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TRUE—What passes the examiners.

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Life in time and time in life. From biological time to time in culture

Jerzy Andrzej Chmurzyński[a]

Time is the fourth dimension of the material world, being a correlate of changes. Linear time with a time arrow results from averaged changes in the whole macroscopic Universe and hence is often called "absolute time", in which changes of phenomena, things (including animated objects) or their systems denote their "individual times". Cyclic rotational time depends on recurrent changes in the physical world as well as its culture, take place IN such kinds of TIME. But animals and man also use TIME IN LIFE. The duration of their acts often expresses intensity of their emotions – and hence may constitute an element of communication. The simplest time schedule of animal behaviour is denoted by the genetically determined "spatio-temporal system" of its species; individual man's time schedule of activities, both daily and during the year, moreover depends on his geographical conditions, cultural traditions and individual decisions – hence is another form of "controlling of time".

KEY-WORDS: "absolute time", biological time, time in culture, linear / aperiodic time, rotational / recurrent time

To the Memory of my late friend Piotr Korda, ethologist and humanist, generous to people and animals – on the first anniversary of his death

I. INTRODUCTION – THE PROBLEM OF TIME

The notion of life is indissolubly bound with time. Originally, "life" in many languages meant, and often still means the period from birth to death, especially man's existence on earth. Only secondarily has "life" (Gr. *ζωή, zōē'*) started to denote the quality that distinguishes a vital and functional being from a dead body and from inanimate nature as an attribute of living matter.

Life (Gr. *βίος, bíos*) always takes place in time: human life (Gr. *αἰών, ajō'n*), the existence of communities, individual plants, animals, their elements alike. Similarly, phenomena of inanimate nature, such as rain-storms, floods or rainbows, may vary in **duration**, may or may not occur simultaneously, in the latter case forming a sequence of unrecurring events, at the same time that a recurrence of other phenomena is

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observed in living organisms, as well as in inanimate nature. The notion of time originally sprang from an understanding of the synchronism, succession and duration of phenomena, even if for a long time qualifications remained definite and specific: "the time of day", "another time", or – wait, now, before, afterwards, yesterday, today, tomorrow, in the future (*cf.* Denbigh 1975).

Experienced in this way, time found its reflection in grammar, in the form of tenses. When considering a certain period of time (interval or space of time composed of a sequence of moments), we can perceive it as a continuum of earlier and later moments with three main divisions: past, present, and future.

The moments when two separate phenomena occur can be described as either simultaneous or successive. Similarly, when considering two or more sets of phenomena taking place in certain periods, we can distinguish periods that are coeval (contemporary, when applied to people, synchronous in relation to periodic intervals) and coincident, in contrast to not concurring (diverse). Coevality may be exact or, as it is often the case, approximate, as in the notion of "contemporary"; *e.g.*, Jan Dembowski (1889–1963) and his wife Victoria (1891–1962) were contemporary Polish protistologists, although they were born and died in different years. In history, which obviously draws from mental experience, the notion of "contemporary" is rather extendible, so events or people living in the same age are often perceived as contemporary.

Having observed the development of different words in various languages, one cannot but be convinced that primitive man was not only more concrete, but used more specific terms in his language. Words of a more general nature referring to the experience of time appeared gradually. In the Polish language, "time" was originally *wrzemię* (as in other Slavic languages deriving from *†vermę*, possibly from Proto-Indo-European **vertmen* – "course"), and later on, *czas* (from Proto-Slavic *†čěsú* – "proper time" < Proto-IE **k'ēsos* – "order to execute a certain duty in a specified term") with their adjectives, *wrzemienny*, and *czasowy*, respectively. In English, the word "time" derived from OE *tid*, now *tide* (prob. from Proto-IE **dīmen* "to part", from which also German *Zeit*). "Time" was used primarily in such expressions as "suitable time" or phrases as "I have now no **time**", or "later when I shall have time". Even the gorilla Koko, taught AMErican Sign-LANguage (*Ameslan*), could communicate: "first you pour that", and on another occasion, "later, [now] I drink" (Patterson 1978; Sadowski and Chmurzyński 1989: 532).

Thus, time is above all a notion, **a notion of abstract** human **thought, and hence, an element of culture.**

The notion of time must have developed with the emergence of living creatures capable of such a reflection – not only before the origin of physics, but even before the appearance of regular philosophical reflection. Similarly as human sight has a physiological bias to detect straight lines, even where none exist (for example, the fabulous canals on Mars), so in my opinion Man has a pre-established tendency for

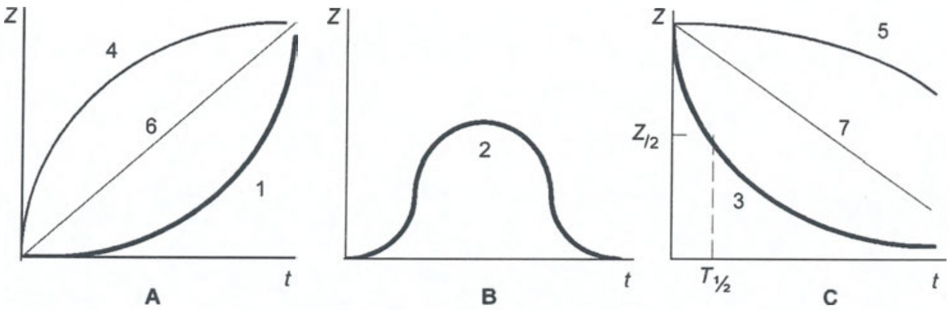

Fig. 1. Examples of dependence of changes (Z) of "absolute" time (t) in natural processes. Especially curve 3 in Figure C shows how such a graph may be reversely used to evaluate time from the changes: natural radioactive decay of half of a radioactive isotope ($Z/_2$) enables the half-life time ($T^1/_2$) of the isotope to be reckoned.

assuming the steady run of infinite time, for instance during the day. Hence, **the notion of linear absolute time appeared in the history of human thought as an "obvious" fourth coordinate of the physical world**, analogous to the three Cartesian dimensions of space. Steadily passing absolute time was an ideal that permitted the dissimilarity of pace of "individual clocks" of diverse phenomena or systems to be observed (for example, Fig. 1B, where Z is "individual time"). The diversity of physiological (biological) and psychological time (Carrel 1936: chapt. V) in different human beings can be observed, especially at the beginning and in the final years of life, with "children developed beyond their age" and others "dying so young".

The notion of time was formed not only based on the unidirectional processes of growth, duration and wane (decay, disappearance) of things, systems and events on the one hand, and categories of the past, present and future, on the other, but **also based on life processes occurring in "periodical time"**, according to the day-night rhythm, recurring lunar cycles, and especially changing seasons in successive years, regularly occurring lunar and solar eclipses, the appearance of comets, *etc.*

The problem of time is one of the more difficult ones. Not without reason Aurelius Augustinus, better known as St. Augustine, wrote about AD 379 in his *Confessions* (Lib. XI, Caput 14) "What [...] is time? If no one asks me, I know what it is. If I wish to explain it to him who asks me, I do not know. Yet I say with confidence that I know that if nothing passed away, there would be no past time; and if nothing were still coming, there would be no future time; and if there were nothing at all, there would be no present time" (translation Albert C. Outler 1955). Philosophy has long dealt with time (*cf.* Kwiatkowski 1947: §§ 157, 243, 407–9; vol. II, §§ 456, 529, 534–8). As Janik (1984: esp. 98–9) writes, already "in Scholastic metaphysics, time is [...] understood as the function of change". In view of this, one considers justified the positivistic assumption of Tadeusz Kotarbiński (1961: 416), who treated time as an apparent name (onomatoid): there is not such a thing as time, nonetheless "this is earlier than that, and something else is later". Although "time does not exist" in Kotarbiński's reistic philosophy for he related the term "to exist" only to things, bodies, and concrete objects, "**time** exists really, objectively, although it is not an independent being. It **exists in a different 'manner of existence' than do things**" (Nowicki 1986: 15–6; *cf.* Augustynek 1972, 1975).

