the Earth and a body at epoch TDB are transformed into the co-ordinates of the body as viewed from the centre of the Earth at the epoch TDT when a light ray from the body would arrive there. Almanacs tabulate these geocentric co-ordinates for equal intervals of TDT; since TDT is available immediately from TAI, comparisons between computed and observed positions are readily made. Publishing the principal ephemerides in The Astronomical Almanac (since 1st January, 1984), involve simultaneous numerical integration of the equations of motion of the Sun, the Moon, and the planets. The co-ordinates and velocities at a known time are based on very accurate distance measurements (made with the aid of radar, laser beams, and spacecraft), optical angular observations, and atomic clocks. [6]

6.3 Atomic Time

The *atomic* clock is the only object that both generates a precise *time scale* and tells time. It has made possible new, highly accurate techniques for measuring time and distance. These techniques, involving radar, lasers, spacecraft, radio telescopes, and pulsars, have been applied to the study of problems in celestial mechanics, astrophysics, relativity, and cosmogony. Atomic clocks serve as the basis of scientific and legal clock times. A single clock, atomic or quartz crystal, synchronised with either TAI or UTC provides the SI second (that is, the second as defined in the International System of Units), TAI, UTC, and TDT immediately with very high accuracy.

Transitions between two states differing in energy in many atoms and molecules involve sharply defined frequencies in the vicinity of 10^{10} hertz, and, after dependable methods of generating such frequencies were developed during World War II for microwave radar, they were applied to problems of timekeeping. In 1946, principles of the use of atomic and molecular transitions for regulating the frequency of electronic oscillators were described, and in 1947 an oscillator controlled by a quantum transition of the ammonia molecule was constructed. An ammonia-controlled clock was built in 1949 at the National Bureau of Standards, Washington, D.C.. In this clock the frequency did not vary by more than one part in 10^8. In 1954 an ammonia-regulated oscillator of even higher precision - the first maser - was constructed. In 1938 the so-called resonance technique of manipulating a beam of atoms or molecules was introduced. This technique was adopted in several attempts to construct a caesium-beam atomic clock, and in 1955 the first such clock was placed in operation at the National Physical Laboratory, Teddington, Eng. In practice, the most accurate control of frequency is achieved by detecting the interaction of radiation with atoms that can undergo some selected transition. Between 1955 and 1958 the National Physical Laboratory and the U.S. Naval Observatory conducted a joint experiment to determine the frequency maintained by the caesium-beam clock at Teddington in terms of the ephemeris second, as established by precise observations of the Moon from Washington, D.C. The radiation associated with the particular transition of the caesium-133 atom was found to have the fundamental frequency of 9,192,631,770 cycles per second of Ephemeris Time. The merits of the caesium-beam atomic clock are that (1) the fundamental frequency that governs its operation is invariant; (2) its fractional error is extremely small; and (3) it is convenient to use. Several thousand commercially built caesium clocks, weighing about 70 pounds (32 kilograms) each, have been placed in operation. A few laboratories have built large caesium-beam oscillators and clocks to serve as primary standards of frequency.

Clocks regulated by hydrogen masers have been developed at Harvard University. The frequency of some masers has been kept stable within about one part in 10^{14} for intervals of a few hours. The uncertainty in the fundamental frequency, however, is greater than the stability of the clock; this frequency is approximately 1,420,405,751.77 Hz. Atomic-beam clocks controlled by a transition of the rubidium atom have been developed, but the operational frequency depends on details of the structure of the clock, so that it does not have the absolute precision of the caesium-beam clock.

The CGPM redefined the second in 1967 to equal 9,192,631,770 periods of the radiation emitted or absorbed in the hyperfine transition of the caesium-133 atom; that is, the transition selected for control of the caesium-beam clock developed at the National Physical Laboratory. The definition implies that the atom should be in the unperturbed state at sea level. It makes the SI second equal to the ET second, determined from measurements of the position of the Moon, within the errors of observation. The definition will not be changed by any additional astronomical determinations. An atomic time scale designated A.1, based on the caesium frequency discussed above, had been formed in 1958 at the U.S. Naval Observatory. Other local scales were formed, and about 1960 the BIH (Bureau International de l'Heure) formed a scale based on these. In 1971 the CGPM (General Conference of Weights and Measures) designated the BIH scale as International Atomic Time (TAI). The long-term frequency of TAI is based on about six caesium standards, operated continuously or periodically. About 175 commercially made caesium clocks are used also to form the day-to-day TAI scale. These clocks and standards are located at about 30 laboratories and observatories. It is estimated that the second of TAI reproduces the SI second, as defined, within about one part in 10^{13}. Two clocks that differ in rate by this amount would change in epoch by three milliseconds in 1,000 years.

Accuracies of atomic clocks and modern observational techniques are so high that the small differences between classical mechanics (as developed by Newton in the 17^{th} century) and relativistic mechanics (according to the special and general theories of relativity proposed by Einstein in the early 20^{th} century) must be taken into account. The equations of motion that define TDB include relativistic terms. The atomic clocks that form TAI, however, are corrected only for height above sea level, not for periodic relativistic variations, because all fixed terrestrial clocks are affected identically. However, because of the consequences of Einstein's special theory of relativity, TAI and TDT differ from TDB by calculable periodic variations. Also apparent positions of celestial objects, as tabulated in ephemerides, are corrected for the Sun's gravitational deflection of light rays. Moreover, as it has been suggested by E. A. Milne, Paul A.M. Dirac, and others, the coefficient G in Newton's equation for the gravitational force might not be constant. Searches for a secular change in G have been made by studying accelerations of the Moon and reflections of radar signals from Mercury, Venus, and Mars. The effects sought are small compared with observational errors, however, and it is not certain whether G is changing or whether dynamical and atomic times have a relative secular acceleration.

A clock displaying TAI on Earth will have periodic, relativistic deviations from the dynamical scale TDB and from a pulsar time scale PS (see below). These variations, denoted R above, were demonstrated in 1982-84 by measurements of the pulsar PSR 1937+21. The main contributions to R result from the continuous changes in the Earth's speed and distance from the Sun. These cause variations in the transverse Doppler effect and in the red shift due to the Sun's gravitational potential. The frequency of TAI is higher at aphelion (about July 3) than at perihelion (about January 4) by about 6.6 parts in 10^{10}, and TAI is more advanced in epoch by about 3.3 milliseconds on October 1 than on April 1. By Einstein's theory of general relativity a photon produced near the Earth's surface should be higher in frequency by 1.09 parts in 10^{16} for each metre above sea level. In 1960 the U.S. physicists Robert V. Pound and Glen A. Rebka measured the difference between the frequencies of photons produced at different elevations and found that it agreed very closely with what was predicted. The primary standards used to form the frequency of TAI are corrected for height above sea level. Two-way, round-the-world flights of atomic clocks in 1971 produced changes in clock epochs that agreed well with the predictions of special and general relativity. The results have been cited as proof that the gravitational red shift in the frequency of a photon is produced when the photon is formed, as predicted by Einstein, and not later, as the photon moves in a gravitational field. In effect, gravitational potential is a perturbation that lowers the energy of a quantum state.