In the introduction to the chapter on *Neural representation of time*, Robert Thatcher and E. Roy John (1977, chapt. 7: 165–7) wrote: "It is clear that time is merely an abstraction and, in a concrete sense, does not exist. [...] The word 'change' should be used instead, since this word is fundamental to time. [...] It is believed that the subjective perception of time (*e.g.*, duration, passing of time, temporal perspective, simultaneity, and so forth) can best be understood by first examining the means by which objective or external time is measured. [...] An understanding of subjective time must ultimately stem from the fact that a living organism operates in a world that exhibits succession and change. [... Also] man is in a universe that exhibits ordered change. 'Time's arrow' is an inexorable movement of events which follows the laws of cause and effect and exhibits a specific direction".

A clearer perspective of the nature of this process can be obtained by considering the various aspects of subjective time operations. For convenience, subjective time can be divided into at least four [non-mutually exclusive] categories (Ornstein 1969): "(1) succession (change) and simultaneity – constituting the basis for the following ones: (2) awareness of time passing (the specious present); (3) estimates of duration; and (4) time ordering (temporal perspective). [...] At the root of succession is the concept of change, and [...] this involves the representation of a relationship between events. Event *A* can be discriminated from succeeding event *A'* when a minimum interval of time elapses (in the case of a human observer this is 20 to 60 ms[1]). The relationship between simultaneity and succession is clear since two events will be perceived as one, if they occur successively within a short interval of time [shorter than noticeable – JAC]. It is important to emphasize that both succession and simultaneity involve comparison, namely, comparisons between the neural representations of events".

For **time cannot be separated from the "clock"**. One would be mistaken, however, to believe that it is always a mental process alone. "Objective" time is constituted by multifarious material (energetic) processes of the inanimate world. In relation to the earlier mentioned two "kinds" of time, one can distinguish two, basically different, clocks: "linear" (dynamic; Scharf [1977: 11] calls it "infinite"and "rotational" (periodic; Scharf [1977: 11] calls it "finite"). It is reasonable to assume that time is

[1] In this article, seconds are symbolized with s or^{s}; a minute (min or^{m}) is 60 s; an hour (hr, plural hrs, or^{h}) is 60 min or 3600 s. An astronomical day (^{d}) equals 86,400 s.

a vector coordinate of the material world, being a correlate of events taking place in the system: there is no time without events, similarly as there cannot be spatial dimensions without matter. With this statement we now basically differ from Isaac Newton (Czernin 1988; Auffray 1996; Whitrow 2004: 258). "Chronological time" (better called "chronometric" from the physical clocks that measure it) – otherwise **"absolute time"– is set by macrophysical phenomena of the universe among which the time arrow presumably is constituted by an increment of entropy** (Mostiepanienko 1976) and, as is thought recently, by an expansion of space (Hawking 1988). We like to treat it as flowing steadily (Fig. 1 A, C – straight lines), and it is often the case in fact. For instance, Niko Tinbergen (1951: fig. 54 B) found a straight-line decline of motivation for parental care with time. Nevertheless, in many local phenomena an exponential* correlation of changes (*Z*) with such linear theoretical time (*t*) has been observed (see curves in Fig. 1 A, C). Nowadays, physicists are considering the possibility that time is a quantified* dimension (Smolin 2004), as alleged by Henri Bergson (1907 [1913: 283–310]).

A special situation occurs when people notice only the beginning or termination of long-lasting phenomenon. We know, for example, that tooth decay disease (*caries*) emerged in Man after the Neolithic revolution in consequence of dietary changes from meat to grain, but we do not know when it will fade. On the other hand, cases of extinction have been noted, usually as a result of human hunting, *e.g.*, the large post-Pleistocene Madagascar ostrich (*Aepyornis titan*), which reached over 3 m in height. Other flightless birds were exterminated by man and animals introduced by him later: the dodo (*Didus ineptus sive Raphus cucullatus*) of Mauritius was extinct by 1681, the Réunion solitaire (*Raphus solitarius*) by 1746, and the Rodrigues solitaire (*Pezophaps solitaria*) by about 1790. Also the larger moa birds (*Pachyornis elephantopus*), reaching 3 m in height, were exterminated by the Maoris by the end of the 17th century AD. The last auroch (*Bos primigenius*) died in Jaktorowska Forest in central Poland in 1627. Of course, all these species were descended from more primitive forms living earlier, but for creationists of all kinds it might have been just as well "at the beginnings of time". Similarly, the last Tasmanian woman died in 1876.

Last but not least, one can mention events taking place at "time points" or during brief periods. Some of them marked important moments in human (or local) history, others became *caesuras*. Such events included the Battle of Granicus in May 334 BC, the crossing of the Rubicon in 49 BC, the Battle of the Teutoburg Forest in AD 9, the fall of the Western Roman Empire (AD 476), the Baptism of Poland on 14 April ‹?› 966), the Battle of Hastings on 14 October 1066, the Victory at the Kahlenberg near Vienna (12 September 1683), the so-called "Battle of Warsaw" on the Vistula (13–20 August 1920). Some important dates are not precise, such as

* Asterisks refer to the glossary at the end of the article.

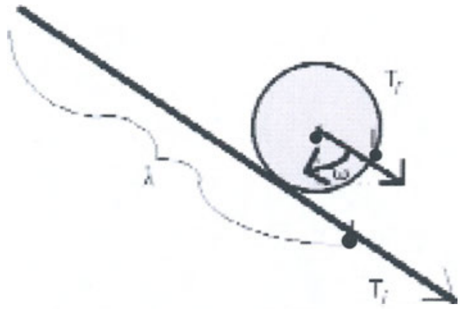

Fig. 2. Combining of "continuous limitless time" (T_i), with "discrete finite, periodic time" (T_f) "rolling" along it. This model assumes that there may be many individual cases of cyclic time with different angular velocity ω (day, month, year, *&c.*) "rolling" on the same axis of universal time (orig.).

the crucifixion of Jesus of Nazareth (on 13/14 Nissan – possibly on Friday 4 April 30 AD or 3 April 33 AD).

Apart from clocks based on a single appearance of a thing, state or process, its degradation and disappearance, one can distinguish **clocks for repeatable, recurring events. From these comes the antinomy of "two kinds of time"**, known from antiquity and discussed by Joachim-Hermann Scharf (1977: 13, 15) in his study on the *Dialectics of time*, where he described Plato's view curtly: "Time is cyclic, and duration – a static timelessness," and then Aristotle's statement from *Physics* (IV, 10) that "**time is both continuous and discrete**". This antinomy was expressed in Persian Zervanism *vel* Zurvanism with *Zervan akarana* (Eliade 1978 [1994: 203]) *vel Zurvan akarana*, *i.e.*, Eternal Lord (Scharf 1977: *Tempus infinitum [directum]*, infinite, Limitless Time (T_i in Fig. 2) and Time of Long Dominion, *Zervan karana* (Eliade, *loc. cit.*) or *Zervan darega* (Scharf, *loc. cit.* [aw. *dareγō, x*ᵛ*aδātō, Daregho-Chvadhata*], *i.e.*, Lord of the Existing World, *Tempus finitum [orbi simile]*), Limited Time, T_f in Fig. 2, better called Periodic Time).

Figure 2 endeavors to solve this antinomy. To assist in its intuitive comprehension, it should be kept in mind that periodic (rotational) time, T_f, is here represented by a circular clock (circle), the drive of which is constituted by a vector parallel to the T_i axis, which is one of the components of the force of gravity. This drive brings about the turn of the circle in ("along") linear infinite time (T_i) with the time rate at which it rotates, called angular velocity, ω (for example measured by °/s). (Obviously, in this model one should include some kind of friction stabilizing the rolling movement, *i.e.*, counteracting its acceleration, something which is not indispensable, however, to understand the idea of the model).

If recurrence happens three or more times at the same intervals, it is a regular or periodical recurrence. Oscillation ⟨L *oscillā're* 'to swing'⟩ is the fluctuation of a certain factor or process around a mean value or position; oscillations can be (i) steady, continuing forever at a constant amplitude, or (ii) damped, tending to die away as time goes on, due to friction for instance. Simple harmonic oscillations are a specific form of the first ones; these are values (y) depending on time (t) as described by the formula

$y = A \sin(\omega t + \varphi)$.

A graph can be obtained transforming appropriately the sine curve (sinusoid) – unless conditions $A = 1$ and $\omega = 0$ are not fulfilled, when it is a normal sinusoid.[2] Such a rhythm consists of repetitive units; each of them is called a cycle (vibration), and lasts for one **period**, $\omega = 2\pi/T$, its length equals the circumference of the circle from a certain point • to its return to the same position in relation to the axis T_i in Fig. 2. On the graph of a simple harmonic oscillation, period T gives the length of one wave, λ. Frequency (ν) is the number of vibrations in a time unit, its value being equal to the reciprocal of the period, *i.e.*, $1/T = \omega/2\pi$. The amplitude of vibration (A) is the extreme (maximum or minimum) deviation of the wave from its equilibrium position, or from a mean value of the sine function. Each stage in a period of uniform circular motion (harmonic motion) is called a phase; φ_0 is an initial phase (*cf.* Bronsztejn and Siemiendiajew 1968: 237), φ being an *acrophase*, *i.e.*, a position of the point of the amplitude of rhythm, expressed in angular degrees. In a strict sense, "a rhythmic phenomenon is [just such] a process with regular oscillations repeating through a certain time interval. It has a wavy character, and its maxima and minima occur at even time periods. Each rhythm [...] can be represented by a properly fitted mathematic curve, and may be described by a proper mathematical function" (Chlewiński 1977: 95).

When recurrences of the same phase take place with periods not exactly equal to each other, we are dealing physically with non-periodic repeatability or intermittent phenomenon; however, in the other natural sciences (such as astronomy or biology), they are customarily called rhythmical ones, if only they maintain an uniform mechanism, as it is with the lunar day* which fluctuates by 13 hrs between $29.^{d}25$ and $29.^{d}83$. Ideally, regular oscillations are rare in celestial body movement. Observed rhythms may also be the result of interference of a few or several periodic changes.

Irregular repetition of events due to heterogeneous causes, as, *e.g.*, periods of mountain formation (orogeny) or glaciations in the history of the Earth (according to Milanković, see Stenz 1956: 135–44), are called pseudorhythms. Events exerting influence on man, such as the appearance of locust swarms, epidemics, and climate fluctuations depending on El Niño can be numbered among such pseudorhythms.

Finally, recurrent events, such as the individual sequence of an organism's behavioural repertoire on particular days, either genetically determined or assigned consciously usually in a cultural context, shall be referred to here as temporal schedules.

In my considerations, the problems of relation between time and life of animals and humans will be dealt with in two major aspects: LIFE IN TIME and TIME IN LIFE. The reader will find some references to the historical sciences, such as palaeontology and history, but time as understood in these sciences will not be the subject of this essay. It is naturally an important question, but it would lead us too far, as it touches on matters such as, firstly, a structuralist attitude (*cf.* Piaget 1968) *versus*

[2] In chronobiology, the cosine function is used instead as equivalent: sine shifted left by a segment $\frac{1}{2}\pi$ or $\frac{\pi}{2}$.

the historical one, and, secondly, various aspects of time. For a historian or archaeologist, it is not only a question of the role of time for people living in a considered period of time (see Whitrow 2004). As Braudel says (1971, especially the chapter *History and social sciences: long duration*), it is also justified to distinguish "the traditional history, susceptible to the 'brief time', individual vicissitudes, events" and "a long-winded history which employs measure of centuries: the history of long, very long duration (*la longue durée*)". The same refers not only to archaeology, but also to palaeontology (see "ecological time" and "geological time" in Dzik 2003, chapter 2).

II. LIFE IN TIME

1. Aperiodic Time

Everyone knows from autopsy and introspection **the unidirectional course of the individual life of organisms** – its growth (often multiphasic, and sometimes including metamorphosis), *plateau*, and, eventually, involution leading to death (Chmurzyński 2004). It is worth noting that, if mortality is included in the genetic programme of multicellular organisms, the duration of ecological or social communities is the result of their interactions with environmental change, in abiotic as well as biotic surroundings, including a social one. It is not difficult to find analogies in civilisations, cultures, social communities and human institutions within the range of human history.

Subjective psychological time has such **unidirectional character**, expressing itself in a memory of the past, the flow rate of which changes with individual age. (Indeed, one can reasonably speak of a sense of time in animals). Consideration of psychological time leads us to cultural phenomena. Jan Bułhak (2003: 144) was correct when he said that "only youth can live solely with the **present day**, and places a promising **tomorrow** prior to a neglected **yesterday**. In elderly age, when one is closer to his end, thought more eagerly turns back to the past, to the life of bygone generations, to the problems of one's kin. A mature human would like to know everything about his ancestors ..."

Interestingly, in similarity to a community of individuals as a biocoenosis* with its own ecological time[3] and to the species with its evolutionary time, also particular cultures maintaining a relative continuity seem to have their own immanent time. Cultures and civilizations, are confined to a certain period of time due to external

[3] Not in the meaning of Dzik (2003)! The plant habitat shows ecological succession tending to the final stage called *climax*. In physical time, it happens at a decreasing rate during the life of a community.

factors (Bagby 1976: 145–54), and, similarly as biocoenoses, possibly change more quickly at the beginning, gradually achieving *stasis*, and eventually declining (*cf.* Fig. 1 A4, B). One might speak of "cultural time", considering that expressions like "young culture", "mature culture" and "decadent culture" – as that of ancient Roman Empire – are often used. To the contrary, similarly as in the biology of an individual, some events may have just the opposite, increasing progress in objective time. As Andrzej Wierciński pointed out to me once, the growth of the number of tool behaviours in the course of human cultural evolution appears to be exponential (*i.e.*, accelerating) – *cf.* Fig. 1 A1.

A naturalist cannot neglect one substantial difference between psychological time and the time of biological transformations in the course of individual development of a living organism (ontogeny): while subjective psychological time flows continuously,[4] stages can be observed in individual development, from minor caesurae to apparent discontinuities, almost disjunctions. In viviparous organisms as, for instance, in man, after the fertilized egg stage (zygote) and its divisions, and after embryonic and foetal development, birth constitutes a distinct caesura, although it is still the same organism [a fact not appreciated by abortionists]. Animals which undergo incomplete metamorphosis, as some insects or tailless (ecaudate) amphibians, such as frogs and toads, pass through more serious changes: from protectively enveloped egg [in which embryonic development takes place] through the larva form (tadpole), at which point gills are slowly replaced by lungs and extremities appear, to the final form (*imago* in insects), which continues to mature steadily and then begins to age. More distinct disjunctions occur in the ontogeny of animals undergoing a complete metamorphosis, such as certain insects, where apart from the caesurae of a larva hatching from an egg and later on, when its consecutive stages (instars) hatch from molts (ecdyses), we observe a far going disjunction at pupation and, eventually, at the emergence of the adult insect (*imago*) from *exuvium*.

One aspect of human life in passing aperiodic time seems to be important. It shows the dependence of temporal phenomena in human culture on man's biological nature – where some cultural matters stem from the biological origins of Man, whereas culture utilizes the biological "material" of our animal heritage.

I mean especially the cultural pattern of changing tasks during an individual human life. It is biology that determines childhood with its education by play, then "apprenticing" in youth under adult supervision (parents, grandparents, uncles and aunts), followed by marriage and the upbringing of children characterized by a primary division of roles between the genders. Man was often diverted from his duties

[4] Jokingly called "gaps in one's life-history", they are noticed rather *ex post* as disturbances of memory continuity. They escape current perception, similarly as a blind spot in an eye does not create a "hole" in the visual field.