Precise time and frequency are broadcast by radio in many countries. Transmissions of time signals began as an aid to navigation in 1904, but now they are widely used for many scientific and technical purposes. The seconds pulses are emitted on Coordinated Universal Time, and the frequency of the carrier wave is maintained at some known multiple of the caesium frequency. The accuracy of the signals varies from about one millisecond for high-frequency broadcasts to one microsecond for the precisely timed pulses transmitted by the stations of the navigation system loran-C. Trigger pulses of television broadcasts provide accurate synchronisation for some areas. When precise synchronisation is available, a quartz-crystal clock suffices to maintain TAI accurately. Caesium clocks carried aboard aircraft are used to synchronise clocks around the world within about 0.5 microsecond. Since 1962 artificial satellites have been used similarly for widely separated clocks. [6]

6.4 Pulsar Time

A scale that possibly brings about a more universal and precise time measurement is the *pulsar time scale*. Pulsars, rapidly rotating neutron stars whose magnetic and rotational axes do not coincide, emit sharp pulses of radiation, at a short period P, detectable by radio telescopes. The emission of radiation and energetic subatomic particles causes the spin rate to decrease and the period to increase. $\underline{P}$, the rate of increase in P, is essentially constant, but sudden changes in the period of some pulsars have been observed. Although pulsars are sometimes called clocks, they do not tell time. The times at which their pulses reach a radio telescope are measured relative to TAI, and values of P and $\underline{P}$ are derived from these times. A time scale formed directly from the arrival times would have a secular deceleration with respect to TAI, but if P for an initial TAI and $\underline{P}$ (assumed constant) are obtained from a set of observations, then a pulsar time scale, PS, can be formed such that d, the difference between TAI and PS, contains only periodic and irregular variations. PS remains valid as long as no sudden change in P occurs.

It is the variations in d, allowing comparisons of time scales based on very different processes at widely separated locations, that make pulsars extremely valuable. The chief variations are periodic, caused by motions of the Earth. These motions bring about (1) relativistic variations in TAI and (2) variations in distance, and therefore pulse travel time, from pulsar to telescope. Observations of the pulsar PSR 1937+21, corrected for the second effect, confirmed the existence of the first. Residuals (unexplained variations) in d averaged one microsecond for 30 minutes of observation. This pulsar has the highest rotational speed of any known pulsar, 642 rotations per second. Its period P is 1.55 milliseconds, increasing at the rate $\underline{P}$ of 3.3×10^{-12} second per year; the speed decreases by one part per million in 500 years. Continued observations of such fast pulsars should make it possible to determine the orbital position of the Earth more accurately. These results would provide more accurate data concerning the perturbations of the Earth's motion by the major planets; these in turn would permit closer estimates of the masses of those planets. Residual periodic variations in d, not due to the sources already mentioned, might indicate gravitational waves. Irregular variations could provide data on starquakes and inhomogeneities in the interstellar medium. [6]

6.5 Radiometric Time

Yet another way of measuring time is the radiometric one. Contrary to the scales discussed above, *radiometric time* is less precise, but allows to measure very long time periods with a satisfying precision. Atomic nuclei of a radioactive element decay spontaneously, producing other elements and isotopes until a stable species is formed. The life span of a single atom may have any value, but a statistical quantity, the half-life of a macroscopic sample, can be measured; this is the time in which one-half of the sample disintegrates. The age of a rock, for example, can be determined by measuring ratios of the parent element and its decay products. The decay of uranium to lead was first used to measure long intervals, but the decays of potassium to argon and of rubidium to strontium are more frequently used now. Ages of the oldest rocks found on the Earth are about 3.5×10^9 years. Those of lunar rocks and meteorites are about 4.5×10^9 years, a value believed to be near the age of the Earth. Radiocarbon dating provides ages of formerly living matter within a range of 500 to 50,000 years. While an organism is living, its body contains about one atom of radioactive carbon-14, formed in the atmosphere by the action of cosmic rays, for every 10^{12} atoms of stable carbon-12. When the organism dies, it stops exchanging carbon with the atmosphere, and the ratio of carbon-14 to carbon-12 begins to decrease with the half-life of 5,730 years. Measurement of this ratio determines the age of the specimen. [6]

7. TIME IN BIOLOGY

Organisms often have some sort of *internal clock* that regulates their behaviour. There is a tendency, for example, for leaves of leguminous plants to alter their position so that they lie in one position by day and in another position by night. This tendency persists if the plant is in artificial light that is kept constant, though it can be modified to other periodicities (e.g., to a six-hour instead of a 24-hour rhythm) by suitably regulating the periods of artificial light and darkness. In animals, similar daily rhythms are usually acquired, but in experimental conditions animals nevertheless tend to adapt better to a 24-hour rhythm than to any other. Sea anemones expand and contract to the rhythm of the tides, and this periodic behaviour will persist for some time even when the sea anemone is placed in a tank. Bees can be trained to come for food at fixed periods (e.g., every 21 hours), and this demonstrates that they possess some sort of internal clock. Similarly, humans themselves have some power to estimate time in the absence of clocks and other sensory cues. This fact refutes the contention of the 17th-century English philosopher John Locke (and of other philosophers in the Empiricist tradition) that time is perceived only as a relation between successive sensations. The U.S. mathematician Norbert Wiener has speculated on the possibility that the human time sense depends on the a-rhythm of electrical oscillation in the brain. Temporal rhythms in both plants and animals (including humans) are dependent on temperature, and experiments on human subjects have shown that, if their temperature is raised, they underestimate the time between events. Despite these facts, the Lockean notion that the estimation of time depends on the succession of sensations is still to some degree true. People who take the drugs hashish and mescaline, for example, may feel their sensations following one another much more rapidly. Because there are so many more sensations than normal in a given interval of time, time seems to drag, so that a minute may feel like an hour. Similar illusions about the spans of time occur in dreams. It is unclear whether most discussions of so-called biological and psychological time have much significance for metaphysics. As far as the distorted experiences of time that arise through drugs (and in schizophrenia) are concerned, it can be argued that there is nothing surprising in the fact that pathological states can make people misestimate periods of time, and so it can be claimed that facts of this sort do not shed any more light on the philosophy of time than facts about mountains looking near after rainstorms and looking far after duststorms shed on the philosophy of space. [6]

8. TIME IN PSYCHOLOGY

Time perception in psychology is defined as an experience or awareness of the passage of time. The human experience of change is complex. One primary element clearly is that of a succession of events, but distinguishable events are separated by more or less lengthy intervals that are called durations. Thus, sequence and duration are fundamental aspects of what is perceived in change. Manifestly, duration is relative to the events people isolate in the sequences through which they live: the duration of a kiss, of a meal, of a trip. A given interval always can be subdivided into a sequential chain delimiting briefer durations, as with the regular units that provide empirical measures of time: the second, the day, the year. Indeed, human experience is not simply that of one single series of events, but of a plurality of overlapping changes. The duration of a radio program, for example, can combine with that of a breakfast, both being inserted within the longer period of an ocean voyage.