Fig. 3. Multigeneration family from Bechuanaland (recently Botswana) on a cultural level corresponding to the Palaeolithic. Photograph by Nat Farbman from the exhibition *The Family of Man* (Mason ed. 1959), illustrating how community life resulted in the psychical harmony of people from this social formation.

of procuring food for his family and community[5] to struggle against animal or human enemies. He spent his time preparing weapons and tools; in the evenings he would sit by a fire and share his knowledge and experience with younger members of the family, conveying at the same time tribal and human traditions (*cf.* Fig. 3). Grandmothers did it more individually, taking care of grandchildren. Philosophically transformed, this simple pattern of individual life, deriving from the biology of man, laid the grounds for the cultural theory of "three stages of which the life of every orthodox Hindu consists: [1] in the youth, studying *Vedas* with a Brahman

[5] *Vide* social care already in the Neanderthaloids from the middle period of the first Würm glaciation in Europe, some 65,000 years B[efore]P[resent] – the case of the so-called "disabled from Shanidar" from a burial in the Shanidar Cave in Zagros Mountains in northern Iraq.

master, then [2] setting up a family and life regulated with ritual norms, and finally [3] hermitic life devoted to philosophical meditations in the old age" (Schayer 1938: 181; *cf.* Sokolnicki ed. 1931: 70).

Another cultural aspect of aperiodical unrecurring time is measuring time. People used to measure the duration of longer time intervals based on unrhythmic phenomena, for instance using short-term "units of time", such as the length of existence of objects, systems or phenomena, *e.g.*, Polish *zdrowaśka*, which is time enough to recite a "Hail Mary", the trickling of water or sand in an hourglass (either water clock [clepsydra] or sandglass), or the burning of a special standard (calibrated) candle. Events like the running of sand in a sandglass were soon treated as repetitive and periodic: after the upper compartment of a sandglass or clepsydra was emptied, one turned it round to repeat the process. They were then used for measuring longer independent periods of time, such as a day.

A cultural phenomenon peculiar to man is the reckoning of long periods of time in archaeology and history using biological or cultural events for dating of other synchronous events. I have in mind the comparison of the short-time duration of external events or life spans of people with similarly long or longer periods in order to date them, as in the case of the reign of particular sovereigns (*cf.* Luke 3: 1–3), dynasties or political periods, prevailing fashion or style, *etc.* Suffice it to mention expressions like "Athens of the Age of Pericles", "Rome in the time of the Republic", "Europe in the time of the German migrations", "Enlightenment", "the period of the Restoration" in France or England, "the First Commonwealth [of Poland and Lithuania]" or "Chippendale style".

2. Life in Recurrent Time

Life on Earth was developed, formed and runs **within** a terrestrial, solar and cosmic **environment, penetrated with recurrent phenomena**, either intermittent or periodical, characterized by both diverse and independent, or interfering rhythms. In his biological nature, man, as many animals, is subject to many cosmic rhythms. Without going into too much detail, one may state that **biological rhythms can be** either exogeneous – being **elicited by** physical [or chemical] **environmental factors, or** they are endogenous – where they can often be **synchronised** by agents which are called *Zeitgebers* ("time givers"), such as the alteration of dark and light, photoperiod, air pressure, attraction of the Sun and Moon,[6] the Earth's magnetic field and the electrosphere, which changes in a 24-hour cycle as the Earth turns on its axis. In this way, the circadian rhythms ⟨L *circa* "about", *dies* "day"*⟩ are formed, which occur in approximately 24-hour periods or cycles (as of biological activity or function), with

[6] The Earth, Moon (of the Earth) and the Sun are written with capital letters as celestial bodies, and with small letters as phenomena observed from Earth.

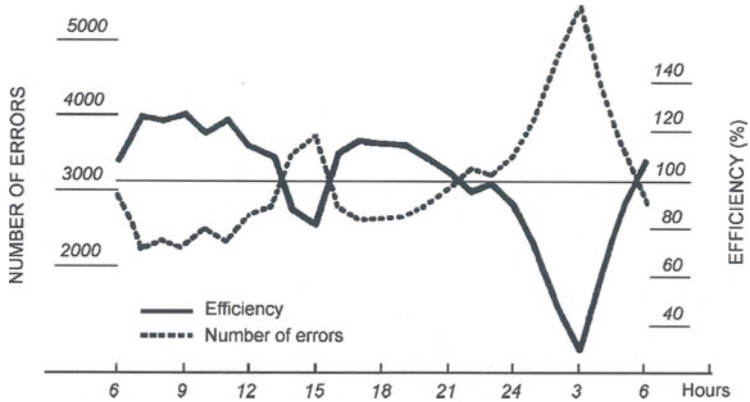

Fig. 4. Rhythm of efficiency (solid line) and committing errors (dashed line) in man (according to Dzierżykray-Rogalski 1986).

a submultiple with a period of 90 min which can be observed in phases of sleep and wakefulness. At the same time, none of them usually has the character of a simple vibration, like that of a pendulum (Emme 1968; see Fig. 4).

The revolution of the Moon around the Earth shows longer, monthly phase changes. A year is an undoubtedly natural astronomical rhythm, within which many biological rhythms take place. I will turn later to phasic cultural phenomena relating to this cycle. The tropical year* amounts to 365.2422 mean solar days, and includes 13.3693 synodic months* (Rybka 1934: column 1105). Improved clocks have shown that the period of a year shortens: "the year 1895 included a full 31,556,926 seconds"; "after a hundred years, it will be shorter by 0.530320 s" (Zajdler 1956: 304).

One should also mention another example of recurrence on Earth, combined with regular succession of astronomic years; these are inundations of the Nile, which we shall consider conventionally as periodical. These inundations probably resulted in the river being deified. The seasonal migrations of Eurasian reindeer and American caribou are also of undoubted social significance.

Fluctuations of population size of predators and their prey, following from their mutual dependence, are counted properly among supra-annual biocoenotic pseudorhythms (see Chmurzyński 2004).

Cosmic rhythms longer that one year, as a period of *c.* 11 yrs of an increase and decrease in the number of sunspots, do not seem to exert influence on man in such an extent as they do on plants, and trees in particular. However, at least three long-term cosmic rhythms influence the biology of human beings, as they change the inflow of solar radiation energy to Earth as a whole, and particularly to specified zones of the Earth surface – equalizing or sharpening seasonal changes of temperature in different climatic zones within a time frame that holds interest for the palaeoanthropologist, as much as for the historian (as in the Medieval optimum, when vineyards flourished in western Poland). These are: (1) a period of cyclic precession* of the Earth's axis of rotation, in Polish astronomy called the Platonic year; (2) fluctuation of inclination of the Earth's axis to the plane of the earth's orbit from 62°30' to 68°40' – with a period of 40 700 years (the actual inclination angle is, 66°33'), and (3) pulsation of elongation of Earth's elliptical orbit around the Sun, *i.e.*, regular changes of the mean distance from the Earth to the Sun within a period of 92 000 years.

In the Platonic year, with a period of *c.* 25 725 years, the movement of the Earth's poles (called precession) results in the tracing of circles on the celestial sphere with a radius of 23°27', which has given even within the history of civilized mankind an observable change of the North Polar Star: *viz.* 4660 years ago, when Khufu (Cheops) was building the Great Pyramid at Giza, the alpha of Dragon (α *Dra*) used to be the Polar Star (Narolewski 1935: 929), in AD 2017 it will be closest to *Polaris* (*i.e.*, alpha of Little Bear, α *UMi*), whereas in c. 13 500 years the north pole will point close to *Vega* (alpha of Lyra, α *Lyr*) one the three brightest stars in our sky (Zonn 1973: 230). Precession causes the equinoxes* to drift westward along the ecliptic (the plane of the Earth's orbit) at a rate of 50.2" annually, which is why the sun rose at the summer solstice* along the northeast axis line of the Stonehenge III circle (built in the Bronze Age between 2000–1550 BC) only between 1940–1740 BC, as the English astronomer Sir Norman Lockyer demonstrated in 1901 – provided, of course, that the basic conception of Stonehenge and the other megalithic structures actually combined religious and astronomical purposes.

3. Nature – culture of periodic time

As pointed out already by the author (Chmurzyński 1990), the "immemorial problem" of nature-culture cannot be univocally solved: one should say that not infrequently they are complementary elements which have to cooperate in conjunction, not in opposition. Władysław Kunicki-Goldfinger (1993) has drawn attention to still another aspect of this combination: that **the capability of creating culture belongs to human nature**. "Although nature demarcates culture's impassable area of possibilities, within this area the choice is not determined beforehand but it depends on man itself and is decided both historically and by personal experience of people who perform the choice" (Amsterdamski 1996).

Coupling of these two aspects in human life may be seen particularly in relation to time. Their dichotomy has, in fact, a threefold character. Here, the most important "natural time" seems to be periodic (circular) time. Its "basis" is constituted mainly by astronomical and geophysical rhythms, and biological and psychological rhythms, largely triggered or synchronized by the former ones (Fig. 5). The means for measuring time related to these rhythms (Zawielski 1981; Whitrow 2004) based upon artificial

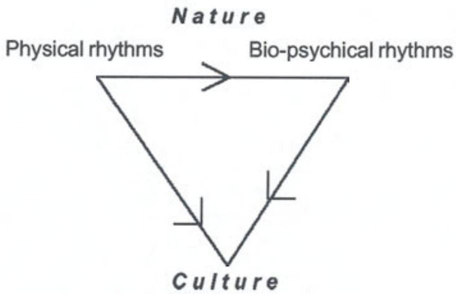

Fig. 5. Time in the *nature–culture* relation.

clocks, which are idealizations of respective physical (cosmic) rhythms, are cultural phenomena.

Human practice, which undoubtedly preceded theoretical considerations of the nature of time, thus created the notions of day, month, and year. Artificial circular clocks with periods shorter than those natural ones, which were alleged to have stable rhythmicity, were used for analysing singular dynamic natural clocks – the duration of things. The time units of a month and its submultiple, the week, and periods greater than a year – century or millennium – are entirely cultural as they are not synchronous with any cosmic rhythms. [Not taken into account here are the more sophisticated periods of the Aztec or Maya calendars which are exotic to us (Zajdler 1968: 102, 245–56)].

Solar day* amounts now to 24 hours. The primeval division of the *doba* ("day–and–night" in Polish) to separately taken day and night,[7] was almost natural for terrestrial living organisms due to the differences of input of radial energy from outer space. The sub-division of a day into smaller parts is an entirely artificial product (Zajdler 1956: 39–40). First came the smaller parts of the day like dawn, morning, forenoon, noon (upper culmination of the sun), afternoon, evening and dusk. Night was divided into the beginning, middle (whence midnight), and end. Later on both parts of the *doba* were divided into separate hours – the night ones called often "guards" or "watches" (whence the English name of a portable clock!). In antiquity, there arose two systems of dividing the *doba*: a Babylonian one with equal hours, and Egyptian with unequal ones – different in the daytime, and different at night. In the beginning, the Babylonians divided the *doba* into six parts: three hours of day, and three hours of night; however since 800 BC people in Mesopotamia started to divide the *doba* into 12 *kasbu*, "double-hours" which were further divided into 30 *us*, corresponding to our four minutes each (Zajdler 1956). It is possible that *kasbu* were first divided into two parts, as Hindu and Chinese sages, similarly as Egyptians and Greeks living west of Babylonia – who benefited from ready standards coming from the knowledge of Babylonian priests – divided the *doba* into 24 hours (Zajdler 1956: 45). Egyptians counted separately the hours of the day (from dawn to dusk) and of the night – for the length of the day and night changed in Egypt depending

[7] Even recently, English has not a general term for it (German *voller Tag* is still less general than Polish *doba* [pronounce: "*dawbah*" with mute *h*] ⟨PIE**dhobh-* "suitable, proper"⟩, whereas *dzień* "day" and *noc* "night" are of common Proto-IE origin, respectively **oghes* "day", **nokwt-* "night").

on the season, from 10 to 14 hrs. Day and night hours are usually of different length, except for the spring (*c.* 21 March) and autumn (*c.* 23 September) equinox*.

Clocks (in the ordinary sense of the word) have been serving the purpose of counting parts of the day and night since a long time ago. At the beginning, men availed themselves of periodic trickling of sand or water in an hourglass, burning of standardized candles, and later on – of various man-made mechanical, electric, and, lastly, electronic clocks. It should be added that in antiquity, night and day hours were counted separately as a rule, starting from the beginning of each of them. We know it even from the New Testament Gospels, where six o'clock marked the noon (*cf.* Matthew, 20). The 24-hour measure of the *doba* was introduced in Poland still within my memory; before that a.m. and p.m. hours were used officially, similarly as is still the case in English-speaking countries. We owe it to the newest clocks, the most recent atomic ones in particular, that an unexpected fact was discovered (being unnoticeable within the ordinary lifespan of man), namely that of a variation in the duration of the astronomical *mean sun day*. It grows longer $^1/_{1000}$ s every 100 years (Rybka 1933: col. 1098). Thus, Silurian trilobites experienced a day consisting of 21.5–21.6 (present) hours. Such slow changes, however, have no meaning either for history or for archaeology. Only the palaeoanthropologist may be interested in the knowledge that in the Tertiary epoch a day[8] had 23.7 hours, *i.e.*, *c.* 23^h42^m, and that the number of such days in a tropical year* was 368.3 (whereas recently it is 365.242 d). It should be borne in mind that 12 million years ago, at the beginning of the last Tertiary period, the Pliocene, the evolutionary line of the Primates, which has led to the human species, separated from the branch of the apes.

In the world of higher arthropods (such as insects) and vertebrates – especially of birds and mammals – one can observe recurrent activities running even more loosely in time than pseudorhythms; I call them "temporal schedules". They have the character of individual programmes of activity on particular days, and especially at given times of day and night – within the limits determined genetically by evolutionary, so-called ultimate causes, and based on a so-called spatio-temporal system (Germ. *Raum-Zeit-System* [Hediger 1942]), *i.e.*, system of points in space, proper to an individual and adjusted to its species requirements, in which it fulfills its respective vital activities (as sleep, rest, ingestion, *i.e.*, food, water and mineral salts intake, eliminative behaviours such as defecation and urination, or comfort behaviours) at a particular time – determined by biological rhythms, own needs and external circumstances. Achievement of the space and time system is a condition *sine qua non* of an individual's welfare. It is interesting that the spatio-temporal system of an animal may include not only genetically determined biological activities, but also individual voluntary customs. My favourite female cat, Dusia, is in the habit of visiting me in the

[8] Day corresponds in astronomy to Polish *doba*, *i.e.*, denotes a "period of one day and night".

early morning, trampling over me in bed, unless I allow her to slip under the blankets where she can stay for a few minutes of caresses, and sometimes for a brief nap.

Although human life is not controlled by biological drives to such an extent as an animal one, nevertheless its framework depends on biological rhythmicity. Therefore, one may speak of a human space and time system – which is worthwhile to realize in the context of military service or the penitentiary system (Chmurzyński 2004). For obvious reasons, in humans it is more individualized than in animals, according to man's conscious plans (Immanuel Kant's daily routine in Königsberg was a well known example of man's spatio-temporal-system); therefore, it is often considered as controlling of time. It also depends on local cultural patterns of life: *cf.*, for instance, times of daily meals in Britain, France, Italy, Germany and Poland; the same refers to rest, such as the Mediterranean *siesta* (Le Goff 1964). It is so because man is a species whose biological programme is insufficient for coping with life in cultural conditions: instincts have to be supported by morality and law, *i.e.*, by culture with its ideological controlling subsystem (in the sense of Wierciński [1994: 71–86]) which comes down in the way of tradition (Chmurzyński 1999).