Humans seem to be unable to live without some concept of time. Ancient philosophies sought to relate the concept of time to some objective reality to which it would correspond. René Descartes (1596-1650) inaugurated a critical era of philosophy by stressing the ancient problem of the origin of ideas, including the idea of time. Immanuel Kant (1724-1804), providing a radical answer to the epistemological problem of time, wrote that we do not appreciate time objectively as a physical thing; that it is simply a pure form of sensible intuition. Other philosophers of the 18th and 19th centuries sought to explain the notion of time as arising from association and memory of successive perceptions. A move to empirical psychology emerged with the growth of research on the introspective data of experience. From about mid-19th century, under the influence of the psychophysical notions of Gustav Theodor Fechner, psychologists conducted experiments to study the relationship between time as perceived and time as measured in physics. Their work with adults gradually spread to the study of children and of animals. The psychologists then broadened their investigations of time to cover all forms of adaptation to sequence and duration.

The idea that psychological studies of temporal experience are philosophically important is probably connected with the sort of Empiricism that was characteristic of Locke and still more of the Empiricists George Berkeley and David Hume and their successors. The idea of time had somehow to be constructed out of the primitive experience of ideas succeeding one another. Nowadays, concept formation is thought of as more of a social phenomenon involved in the "picking up" of a language; thus, contemporary philosophers have tended to see the problem differently: humans do not have to construct their concepts from their own immediate sensations. Even so, the learning of temporal concepts surely does at least involve an immediate apprehension of the relation of "earlier" and "later." A mere succession of sensations, however, will go no way toward yielding the idea of time: if one sensation has vanished entirely before the other is in consciousness, one cannot be immediately aware of the succession of sensations. What Empiricism needs, therefore, as a basis for constructing the idea of time is an experience of succession as opposed to a succession of experiences. Hence, two or more ideas that are related by "earlier than" must be experienced in one single act of awareness. William James, a U.S. Pragmatist philosopher and also a pioneer psychologist, popularised the term *specious present* for the span of time covered by a single act of awareness. His idea was that at a given moment of time a person is aware of events a short time before that time. (Sometimes he spoke of the specious present as a saddleback looking slightly into the future as well as slightly into the past, but this was inconsistent with his idea that the specious present depended on lingering short-term memory processes in the brain.) He referred to experiments by the German psychologist Wilhelm Wundt that showed that the longest group of arbitrary sounds that a person could identify without error lasted about six seconds. Other criteria perhaps involving other sense modalities might lead to slightly different spans of time, but the interesting point is that, if there is such a specious present, it cannot be explained solely by ordinary memory traces: if one hears a "ticktock" of a clock, the "tick" is not remembered in the way in which a "ticktock" 10 minutes ago is remembered. The specious present is perhaps not really specious: the idea that it was specious depended on an idea that the real (non-specious) present had to be instantaneous. If perception is considered as a certain reliable way of being caused to have true beliefs about the environment by sensory stimulation, there is no need to suppose that these true beliefs have to be about an instantaneous state of the world. It can therefore be questioned whether the term specious is a happy one.

Two matters discussed earlier in connection with the philosophy of physics have implications for the philosophy of mind: (1) the integration of space and time in the theory of relativity makes it harder to conceive of immaterial minds that exist in time but are not even localisable in space; (2) the statistical explanation of temporal asymmetry explains why the brain has memory traces of the past but not of the future and, hence, helps to explain the unidirectional nature of temporal consciousness. It also gives reasons for scepticism about the claims of parapsychologists to have experimental evidence for precognition; or it shows, at least, that if these phenomena do exist they are not able to be fitted into a cosmology based on physics as it exists today. [6]

9. TIME IN LANGUAGES

Time in language grammar, i.e. tense, is a verbal category relating the time of a narrated event to the time of the speech event. In many languages the concept of time is expressed not by the verb but by other parts of speech (temporal adverbials or even nouns, for example). Time is frequently perceived as a continuum with three main divisions: past, present, and future. The past and future times are defined in relation to the present time (now). Past tense refers to any time before the present time, and future tense refers to any time after the present. Not all languages perceive this relationship as a linear one, nor do these categories characterise all possible times. Tense, then, is a grammatical expression of time reference. The correlation between tense and time is not necessarily one-to-one; languages do not recognise as many oppositions of tense as they have conceptions of time. English has past, present, and future times, but only a past and a nonpast opposition of tense.

For example: (*past*) “John ate lasagna”, (*present*) “John is eating lasagna”, (*future*) “John will eat lasagna”. Grammatical tense may not equal real time: “The flight is leaving at 5:00 PM”, “That will be $5.00, please” (at a grocery check-out line). In the first sentence, the verb form that usually indicates present time is here used to indicate future time. In the second sentence, the verb form usually indicating future time is here used to indicate present time. The past form of the verb generally refers to past time, to a narrated event prior to the speech event. In other languages the category of tense may express other oppositions, such as proximate versus nonproximate, now versus not now, etc. In English, however, the grammatical category of tense relates to the ontological concept of time in a binary opposition: past versus nonpast. Nonpast tense is considered "unmarked" for tense and thus can comprise present, future and even past times. With the exception of some problematic modal constructions - such as would in "John said he would go tomorrow," in which would is grammatically a past tense of will but is used to indicate future time - the past tense indicates only past time and is thus said to be "marked" with respect to tense. Other grammatical categories, such as mood and aspect, may add another dimension to the time reference, further specifying the action as definite or indefinite, completed or not completed, lasting or nonlasting. [6]

In English language, it is interesting, that the word *time* itself is akin to *tide*, one of the most common natural time-like phenomena. It can be used in a number of ways, e.g.:
1. (a) the measured or measurable period during which an action, process, or condition exists or continues, (b) (duration) a nonspatial continuum that is measured in terms of events which succeed one another from past through present to future, (c) (leisure) (time for reading);
2. the point or period when something occurs (occasion);
3. (a) an appointed, fixed, or customary moment or hour for something to happen, begin, or end (arrived ahead of time), (b) an opportune or suitable moment (decided it was time to retire), often used in the phrase about time (about time for a change);
4. (a) an historical period (age), (b) a division of geologic chronology, (c) conditions at present or at some specified period - usually used in plural (times are hard) (move with the times), (d) the present time (issues of the time);
5. (a) lifetime, (b) a period of apprenticeship, (c) a term of military service, (d) a prison sentence
6. season (very hot for this time of year);
7. (a) rate of speed (tempo), (b) the grouping of the beats of music (rhythm);
8. (a) a moment, hour, day, or year as indicated by a clock or calendar (what time is it), (b) any of various systems (as sidereal or solar) of reckoning time;
9. (a) one of a series of recurring instances or repeated actions (you've been told many times), (b) plural (1) added or accumulated quantities or instances (five times greater), (2) equal fractional parts of which an indicated number equal a comparatively greater quantity (seven times smaller) (three times closer), (c) turn (three times at bat);
10. finite as contrasted with infinite duration;
11. a person's experience during a specified period or on a particular occasion (a good time) (a hard time);
12. (a) the hours or days required to be occupied by one's work (make up time) (on company time), (b) an hourly pay rate (straight time), (c) wages paid at discharge or resignation (pick up your time and get out);
13. (a) the playing time of a game, (b) time-out
14. a period during which something is used or available for use (computer time)

Examples of some expressions using the word time:
- *at the same time* = nevertheless, yet (slick and at the same time strangely unprofessional);
- *at times* = at intervals, occasionally;
- *for the time being* = for the present;
- *from time to time* = once in a while, occasionally;
- *in no time* = very quickly or soon;
- *in time* = (1) sufficiently early, (2) eventually, (3) in correct tempo (learn to play in time);
- *on time* = (1) (a) at the appointed time, (b) on schedule, (2) on the instalment plan;
- *time and again* = frequently, repeatedly.