Daily time schedules of both the ancient Egyptians (Bator 1993) and later of pagan Polans (Polish: *Polanie* tribe) inhabiting the territory of subsequent Medieval Poland (Kostrzewski 1946: chapt. 5; Brückner 1930: 195–6), were in one aspect convergent: they were enforced by the natural course of their housekeeping and apicultural routines. For the Polans there was little to restrain their liberty of action, whereas we do know that for the inhabitant of ancient Egypt "each time of day [... was] assigned as: good, evil, or good and bad at the same time" (Narolewski 1935: 932) – although it seems that Julian Ochorowicz (1898: 92–3) exaggerated when he wrote that there "must have ruled strict conformity with daily time schedule of occupations and leisure. Everything, from meals to prayer and from learning to bathing had its appropriate hour".

Contrary to the system of decades in the French Revolution, which was purely cultural, weekly periodicity – similarly as the month – has a loose relation to astronomical phenomenon, that is, to showing the four main phases by the moon – although one could also defend eight periods in a month, corresponding to (**1**) the new moon, (2) waxing crescent, (**3**) first quarter, (4) waxing gibbous, (**5**) full moon, (6) waning gibbous, (**7**) last quarter, (8) waning crescent. In the culture of ancient Mesopotamia and then among the Jews, the month was a basic unit of time longer than a day. It is undoubtedly related to lunation*, with a mean period of $29.^{d}53$. Within this time, called in astronomy the synodic month*, the moon goes through four phases (indicated in boldface above), so that the mean time distances between them last 7.38 days (the period fluctuates as much as 13^{h}, between $29.^{d}25$ and $29.^{d}83$). So came the 7-day week.

Month in the Indo-European languages (excluding Greek, Latin and its derivatives, such as French) often bears a name originating from the name of the Earth's satellite (in English month and moon, in Polish *miesiąc* and in old Polish also *miesiąc* ("moon"), Germ. *Monat* and *Mond*). The lunar rhythmicity is easily noticeable, especially as only modern man living in brightly lit towns has ceased to pay attention to the moon, naturally excluding cases of an eclipse. However, paradoxically, lunar rhythms seem not to exert a noticeable influence on human biology, unlike marine and sea-shore organisms which are dependent on the tides. In spite of that, the lunar rhythm along with the moon (as celestial phenomenon) constitutes an important element in human culture (*cf.* Eliade 1949 [1966: 155–8]), which may be exemplified by the initial verse in Juliusz Słowacki's (1932) *The father of the plague-stricken at Al-Arish*, well known to almost every Pole: "Thrice, only thrice, had waxed and waned the moon / Since I pitched tent upon this barren dune". So Eliade (1949) writes: "Phases of the moon have revealed to man what is concrete time, different from the astronomical one [here he probably means unidirectional time – JAC]. Concrete time has undoubtedly been measured everywhere with phases on the moon. [...] The oldest Indo-Aryan root referring to stars [obviously all the natural lights in the night sky – JAC] denotes the moon; it is the root *me-*, which in Sanskrit gives *mami* – "[*I*] measure" (in Polish: *mierzę*). The moon has always been an universal measure [of time]. All the terminology referring to the moon [originally equal to month, as mentioned above – JAC] in the Indo-European languages derives from that root".

The term for the menstrual cycle in women shows a clear reference to moon and month (Gr. *mēn*), and woman has been linked with a waxing crescent ever since the Palaeolithic (Eliade 1949 [1966: 92]). As Eliade (1949 [1966: 156]) wrote, "the definite time measured with the moon phases is [...] the 'living' time. It refers always to the bio-cosmic reality, to rain or tide, to sowing or to the menstrual cycle". Therefore, Gustave Flaubert (1950) in his novel *Salammbo* included in the prayer to the chief goddess of Carthage, Tanit, a verse that "monkeys are sick when you rejuvenate", which the translator Wacław Rogowicz, explained in a footnote that "monkeys have menstruation during the new moon". This would mean that the fecund period, which is favourable for procreation, falls on bright moonlight nights near to full moon, which, however, is not true. Although doctors tend to relate the menstruation period to the lunar monthly rhythm, it is presumably due to their astronomic ignorance that they qualify this period as 28 days, not $29.^{d}53$ as the synodic month (so, $1.^{d}53$ too short). It is slightly similar to the sidereal month*, which has period of c. $27.^{d}321$ (only $0.^{d}279$ shorter), but there seems to be no reason for human physiology to cope with the latter period. Therefore serious students of chronobiology find the length of 29.53 days as more plausible here as well. In fact, an analysis of the graphs in Fig. 6 show not only a large variance of the period for particular individuals between 27 and 33 days, but also its variability in time in particular women. Moreover, none of the apes or monkeys have a menstrual period of either 29.53 or 28 days, nor any other period which could reasonably be compared with any known astronomical or

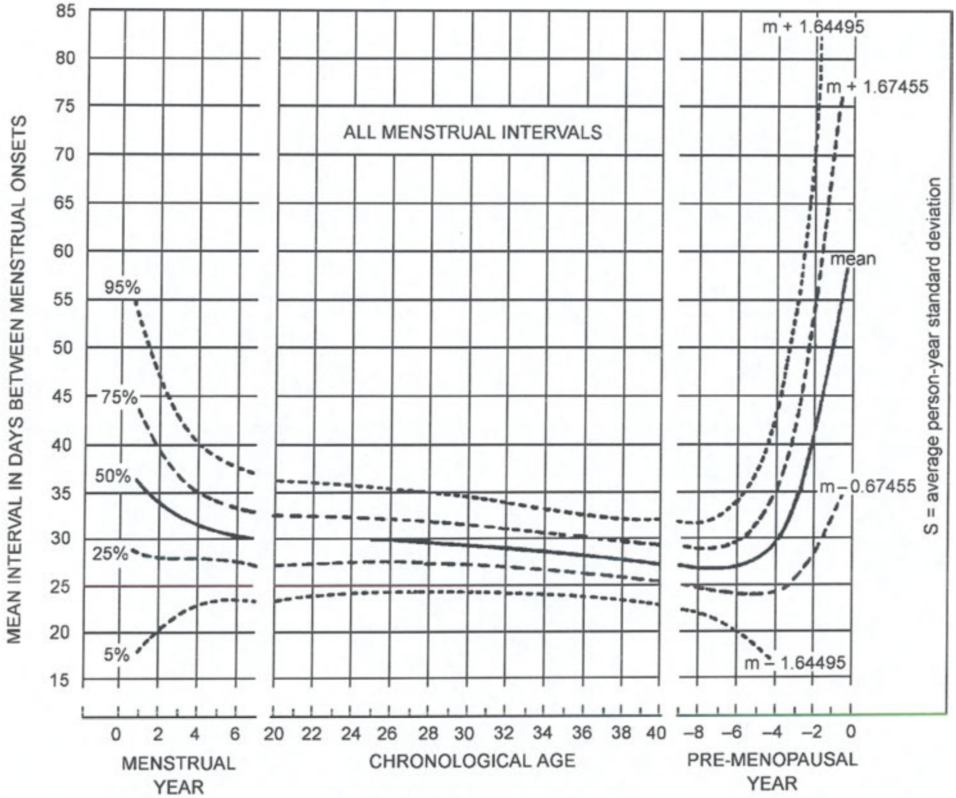

Fig. 6. Menstrual cycles in women in the starting phase, after *menarche* (left), in the fecund age (middle) and before the climacteric (right), showing variance of periods (after Palmer, Brown and Edmunds 1976).

geophysical rhythm. The only answer to the question is that the menstrual cycle in women is an innate, endogenous one, which only resembles the lunar month in length.

The crescent, as well as the horns of a bull that resemble it, was connected with fertility in similar fashion, just as the heart became an archetypical symbol of emotions (Fig. 7). The reason is simple. The heart is a servomechanism*, and its endogenous rhythm of the heartbeat (*c.* ^{70}/min, thus its period, $1^{m}/70$, being similar to a second) reacts, among others, to emotions. Moreover, the rhythm of a mother's heart is imprinted on the foetus prior to its birth, so it becomes the most important sound in a child's life (therefore, the sound of a heartbeat is calming not only to babies, but also to adult mammals and people).

"Rules used for combining days into longer periods of time, as, *e.g.*, [weeks,] months and years [...] are called a calendar" (Rybka 1934, col. 1103). In the face of the fact that the duration of a day and of a synodic month are incommensurable, people from the remotest ages established the length of the month to be similar to the latter. In practice, in the Babylonian calendar they counted twelve months with either 30 or 29 days, and so a lunar year consisted of 354 days. "The month began (similarly as still among the Jews and Muslims) at the sunset of a day with the first visibility of the waxing crescent in the evening" (Saggs 1962 [1973: 406]). In Babylonia since the $18^{th}/17^{th}$ century BC, and in Assyria since *c.* 1100 BC – when the lunar-solar calendar was introduced – one endeavoured for the new year to fall in about the same period.

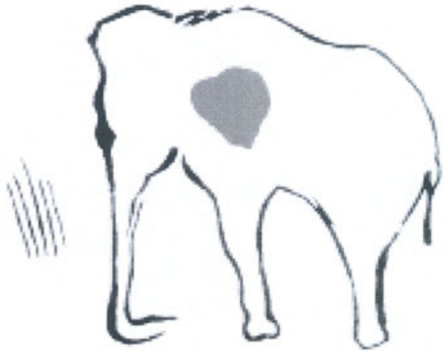

Fig. 7. Palaeolithic drawing (length 44 cm) of a young mammoth with marked heart, from Pindal cave in Spain (after Jelinek 1977, fig. 479).

"Therefore, more or less every three years one needed an additional month to fit a moon calendar into the sun year". In the 4^{th} century BC, "as it seems, seven leap-years during nineteen years was applied. [...] In the first year of the cycle, an intercalated month was introduced in the middle of the year, whereas in others – at the end of year" (Saggs 1962). Among Jews, ordinary years have usually 353–355 days, and leap years 383–385 days. "Ordinary years include twelve months, 29 or 30 days each, and the leap years have thirteen months, where an additional month has always 30 days" (Rybka 1934, col. 1106–9). Such was, it seems, the origin of the superstition about the number thirteen.

It was different in Egypt. Here, the year consisted of twelve equal months, each thirty days long, and with five additional days, *i.e.*, 365 days altogether. A thirty-day period was, of course, related to the synodic month; however, regardless of how far one steps back in history, one will not find any attempt to adjust months to the course of real phases of the moon". The Egyptian solar year was not a tropical year, but it was close to "a sidereal year, *i.e.*, a period of one revolution of the Earth around the Sun" measured with respect to the fixed stars (which amounts to $365^d69^m9^s.5 = 365.25$ days on average). Its beginning was established on the heliacal rising of Sirius, "due to which the beginning of the year" would "fall earlier and earlier, running through all the seasons during 1506 calendar years" (Rybka 1934). We do not know exactly how they prevented such a situation. "Strabon adds, somewhat unclearly, that a day was added at certain intervals, after surplus day fractions that had been omitted each year, finally summed up into one whole day". In certain periods they may have added such a day every four years (Montet 1946 [1964: 33]). People worshipping the Sun were in a better position, for they observed it at a proper moment of the tropical year. So must have done the creators of megalithic graves and monuments from Bronze Age in Europe. As mentioned already, a structural element in a set of menhirs in Stonehenge permitted a glimpse of the sun at a moment of the summer solstice* on 22nd June in the period between 1940 and 1740 BC.

Since 1583, today's Gregorian calendar has fixed the date of the spring equinox for the 21st of March, and its mean year "came up to 365.2425 days. So the year turned out to be only 0.0003 days longer than a tropical year. Therefore, acceleration of the equinox date by one full day will occur only after 3333 years, [... especially] that the tropical year is not a fixed period but becomes shorter by *circa* 0.54 s every 100 years" (Rybka 1934). Due to this, a year in the Tertiary Period had as many as 368.3 days (Nawara 1978).

Although the calendar itself is an achievement of human culture, it is perhaps more interesting to historians to avail themselves of the year both in customs and in works, in particular – after the Neolithic Revolution – in soil cultivation, especially in the higher geographical latitudes. So the "Polish Year" (Kossak 1974; Szczypka 1984; Uryga 2003) was determined closely by the nature of the countryside, which was in turn conditioned geographically, in our case mostly due to the latitude, but after the introduction of Christianity (AD 966) also due to a significant influence of the ecclesiastical calendar (Geremek 1985: 432–82, 515–9; Bogucka 1994: 11–24). Although in accordance to the historical principle of geographical possibility (Polish: *posybilizm geograficzny* – Arnold 1928: 1), one should not exaggerate the influence of geographical factors upon development of the human psyche, and especially on modelling human culture. However, whereas we have four basic seasons of the year, the civilization of ancient Egypt assumed three four-month seasons: the annual inundation of the Nile, the ripening of crops and harvesting, and the torrid heat (Narolewski 1935: 932). Three seasons were also distinguished in Assyria, whereas in southern Mesopotamia bipartition of the year was more common: in Babylonia and earlier, in the Sumerian-Akkadian culture as late as *c.* 1800 BC, the solar year was divided into two seasons, the "summer" which included the barley harvest in the second half of May or in the beginning of June, and the "winter", which roughly corresponded to today's autumn-winter. Hence the different perceptions of longer periods of time among various people (Zajączkowski 1988).

A century is an arithmetic derivative of the year, depending on our decimal system of counting; for the Sumerians and subsequent inhabitants of Mesopotamia a "century" would presumably cover 60 years. Proof of the conventionality of the notion lies in the fact that in regard to culture, the 19th century lasted from 1815 to 1918, and in Polish history probably even from 1795. Another piece of evidence to show that a cultural count of time is limited to a given historical period and particular cultural milieu is the fact that none of the contemporaries noted the end of Aztecan "infernal epoch" in 1987 (Eliade 1990: 36). Also *aeons* (similarly as myriads) appear in literature rather than elsewhere. But another notion created by man, eternity, is important for human culture.

4. Cultural time and nature

It is not only rhythms that impose time divisions upon human culture. Also the occurrence of stages in the biological processes is utilized as a specific determinant of stages of human activity.

A careful popularizer of biological and ethnographic knowledge, Alfred Szklarski (1988: 10) says in one of his travel and adventure books for youth (I was not able to trace the original source of this data – JAC) that aborigines in New Guinea "exquisitely knew the habits of *golove* [which is a bird from the family of bower-birds, *Ptilonorhynchidae*, the brown, or crestless, gardener, *Amblyornis inornatus* – JAC], and they observed carefully the bird's occupation with building 'nuptial grounds'. Particular activities of a gardener male served the people as a natural time schedule for their own agricultural activities. When *golove* started to scratch the ground, women knew that it was time to prepare a place for the plot. When the bird started to build a platform, women dug their soil with sharpened sticks, whereas when the bird strengthened the platform with moss, women fenced off their plots for protection from wild hogs. Adorning of [the gardener's] platforms would mean the time to plant vegetables, whereas finishing of the garden and the bird's nuptial voice would announce that vegetables were already ripening in the plots".

So far, we have discussed phenomena and events as a function of time – tracing their changes (Z) in time (t) – *cf.* Fig. 1. However, in the natural sciences the situation is often reversed (in these cases, curves of changes Z are often discrete, not smoothly continuous). That is the case in geology when we estimate relative stratigraphy on the basis of fossil markers, reversing the chronological sequence of these forms occurring on Earth as established by palaeontologists. Similarly, one may estimate ontogenetic age of a specimen at a given developmental stage, as do palaeoanthropologists when evaluating the age of human remains based on state of dentition and skull suture development.