Time can be borrowed (an uncertain and usually uncontrolled postponement of something inevitable), wasted or saved, bought (to delay an imminent action or decision), called (to ask for or grant a time-out), cut (in music), hung (in sport), passed (to exchange greetings or engage in pleasant conversation), taken (to be leisurely about doing something), killed (by doing nothing particular), etc., it can fly, flow, run, and even stop or linger, it can be hard or happy, easy, etc. [19] [14] It is justified to claim that the equivalents of the word "time" are used in a multitude of ways in all languages. However, the actual usage, expressions and meanings will differ from culture to culture, reflecting the very local version of the cultural meaning of time.

10. TIME IN VARIOUS MYTHOLOGIES

The apparent regularity of the heavenly bodies long impressed every society. The sky was seized as the very image of transcendence, and what seemed to be the orderly course of Sun, Moon, and stars suggested a time that transcended man's - in short, eternity. Many myths and mythological images concern themselves with the relationship between eternity and time on earth. The number four for the number of world ages figures most frequently. The Zoroastrians of ancient Persia knew of a complete world age of 12,000 years, divided into four periods of 3,000 each, at the end of which Ormazd (Wise Lord) would conquer Ahriman (Destructive Spirit). Similarly, the Book of Daniel (in the Old Testament) mentions four kingdoms - of gold, silver, bronze, and a mixture of iron and clay, respectively - after which God will establish an everlasting kingdom. The notion of four world ages, sometimes associated with metals, occurs also in the works of classical writers and in later speculative writings on human history. Judaism developed the view of a 1,000-year period between the four world ages and the everlasting kingdom (hence the words millennium and millenarian). Although other numbers occur (three, six, seven, 12, and 72), four is dominant. In ancient Mexico this world was held to be preceded by four other worlds. India, in both Hindu and Buddhist texts, has developed the most complex system of world ages and worlds that arise and come to an end. Here, too, the number four is important - e.g., the four ages (*yugas*) of decreasing length and increasing evil. Many writings, often with large numbers, reflect exact astronomical observations and calculations. Some mythologies - e.g., those of the Maya in Central America - have developed sophisticated views interrelating time and space. Time was an all-important element of Maya cosmology. The priest-astronomers viewed time as a majestic succession of cycles without beginning or end. All the time periods were considered as gods; time itself was believed to be divine. Mythological accounts of repetitions of worlds after their destruction occur not only in India but also elsewhere, such as in Orphism and in the Stoic philosophy that flourished in classical antiquity. [22] [6]

11. CROSS-CULTURAL TIME UNITS AND CALENDARS

11.1 Principles and Ancient Systems

The basic unit of computation in a calendar is the day, and although days are now measured from midnight to midnight this has not always been so. Astronomers, for instance, from about the 2nd century AD until 1925 counted days from noon to noon. In earlier civilizations and among primitive peoples, where there was less communication between different settlements or groups, different methods of reckoning the day presented no difficulties. Most primitive tribes used a dawn-to-dawn reckoning, calling a succession of days so many dawns, or suns. Later, the Babylonians, Jews, and Greeks counted a day from sunset to sunset, whereas the day was said to begin at dawn for the Hindus and Egyptians and at midnight for the Romans. The Teutons counted nights, and from them the grouping of 14 days called a fortnight is derived.

There was also great variety in the ways in which the day was subdivided. In Babylonia, for example, the astronomical day was divided differently than the civil day, which, as in other ancient cultures, was composed of "watches." The length of the watches was not constant but varied with the season, the day watches being the longer in summer and the night watches in the winter. Such seasonal variations in divisions of the day, now called seasonal or temporal hours, became customary in antiquity because they corresponded to the length of the Sun's time above the horizon, at maximum in summer and at minimum in winter. Only with the advent of mechanical clocks in western Europe at the end of the 13th century did seasonal (unequal) hours become inconvenient.

Most early Western civilizations used 24 seasonal hours in the day - 12 hours of daylight and 12 of darkness. This was the practice of the Greeks, the Sumerians and Babylonians, the Egyptians, and the Romans, and of Western Christendom so far as civil reckoning was concerned. The church adopted its own canonical hours for reckoning daily worship: there were seven of these--matins, prime, terce, sext, none, vespers, and compline - but in secular affairs the system of 24 hours held sway. This number, 2 x 12, or 24, was derived in

Babylonia from the Sumerian sexagesimal method of reckoning, based on gradations of 60 (5 x 12 = 60) rather than on multiples of 10. In Babylonia, for most purposes, both daylight and night were divided into three equal watches, and each watch was subdivided into half- and quarter-watches. Babylonian astronomers, perhaps in preference to the variable civil system, divided every day into 12 equal units, called *beru*, each of which was subdivided into 30 *gesh*. The oldest known astronomical texts are from the Old Babylonian period, but this dual system may be attributable to earlier Sumerian society.

Once the day is divided into parts, the next task is to gather numbers of days into groups. Among primitive peoples, it was common to count moons (months) rather than days, but later a period shorter than the month was thought more convenient, and an interval between market days was adopted. In West Africa some tribes used a four-day interval; in central Asia five days was customary; the Assyrians adopted five days and the Egyptians, 10 days, whereas the Babylonians attached significance to the days of the lunation that were multiples of seven. In ancient Rome, markets were held at eight-day intervals; because of the Roman method of inclusive numeration, the market day was denoted *nundinae* ("ninth-day") and the eight-day week, an *inter nundium.* The seven-day week may owe its origin partly to the four (approximately) seven-day phases of the Moon and partly to the Babylonian belief in the sacredness of the number seven, which was probably related to the seven planets. Moreover, by the 1st century BC the Jewish seven-day week seems to have been adopted throughout the Roman world, and this influenced Christendom. The names in English of the days of the week are derived from Latin or Anglo-Saxon names of gods.

The month is based on the lunation, that period in which the Moon completes a cycle of its phases. The period lasts approximately 29 1/2 days, and it is easy to recognise and short enough for the days to be counted without using large numbers. In addition, it is very close to the average menstrual period of women and also to the duration of cyclic behaviour in some marine creatures. Thus, the month possessed great significance and was often the governing period for religious observances, of which the dating of Easter is a notable example. Most early calendars were, essentially, collections of months, the Babylonians using 29- and 30-day periods alternately, the Egyptians fixing the duration of all months at 30 days, with the Greeks copying them, and the Romans in the Julian calendar having a rather more complex system using one 28-day period with the others of either 30 or 31 days.

The month is not suitable for determining the seasons, for these are a solar, not a lunar, phenomenon. Seasons vary in different parts of the world - in tropical countries there are just the rainy and dry periods, but elsewhere there are successions of wider changes. In Egypt the annual flooding of the Nile was followed by seeding and then harvest, and three seasons were recognized; but in Greece and other more northern countries there was a succession of four seasons of slightly different lengths. However many there seemed to be, it was everywhere recognized that seasons were related to the Sun and that they could be determined from solar observations. These might consist of noting the varying length of the midday shadow cast by a stick thrust vertically into the ground or follow the far more sophisticated procedure of deducing from nocturnal observations the Sun's position against the background of the stars. In either case the result was a year of 365 days, a period incompatible with the 29 1/2-day lunation. To find some simple relationship between the two periods was the problem that faced all calendar makers from Babylonian times onward. The lunisolar calendar, in which months are lunar but years are solar - that is, are brought into line with the course of the Sun - was used in the early civilizations of the whole Middle East, except Egypt, and in Greece. The formula was probably invented in Mesopotamia in the 3rd millennium BC. Study of cuneiform tablets found in this region facilitates tracing the development of time reckoning back to the 27th century BC, near the invention of writing. The evidence shows that the calendar is a contrivance for dividing the flow of time into units that suit society's current needs. Though calendar makers put to use time signs offered by nature - the Moon's phases, for example - they rearranged reality to make it fit society's constructions.

A number of non-astronomical natural signs have also been used in determining the seasons. In the Mediterranean area, such indications change rapidly, and Hesiod (c. 800 BC) mentions a wide variety: the cry of migrating cranes, which indicated a time for plowing and sowing; the time when snails climb up plants, after which digging in vineyards should cease; and so on. An unwitting approximation to the tropical year may also be obtained by intercalation, using a simple lunar calendar and observations of animal behaviour. Such an unusual situation has grown up among the Yami fishermen of Botel-Tobago Island, near Taiwan. They use a calendar based on phases of the Moon, and some time about March (the precise date depends on the degree of error of their lunar calendar compared with the tropical year) they go out in boats with lighted flares. If flying fish appear, the fishing season is allowed to commence, but if the lunar calendar is too far out of step with the seasons, the flying fish will not rise. Fishing is then postponed for another lunation, which they insert in the lunar calendar, thus having a year of 13 instead of the usual 12 lunations. [6]

There has been much research devoted to calendar systems of the ancient civilisations, and religious and ethnic groups. The most important ones include Babylonian, Persian (Iranian) and other calendars used in the ancient Near East, the Egyptian calendar, the Greek calendars, the early Roman calendar, the Jewish calendar, the Muslim calendar. In the Far East, the most important ones are Hindu and Chinese calendars, in the Americas the Mayan calendar, Mexican (Aztec) calendar, Peruvian Inca calendar and North American Indians time counts. There are many more peculiar time systems among the Amazon Indians, in African cultures, in the Central Asian and Siberian ethnic groups, in the Pacific island cultures, etc.

11.2 Western Systems

The familiar subdivision of the day into 24 hours, the hour into 60 minutes, and the minute into 60 seconds is of ancient origins but has come into general use since about AD 1600. When the increasing accuracy of clocks led to the adoption of the mean solar day, which contained 86,400 seconds, this mean solar second became the basic unit of time. The adoption of the SI second, defined on the basis of atomic phenomena, as the fundamental time unit has necessitated some changes in the definitions of other terms. In this chapter, unless otherwise indicated, second (symbolised *s*) means the SI second; a minute (*m* or *min*) is 60 s; an hour (*h*) is 60 m or 3,600 s. An astronomical day (*d*) equals 86,400 s. An ordinary calendar day equals 86,400 s, and a leap-second calendar day equals 86,401 s. A common year contains 365 calendar days and a leap year, 366.

Calendar is a term used for any system for dividing time over extended periods, such as days, months, or years, and arranging such divisions in a definite order. A calendric system is essential for regulating the basic affairs of civil life - e.g., agricultural, business, and domestic - and for reckoning time for religious observances and scientific purposes. There are several standard units common to virtually all calendric systems.

The *day* is the fundamental unit of computation in any calendar. It is to some extent a natural division of time, since it is based on the length of time required for a celestial body to turn once on its axis (especially the period of the Earth's rotation), but its subdivision into a number of equal intervals of, for example, 24 *hours* is purely artificial. The sidereal day is the time required for the Earth to rotate once relative to the background of the stars - i.e., the time between two observed passages of a star over the same meridian of longitude. The apparent solar day is the time between two successive transits of the Sun over the same meridian. Because the orbital motion of the Earth makes the Sun seem to move slightly eastward each day relative to the stars, the solar day is about four minutes longer than the sidereal day; i.e., the mean solar day is 24 hours 3 minutes 56.555 seconds of mean sidereal time; more usually the sidereal day is expressed in terms of solar time, being 23 hours 56 minutes 4 seconds of mean solar time long. The mean solar day is the average value of the solar day, which changes slightly in length during the year as Earth's speed in its orbit varies. The solar day is the fundamental unit of time in both astronomical practice and civil life. It begins at midnight and runs through 24 hours, until the next midnight. A day is commonly divided into two sets of 12 hours for ordinary timekeeping purposes; those hours from midnight to noon are designated Am (ante meridiem, "before noon"), and those from noon to midnight are designated Pm (post meridiem, "after noon"). In law the word day, unless qualified, means the 24 hours between midnight and midnight, rather than the daylight hours between sunrise and sunset.

The *week*, too, is an artificial division of time and cannot be correlated with any astronomical or natural phenomena except insofar as it is a closed cycle of days. The seven-day week that is now universally used may have been derived from the mystical significance attached to the number seven. Support for this view may perhaps be derived from the use of the names of gods and goddesses for each of the days. The origin of the term is generally associated with the ancient Jews and the biblical account of the Creation, according to which God laboured for six days and rested on the seventh. Evidence indicates, however, that the Jews may have borrowed the idea of the week from Mesopotamia, for the Sumerians and the Babylonians divided the year into weeks of seven days each, one of which they designated a day of recreation. The Babylonians named each of the days after one of the five planetary bodies known to them and after the Sun and the Moon, a custom later adopted by the Romans. For a time the Romans used a period of eight days in civil practice, but in AD 321 Emperor Constantine established the seven-day week in the Roman calendar and designated Sunday as the first day of the week. Subsequent days bore the names Moon's-day, Mars's-day, Mercury's-day, Jupiter's-day, Venus'-day, and Saturn's-day. Constantine, a convert to Christianity, decreed that Sunday should be a day of rest and worship. The days assigned by the Romans to the Sun, Moon, and Saturn were retained for the corresponding days of the week in English (Sunday, Monday, and Saturday) and several related languages. The other weekday names in English are derived from Anglo-Saxon words for the gods of Teutonic mythology. Tuesday comes from *Tiu*, or *Tiw*, the Anglo-Saxon name for Tyr, the Norse god of war. Tyr was one of the sons of Odin, or Woden, the supreme deity after whom Wednesday was named. Similarly, Thursday originates from Thor's-day, named in honour of Thor, the god of thunder. Friday was derived from Frigg's-day, Frigg, the wife of Odin, representing love and beauty, in Norse mythology.