III. TIME IN LIFE

Our considerations would be incomplete were we to confine ourselves to time as a parameter of the *milieu* of life and of vital processes, including etho-psychological ones (LIFE IN TIME), not taking into account that **time is** also **used by animals and humans for their** biological and social **aims**, including cultural ones (TIME IN LIFE). I am referring to situations when, to put it figuratively, time is not represented on abscissa but on ordinate. Among animals, it happens as a rule in drive-controlled behaviours. Perhaps this is always informative in character – **often in communication**. It may be similar among humans; for instance, the expression of emotion avails time parameters: frequency, speed and duration (I deliberately omit here other, non-temporal aspects of phenomena, as their intensity). It is well known that the more embittered a child, the longer it cries. A similar expression may be read from the applause at a concert hall. Still another example is given by "informative" flights of *Hymenoptera*, which often constitute symptoms of insufficiently informed information. "A wasp flies around one's nose" to get to know whom it has met – and the more curious it is, the longer it flies. Similarly, the duration of recognition or the [re]orientation flight of a hymenopteran is an expression of its disorientation in the vicinity of its nest (Chmurzyński 1996). But do we not ourselves wander about in search of a certain house, unable to recognize the changed surroundings after many years?

Some species of birds affect a more or less rhythmic dance during courtship (doves) or when carrying on display behaviour (cranes, rails, corncrakes, black cocks, or ruffs). For the common crane (*Grus grus*), dances are related not so much to nuptials, as to good spirits; one can thus consider them as a pro-aesthetic phenomenon (*cf.* Chmurzyński 2002).

The chimpanzees' "rain dance" observed by Jane van Lawick-Goodall (1971 [1974: 75–7, 143–5]) is not a real dance in fact. A male commenced it, according to Goodall, standing in the rain; he shifted his weight from one foot to the other, puffing and bellowing *crescendo*. Afterwards, he and the others ran up to the trees, tore off the branches and ran around. Suddenly one of them stopped, stood upright and rhythmically shook the tree branches forward and backward. I would not be surprised, if such were the biological roots of human joyful celebrations on Midsummer eve (Sweden) or night (Poland)...

Of greater interest was the dance of Wolfgang Köhler's chimpanzee, Sultan (Hempelmann 1926: 565). Once, in a room where three females were present, he started vigorously stepping around the cage, at the same time dragging behind himself a wisp of straw and tapping a triple rhythm with his legs. Interesting that afterwards he always made a leap toward a female, so it could be interpreted as a contamination of this behaviour with sexual drive. Nevertheless, it is still far from these phenomena to human ballet or metric poetry, similarly as there is a large distance from bird-song with various rhythms to human music.

It is worth noting that **temporal rhythms** in animal dances, and even more so in human dance, demonstrate far-reaching autonomy [similarly as the spatial rhythm in architecture], even though there also exist opposite examples. For instance, after he had invented his dance, Sultan could be made to do it by hand clapping in a triple rhythm. There exists other proof of animal relations to rhythm and melody which show that the rhythmicity of acoustic stimuli may exert a so-called "magnetic effect", *i.e.*, – what interests us here – the phenomenon of attracting dependent physiological rhythm by the frequency of independent outer rhythm perceived, even unconsciously, by animal or human individuals. Many instances of such a following of rhythms have been presented in a book by Vitus B. Dröscher (1985, chapter 10 *Life in matching time*). For example, rhythmic synchronization of song to a ticking metronome was observed in the Shama thrush (*Copsychus malabaricus*), one of the bird species with the most melodious song of all. In the light of this, the role of military marches becomes clear, as does the psychedelic influence of discotheques with their disco music characterized by hypnotic rhythm and flashes of colour light exerting a trance-eliciting influence.

As far as music tempo perceived by man is concerned, an interesting supposition was brought forward by an outstanding English mathematician, astronomer and cosmologist, Sir Fred Hoyle (1974 [1981: 180–1]), namely that the rhythm of music reflects the main functional rhythms of our brain. One may say that music constitutes the most direct expression of our cerebral processes. Unfortunately, straight evidence for this view is lacking. One observation that can be noted is that the tempo *moderato* is often assumed to be that of a natural walking pace (76 to 80 paces per minute) or of a heartbeat (70 per minute).

The sacred time ("here and now"), described by Mircea Eliade (1970, chapt. *Sacred time and myths*) constitutes a peculiar example of detachment of cultural time from physical time. And the **caesurae in human activity and culture** are defined on the basis of inherent data from history and prehistory, as well as from other humanities, which avail themselves of the year as the only period anchored in nature. It is enough to quote a following sentence: "Adopting 1764 as a great historical *ceasura* dividing old Polish literature from the modern one is undoubtedly an important achievement of the most recent studies on Polish literature" (Kott 1951: 5).[9]

GLOSSARY

Biocoenosis or biocenosis ⟨from G *bíos* 'life' + *koinósis* 'the common'⟩, *n* <*noun*>, *ecol.* – a community of living organisms inhabiting a well isolated part of the environment called a **biotope**.

Day – **solar**, *astr.* – lapse of time between successive noons with mean value of exactly 24^h.
– **lunar**, *astr.*, – lapse of time between successive moonrises with mean value of *c.* $29^d12^h44^m2^s$ 78, *i.e.* $29.^d530\ 588\ 2$.

Equinox ⟨from L *a'equŭs* 'equal' + *nox* 'night'⟩, *n* <*noun*>, *astr.* – either of the two times each year (as about March 21 and September 23) when the sun crosses the equator and day and night are everywhere of equal length [after Merriam-Webster's Collegiate Dictionary].

Exponential function, *math.* function of the type $y = e^{\varphi(x)}$, sometimes written $y = \exp \varphi(x)$, in which e is the base of the natural system of logarithms; $\varphi(x)$ may be a simple (as x) or more complicated expression.

Lunation ⟨ML *lunatio* < L *lūna* 'moon'⟩, *n* <*noun*>, *astr.* – time, called in astronomy the synodic month, between subsequent identical phases of the moon (*e.g.*, the full moons) with mean period of $29^d12^h44^m03^s = 29.^d5305582$.

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Month – **synodic**, *astr*. – see lunation.
– **sidereal** ⟨L *sīdĕrĕus* < *sīdus, -ĕris* 'star'⟩, *astr*. – time of full revolution of the Moon around the Earth with reference to a star's position with mean period of $27^d7^h43^m11.5^s = 27.^d321$.

Quantify ⟨from ML *quantificāre* < L *quantus* 'how much'⟩, *vt* <*transitive verb*> – to determine, express, or measure the quantity of something.

Precession ⟨from L *praecēdāre* 'to precede'⟩, *n* <*noun*>, *astr*. – gyration of the rotation axis of the Earth about its axis; its period, *c*. 25 725 tropical years, is called the Platonic year in Polish astronomy.

Servomechanism, *n* <*noun*>, *cybernetic*, an automatic system – technical or biological mechanism – regulating the output signal (*e.g.*, controlling the heartbeat) but adjusting its level ⟨L *servus* 'slave, servant'⟩ according to the input signal (as indicating an effort of functioning muscles, or emotion).

Solstice ⟨L *solstitium* < *sol* 'sun' + *-stet-, -stes* 'standing' > *stare* 'to stand'⟩, *n* <*noun*> – [loosely:] shortest night (*c*. 22 June) and shortest day (*c*. 22 December).

Year – **sidereal**, *astr*. – the period of one revolution of the Earth around the Sun measured with respect to the fixed stars.
– **tropical**, astr. – the interval between successive passages of the Sun through point of the vernal equinox amounting to 365.2422 mean solar days.

Year, **Platonic**, *astr*. – see Precession.

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CONTENTS