The *month* is a calendric period derived from lunation, the time interval in which the Moon revolves once around the Earth. As the earliest adopted of the longer calendar periods, it had a significance in ancient religious observance. This period, known as the *synodic month*, or complete cycle of phases of the Moon as seen from Earth (from New Moon to New Moon), averages 29.530588 mean solar days in length (i.e., 29 days 12 hours 44 minutes 3 seconds). Because of perturbations in the Moon's orbit, the lengths of all astronomical months vary slightly. The *sidereal month* is the time needed for the Moon to return to the same place against the background of the stars, 27.321661 days (i.e., 27 days 7 hours 43 minutes 12 seconds); the difference between synodic and sidereal lengths is due to the orbital movement of the Earth-Moon system around the Sun. The *tropical month*, 27.321582 days (i.e., 27 days 7 hours 43 minutes 5 seconds), only 7 seconds shorter than the sidereal month, is the time between passages of the Moon through the same celestial longitude. The *draconic*, or *nodical*, *month* of 27.212220 days (i.e., 27 days 5 hours 5 minutes 35.8 seconds) is the time between the Moon's passages through the same node, or intersection of its orbit with the ecliptic, the apparent pathway of the Sun. As a calendrical period, the month is derived from the lunation - i.e., the time elapsing between successive new moons (or other phases of the moon). A total of 12 lunations amounts to 354 days and is, roughly, a year. A period of 12 lunations was therefore used by some primitive peoples to make their calendrical year. As is obvious, the lunar-based year (and a calendar derived from it) cannot be accurately correlated with a solar-based year, and the month's continued use in the Gregorian calendar of modern times is merely a recognition of its convenience as a calendar division. Common *calendar month* may contain 28 to 31 calendar days; the average is 30.437.

The *year* is based on the length of time it takes the Earth to orbit the Sun. There are several ways to measure this period, but the most common is the *tropical year*, which is the interval between successive passages of the Sun through the vernal equinox. Because the Earth's motion is perturbed by the gravitational attraction of the other planets and because of an acceleration in precession, the tropical year decreases slowly, as shown by comparing its length at the end of the 19th century (365.242196 d) with that at the end of the 20th (365.242190 d). The year thus computed consists of 365.242199 *mean solar days*, i.e., 365 days 5 hours 48 minutes 46 seconds. (The mean solar day is the average interval between two passages of the Sun across the meridian.) Unfortunately, the tropical year and the synodic month are incommensurable: 12 lunations come to 354.36706 days, almost 11 days less than a tropical year. In addition, neither the tropical year nor the synodic month is evenly divisible by the length of the day. Therefore, to compile or maintain any calendar that keeps in step with the Moon's phases or with the seasons, it is necessary to insert days at appropriate intervals. These extra days are known as intercalations. The most familiar example of an intercalation is the additional day given to February every fourth year - i.e., leap year.

The origin of the calendric system in general use today can be traced back to the *Roman republican calendar*, which is thought to have been introduced by the fifth king of Rome, Tarquinius Priscus (616-579 BC). Although somewhat similar in style to the dating system of the ancient Greeks, this calendar was more likely derived from an earlier Roman calendar--a lunar calendric system of 10 months--that supposedly was devised about 738 BC by Romulus, traditionally the founder of Rome. The Roman republican calendar consisted of 12 months with a total of 355 days. Like its model, it was basically a lunar system, short by 10 1/4 days of the 365 1/4-day tropical year. To keep it in step with the seasons, a special month was supposed to be intercalated between February 23 and 24 once every two years; but because of negligence and political interference, the intercalations were made irregularly. As a result, by 46 BC the calendar had become so hopelessly confused that Julius Caesar was forced to initiate a reform of the entire system. Caesar invited the Alexandrian astronomer Sosigenes to undertake this task. Sosigenes suggested abandoning the lunar system altogether and replacing it with a tropical year of 365 1/4 days. Further, to correct the accumulation of previous errors, a total of 90 intercalary days had to be added to 46 BC, meaning that January 1, 45 BC, occurred in what would have been the middle of March. To prevent the problem from recurring, Sosigenes suggested that an extra day be added to every fourth February. The adoption of such reformatory measures resulted in the establishment of the *Julian calendar*, which was used for roughly the next 1,600 years. The system of consecutively numbering the years of the Christian Era was devised by Dionysius Exiguus in about 525; it included the reckoning of dates as either AD or BC (the year before AD 1 was 1 BC).

In the course of time, the disagreement between the Julian year of 365.25 days and the tropical year of 365.242199 gradually produced significant errors. The discrepancy mounted at the rate of 11 minutes 14 seconds per year until it was a full 10 days in 1545, when the Council of Trent authorised Pope Paul III to take corrective action. No solution was found for many years. In 1572 Pope Gregory XIII agreed to issue a papal bull drawn up by the Jesuit astronomer Christopher Clavius. Ten years later (1582), when the edict was finally proclaimed, 10 days in October were skipped to bring the calendar back in line. The length of the year was redefined as 365.2422 days, a difference of 0.0078 days per year from the Julian count, which produced a discrepancy between them amounting to 3.12 days every 400 years. Clavius had allowed for such a discrepancy in his suggestion that three out of every four centennial years, which would ordinarily be leap years, should be regarded as common years instead. This led to the practice that no centennial year could be a leap year unless it was divisible by 400. Following this rule, 1700, 1800, and 1900 were common years, but 2000 would be a leap year. These reform measures gave rise to an extremely accurate calendric system; the difference between the Gregorian calendar year and the solar year was less than half a minute. The Gregorian calendar, firmly establishing January 1 as the beginning of its year, was widely referred to as the New Style calendar, with the Julian known as the Old Style calendar.

Although the Gregorian calendar is used throughout much of the world today, it was not immediately accepted everywhere. Most of the Roman Catholic states adopted the improved dating system by 1587. Some Protestant states embraced it around the beginning of the 18th century, but a number of others, such as Great Britain and its colonies, did not do so until the 1750s. Japan, China, and Russia, to name only a few, adopted the Gregorian rules much later. A few dating systems besides the Gregorian calendar still remain in use. The Muslim calendar, for example, has been retained by most Arab countries, while the traditional Hindu and Jewish calendars continue to be used for religious purposes. Besides, astronomers continued to use a sort of Julian calendar: Julian year denotes an interval of 365.25 d, or 31,557,600 s. The corresponding Julian century equals 36,525 d. For convenience in specifying events separated by long intervals, astronomers use Julian dates (JD) in accordance with a system proposed in 1583 by the French classical scholar Joseph Scaliger and named in honour of his father, Julius Caesar Scaliger. In this system days are numbered consecutively from 0.0, which is identified as Greenwich mean noon of the day assigned the date Jan. 1, 4713 BC, by reckoning back according to the Julian calendar. The modified Julian date (MJD), defined by the equation MJD = JD - 2,400,000.5, begins at midnight rather than noon and, for the 20^{th} and 21^{st} centuries, is expressed by a number with fewer digits. For example, Greenwich mean noon of Nov. 14, 1981 (Gregorian calendar date), corresponds to JD 2,444,923.0; the preceding midnight occurred at JD 2,444,922.5 and MJD 44,922.0. [6]

12. CROSS-CULTURAL VIEWS OF TIME

Let us have a look at the different cultural notions of time in the world of international communication (boosted particularly by Internet), travel and business. At first glance, the concept of time is the same around the world. After all, 90 seconds are the same in Berlin or Beijing, aren't they? What is important, however, are subjective attitudes toward time. The question is not "Aren't 90 seconds the same everywhere?" but rather "Are attitudes toward those 90 seconds the same?" The answer is negative. Perceptions of time vary widely in different cultures.

Being sixty seconds late to appointments in Berlin and Beijing, for example, is understood very differently. In the latter city, it probably won't be noticed, but in Berlin it would be taken as an insult. Then, in every country there are people who want to remind others how important they are by showing up late. It doesn't matter if they live in a culture that respects punctuality or not - they're going to leave people sitting in their waiting room just to show you that they can. And in many cultures it is almost the duty of the higher-ranking person to be late. In the Middle East, western businessmen can wait for hours for their appointment with a member of the al-Saud family. When they are seen, the visit may not be private, and may be riddled with interruptions from other family members and friends. The prospect may even get up and leave several times. He may be meeting with another roomful of visitors, agreeing to more appointments, or observing his religious obligation to pray five times a day.

In many areas (including most of Southern Europe, Latin America, Africa, and the Middle East), time is a servant, not a master. The idea that a person should be ruled by the clock is amusing. In these countries, it's fine if a person is on time. But it's also fine if a person is late. After all, life is complex, and many things happen. If you spot a friend on the way to an appointment in Paris, surely it is more important to chat with your friend than to rush to some arbitrary deadline. In contrast, time is money in the United States and most of Northern Europe. Minutes are a precious resource. There are never enough of them. When someone is late, they have wasted your time, which is a serious insult. It is impossible to say which way of looking at time is correct. Both are appropriate - in their own environments. However, everybody generally prefers the prevailing attitude of his/her native culture.

Absolute punctuality is expected in Germany, the Netherlands, Finland, and Japan. In those countries visitors are advised to appear early, because every minute counts. Being late demonstrates that you cannot be trusted to keep your word or manage your time. Countries where virtual punctuality is expected include the United States, Canada, Denmark, and Sweden. In those countries, most people will not be insulted if you are less than five minutes late. (Of course, there are sticklers for exact punctuality in all cultures.) Some countries consider you to be on time if you arrive less than a half-hour late. Such relatively punctual countries include Norway, Austria, Belgium, France, and much of Asia. Countries that practice moderate punctuality allow someone to arrive an hour late. These include Spain, Portugal, Italy, and most of Latin America. And then there are the nations of the Middle East and Africa, where punctuality is not traditionally valued. In such places, people could show up hours late (or not at all) without conveying an insult. But if a person comes from a country like Switzerland where there is a higher standard of punctuality, s/he is expected to adhere to the local culture's tradition. In other words, a Swiss is expected to be punctual even in Saudi Arabia. Rules may vary between business and social events. In many countries, being very late to dinner or parties is expected. One can show up two hours late for a party in Mexico City. It's rude to be on time, since the hosts will probably not be ready. [27]

In addition to punctuality, there are many other important considerations in cross-cultural time-keeping. Different calendars are used throughout the contemporary world. The Western (Gregorian) calendar must compete with the Arabic, Hebrew, and Chinese calendars, among others. When different calendars are in use, it is best to use both calendars' dates in communication. Different calendars have months of different lengths. Working days and hours differ considerably, too. The traditional Islamic Holy Day is Friday, while the Jewish Sabbath is Saturday (actually, sundown Friday to sundown Saturday), etc.

Even when both parties use the Western calendar, there are different ways of keeping and recording the time. In the United States, it is customary to write the month first, then the day, then the year (often just the last two digits). So, in the United States, 5/3/98 means May 3, 1998. However, most of the world considers this backwards. How much more logical it is to write the day, then the month, then the year. To most Europeans and Latin Americans, 5/3/98 means March 5, 1998. They may also separate the numbers using something other than a slash, such as periods (5.3.98) or commas (5,3,98). Then there's military time vs. 12-hour tracking; six-hour vs. 10-hour workdays; coffee breaks vs. tea breaks; six-week vacations vs. comp time for overtime… [27]

By way of conclusion, one anecdotal time measurement: In the Andes, time is often measured by how long it takes to chew a quid of coca leaf. Sometimes, and not just in the Andes, a destination is said to be so many cigarettes away… [12]

13. QUEST OF A UNIVERSAL TIME

This research paper has demonstrated an immense variety of time systems seen from many different points of view, and many related problems that might be decisive for their stamina in the long run. Almost all of them contradict each other, but the major gap is between the cultural concepts (intuitive) and the scientific (mathematical, physical) ones. Epicurus once wrote, "*Our will is autonomous and independent and to it we can attribute praise or disapproval. Thus, in order to keep our freedom, it would have been better to remain attached to the belief in gods rather than being slaves to the fate of the physicists: The former gives us the hope of winning the benevolence of deities through promise and sacrifices; the latter, on the contrary, brings with it an inviolable necessity.*" This dichotomy is still present. Again and again, the greatest thinkers in Western tradition, such as Immanuel Kant, Alfred North Whitehead, and Martin Heidegger, felt that they had to make a tragic choice between an alienating science or an antiscientific philosophy. [25]

Because of this gap, most scientists are extremely careful at putting these two domains any closer together, deeming them incompatible. Author of this article, however, holds that they are two sides of the same coin. There is too much distinction made between mathematicians, physicists and astronomers on one side, and philosophers, anthropologists and theologians on the other one. For hasn't it been physics, headed by Albert Einstein's work, that totally changed views in philosophy lately? Whatever varied and rich, isn't there just one combined knowledge, eventually? All aspects of our lives reflect in and interact with each other - time scales, celestial mechanics, our beliefs and customs, ways of subsistence, days prolonged by electrical lights, punctuality, physical discoveries, communication, travelling, eternal questions of where we go and from where, etc., nothing is spared.

According to Encyclopaedia Britannica, *Science is any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws.* A cultural time concept or cosmology sure is a system of knowledge that is concerned with the physical world. It is often concerned also with the spiritual one, one might say - but that is not excluded in the definition and besides - physical and spiritual worlds often overlap in scopes of single cultures. In this scope also experiments and observations can be considered unbiased and systematic. And, finally, one could not agree more that such system involves a pursuit of knowledge covering general truths and the operations of fundamental laws - within the boundaries of culture at least, again. Therefore: what are cultural time concepts and cosmologies, if not autochthonic variations of science as we know it? Nothing in the definition of science denies it.

And there are more links between these two systems of knowledge. It has been one of the challenges of this research to show that modern relativistic physical theories of time are not that strange to humans as they are often considered. The shock might be caused only by the pure fact of disappearance of the absolute time controlled by clocks, that was so linear and thus comprehensible by common sense. The fact that time is bound up with space, that it is the inseparable fourth dimension of space-time, that time can run at different paces, that all celestial bodies influence it in very complex ways, that there are different sorts of time, etc. - all that is nothing alien or out of this world.

Actually, humans seem to have a sense for such dynamical and relativistic space-time. One can find plenty of examples in the above chapters - different speeds of time in dreams or altered states of mind, the specious time, mixing grammatical tenses, distinguishing different times for different activities, little correlation between actual time and tenses, the all-elastic time in myths and fairy tales, etc. Then, people from many of the non-western cultures, free from the command of clocks, would not hesitate to witness different time speeds, or interchange and overlapping of the past, present and future times - for it is very normal to meet and talk to their dead kinsfolk in their dreams, trance or meditation; cyclic time of the universe - well that's just like many myths of creation, and rebirth of humans, nature, Moon, mornings, etc.

Next, let us have a look, at the Hopi North American Indians of the north-eastern Arizona. Their concept of time is best demonstrable on their language (of the Uto-Aztecan family). In its verb forms, for example, an event at a great distance from the speaker is characterized as having occurred in the distant past; the shorter the spatial distance, the less the temporal distance is seen to be. Hopi verbs have no real tense but instead are distinguished by aspect (the length of time an event lasts), validity (whether an action is completed or ongoing, expected, or regular and predictable), and clause-linkage (giving the temporal relationship of two or more verbs). In addition, verbs can be inflected to show that an action occurs in repeated segments: e.g., *ríya* ("it makes a quick spin") and *riyáyata* ("it is spinning"). (In the 1930s the linguist Benjamin Lee Whorf seized on these characteristics of the verbs of the Hopi language to illustrate the "Whorfian hypothesis": language closely governs our experience of reality. The Hopi language frames the way in which the Hopi talk about their universe. The same holds true, in Whorf 's view, for all individual languages and people.) [6]

A sort of space-time continuum is present also in the culture of the Inuit in Northern Greenland. Distances are perceived in *siniks*, i.e. number of sleeps necessary during cross-country travelling. They are not real distances, because the weather conditions and seasons can change the number of siniks. Is no time-like term, neither. It is together spatial and temporal phenomenon, a perception in the space-time and the movement, very natural to the locals, but hardly translatable. [29]

Another example is *the Dreaming*, also called Dream-time or World Dawn, a mythological period of time recognised by the Australian Aboriginals that had a beginning but no foreseeable end, during which the natural environment was shaped and humanised by the actions of mythic beings. Many of these beings took the form of human beings or of animals (totemic), and some changed their forms. They were credited with having established the local social order and its "laws." Some, especially the great fertility mothers, but also male genitors, were responsible for creating human life - i.e., the first people. Mythic beings of the Dreaming are eternal. Though in the myths some were killed or disappeared beyond the boundaries of the people who sang about them, and others were metamorphosed as physiographic features (for example, a rocky outcrop or a waterhole) or manifested as or through ritual objects, their essential quality remained undiminished. In Aboriginal belief, they are spiritually as much alive today as they ever were. The places where the mythic beings performed some action or were turned into something else became sacred, and it was around these that ritual was focussed. The Dreaming, as a co-ordinated system of belief and action, includes totemism. Together, they express a close relationship: man is regarded as part of nature, not fundamentally dissimilar to the mythic beings or to the animal species, all of which share a common life force. The totem serves as an agent, placing man within the Dreaming and providing him with an indestructible identity that continues uninterruptedly from the beginning of time to the present and into the future. [6]

Of course, in case of stepping out of the frame of the one culture and encountering another system of knowledge, contradictions between the science as we know it and such a culture-shaped system of knowledge would emerge. However, from an *anthropological point of view*, it is senseless to be occupied with such contradictions. There is no point at comparing two cultures, for that would necessarily involve deeming one of them referential, better or right. The only thing one can say, from this point of view, is that these two systems, the mathematical and the cultural, strive for the same in their respective environments, thus can be put on the same level. And that's a step forward in search for a universal definition of time, isn't it? Without an attempt to word a definition of a universal concept of time or times, this shows the viable approach. The rest is, as mentioned in Chapter 2 (Definitions and Notions of Time), just a matter of complex language felicitousness.

So as we have seen on the example of different calendars, succession and meeting of cultures yields fusions of the time-keeping systems. This certainly continues in the present time. One may say - why should it be just the papal Gregorian calendar that rules today? Why not the Mayan, or Chinese, or Babylonian? Well, the reasons why most of the world is dominated by just that system are very complex and all-rooted in the history of expansion in the colonial period. But it would be wrong to consider it as a sheer dominance of one culture. The current system is *just rooted* in the Gregorian one and has undergone many corrections and changes (see Chapter 6 on Time Measurement) that follow the objective, fundamental findings of physics, astronomy and scientific cosmology, excluding misunderstandings world and epoch-wide. In the world of ever-finer time divisions and schedules to meet, global communication represented especially by Internet and cellular telephony, the world tourism, unifying economy, and ever more daring explorations of space, and, perhaps most of all, in the world where cultures meet more and more, a precise and single calendar and time standards are of vital importance.

And this development of ever more precise time will surely evolve further. A goal in scientific timekeeping has been to obtain a scale of uniform time. But if, for example, dynamical and atomic time should have a relative secular acceleration, then which one - if either - could be considered uniform? (By postulates, atomic time is the uniform time of electromagnetism.) Leaving aside relativistic and operational effects, are SI seconds formed at different times truly equal? This question cannot be answered without an invariable time standard for reference, but none exists. The conclusion is that no time scale can be proved uniform by measurement. This is of no practical consequence, however, because tests have shown that the atomic clock provides a time scale of very high accuracy. Perhaps the future will bring some form of a unified dynamical and atomic time, corrected by the pulsar timing or yet another sort of referential point (or kind of "hypertime", for it may be deemed so, in the view of Chapter 2 on Definitions and Notions of Time).

Albert Einstein, for example, claimed a combinative approach. In a message to the great Indian poet, Rabindranath Tagore, he wrote the following: "*If the moon, in the act of completing its eternal path round the earth, were gifted with self-consciousness, it would feel thoroughly convinced that it would travel its path on its own, in accordance with a resolution taken once and for all. So would a Being, endowed with higher insight and more perfect intelligence, watching man and his doings, smile about this illusion of his that he was acting according to his own free will. This is my belief, although I know well that it is not fully demonstrable. If one thinks out to the very last consequence what one exactly knows and understands, there would hardly be any human being who could be impervious to this view, provided his self-love did not rub up against it. Man defends himself from being regarded as an impotent object in the course of the Universe. But should the lawfulness of happenings, such as unveils itself more and more clearly in inorganic nature, cease to function in the activities in our brain?*" [25] That is rather determinist approach. Nevertheless, Einstein at the same time assumed that some basic phenomena in microphysics, and axioms or basic physical constants, are ruled by chance - or by some higher order. This means that all the lauded science could be not more that thinking of the moon gifted by self-consciousness, or of some ethnic groups, who are very sure the world has originated from a cosmic egg… There is also a very interesting remark about the fear of humans to discover that they are helpless against their fate. One wonders how much of the denial of the objective science is rooted in this fear.

The presented affinity of the two systems of knowledge (and resulting world-views) means that future can bring about their unconscious marriage. Provided that this affinity is broadened and well nurtured, instead of a catastrophic destruction of the cultural time notions (that has seemed to be looming) a smooth transition into something new might take place. By recognition and repetition these two concepts will be able converge, into something more human (anthropological) than either mathematical science or myths alone. Because accepting solely the latter would be obscurant and accepting only the former would be inhuman and culturally uprooting - for who would tell spooky stories to the children of the nuclear physicists, then?

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