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Chronoastrobiology: Neonatal Numerical Counterparts to Schwabe's 10.5- and Hale's 21-year Sunspot Cycles

In memoriam Boris A. Nikityuk

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Abstract: By the coordination of physiological archival and cosmophysical mapping, basic and applied purposes are served. First, time structure maps, physical or biological, represent reference values that dynamically define normalcy, including, by the use of certain physiological variables, a quantification of health. Second, analyses of physiological recordings aligned with cosmo-helio-geophysical data detect health hazards such as those posed by magnetic storms. Third, ongoing ontogenetic and phylogenetic mapping may allow hypotheses concerning (if not cosmogeny, then) at least effects from beyond the solar system, if sensitive physiological indices change before a magnetic storm in interplanetary space, as human blood pressure may do, rather than concomitantly with a storm, as may human heart rate, or on the day following a magnetic storm, as human myocardial infarctions do. Fourth, as humans venture further into extraterrestrial space, away from hospitals, the monitoring for the early detection of disease risk syndromes as a step toward the timely implementation of countermeasures for reducing risk becomes a most important task. Fifth, a cross-sectional human and eventually a longitudinal comparative physiological approach,

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examining the evolution of the physiological time structures, can lead to testable hypotheses concerning the origins of life. These points were recognized by the late Boris Nikityuk, to whose memory this article is dedicated.

Zusammenfassung: *Chronoastrobiologie: Die Entsprechung zwischen den Körpermaßen von Neugeborenen zu den 10,5jährigen Sonnenfleckenzyklen von Schwabe und den 21jährigen Zyklen von Hale.* Die Koordination physiologischer und kosmophysikalischer Langzeitdaten ist für Grundlagenfragen und für praktische Zwecke nützlich. Zum Ersten stellen physikalische oder biologische Zeitstrukturkarten Referenzwerte zur dynamischen Definition von Normalität dar; durch die Verwendung gewisser physiologischer Daten kann man zu einer Quantifizierung von Gesundheit kommen. Zum Zweiten geben die Analysen physiologischer Datenaufzeichnungen in ihrer Entsprechung mit kosmo-helio-geophysikalischen Daten Hinweise auf Gesundheitsrisiken, wie sie durch magnetische Stürme verursacht sein können. Zum Dritten können fortlaufende ontogenetische und phylogenetische Aufzeichnungen Hypothesen in Bezug auf Einflüsse von außerhalb des Sonnensystems geben. Solche Zusammenhänge können wirksam sein, wenn sensible physiologische Parameter vor einem magnetischen Sturm im interplanetarischen Raum Veränderungen zeigen, wie dies möglicher Weise beim menschlichen Blutdruck der Fall ist, oder parallel zu einem solchen magnetischen Sturm, wie dies möglicher Weise bei der Herzfrequenz der Fall ist, oder am Tag nach einem magnetischen Sturm, wie dies bei Herzinfarkten gegeben ist. Zum Vierten wird die frühe Aufdeckung von Krankheitsrisiken, wenn die Menschen weiter in die extraterrestrischen Räume weit weg von medizinisch-stationärer Versorgung vordringen, ein Fortschritt in der rechtzeitigen Ergreifung von Gegenmaßnahmen zur Reduzierung der Gesundheitsrisiken eine wichtige Aufgabe sein. Zum Fünften kann ein querschnittartiges auf den Menschen bezogenes und schließlich ein auf den longitudinalen Vergleich physiologischer Daten bezogenes Vorgehen bei der Untersuchung der physiologischen Zeitstrukturen zu testbaren Hypothesen zu den Ursprüngen des Lebens führen. Diese Fragestellungen waren dem späten Boris Nikityuk wichtig, dessen Andenken dieser Artikel gewidmet ist.

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Introduction

In a project on the BIOsphere and the COSmos (BIOCOS), a systematic retrospective and prospective analysis of population statistics, such as natality, morbidity and mortality (archival mapping), is being complemented by mapping the time structures (chronomes) of key physiological variables in individual human and other selected species at different stages of development. Lifelong monitoring of physiological chronomes serves for inquiring into the sites of the origins of life by the mapping of the relative prominence of rhythms with different frequencies, during the development of species and individuals. About 24-hour changes may predominate early in life for species originating on the surface of the earth, as an adaptation to the 24-hour cycle of alternating light and darkness (LD), whereas away from LD, elsewhere or on earth, perhaps at the bottom of the sea, 7-day and/or other changes associated with, among others, geomagnetics, predominate. Apart from the foregoing information, of interest early and also late in the ontogeny of "living fossils", there are morphologically "frozen" periodic patterns in tree rings and bivalves. Repetitive patterns within patterns in materials from

Boris Nikityuk, 10. IX. 1933 – 30. IX. 1998

Professor and Head, Department of Anatomy and Anthropology, Russian Academy of Physical Education, Moscow; Member-Correspondent, Russian Academy of Medical Sciences; President-Founder, International Academy of Integrative Anthropology.

Boris was interested in physical anthropology, since his early years in medical school, when he wrote about venous sinuses on skulls in the (skull) collection of the Anthropology Research Institute of the Moscow State University. Later he worked as an assistant at the Human Anatomy Department of the First Moscow Medical Institute. He then became supervisor of the Anthropological Research Laboratory at the Institute of Physiology of the Academy of Pedagogical Science of the USSR. His career in anthropological studies culminated in the creation of the International Academy of Integrative Anthropology in 1993, of which he was founder and president, up to his sudden untimely death of a massive myocardial infarction in September 1998. His legacy in the form of data is invaluable for analyses scrutinizing human morphology and the periodicities thus ascertained over a span of 112 years also lend credence to findings over shorter spans in physiology and pathology, for associations with the extraterrestrial environment.

extraterrestrial space, including meteorites, may also provide hints of origins, as do neonatal morphological patterns discussed herein.

Rhythm Spectra in and around Us

Any one variable, physical or biological, measured long enough with sufficient density is characterized by a spectrum of rhythms with widely differing frequencies, Figure 1. This rhythmic element is superimposed in dense series upon a deterministically or otherwise chaotic element. In long series, both chaos and rhythms undergo trends, the third element in the chronome of a given variable, cosmo-physical or physiological, Figure 2. Documented for physiologic variables, studied under usual socio-ecologic conditions are, among many others, biological periods of, e.g., about 0.1, 1, 3.6 and 10.5 seconds, of about 90 minutes, about 1, 3.5, 7, 20 and 30 days, and about 0.5, 1, 7, 10.5, and 21 years, Figures 3 and 4

(Halberg, 1969; Roederer, 1996; Halberg and Cornélissen, 1998; Nikityuk et al., 1998a-c).

Academy Endorsement

These periodicities were the topic of a special session at the Russian Academy of Medical Sciences in Moscow on June 30, 1997, triggered and organized by the Institute of Pediatrics of the same Academy. At this conference, a project on the BIOsphere and the COSmos, BIOCOS, was officially endorsed (Halberg et al., 1998) for presentation at the meeting in St. Petersburg of the International Union of Physiological Sciences immediately following this conference, and elsewhere (Halberg, 1997). At the meeting in Moscow, Boris A. Nikityuk gave a lively presentation. His slides were a delight to the eyes of physiologists who wish to broaden the rhythm spectrum, as they were for clinicians who wish to exploit this spectrum, and to chronobiomimetic engineers, who should construct appropriate devices (Cornélissen et al., 1999). Boris presented much data on the length and weight of Muscovite newborns. He aligned these curves with those on geomagnetic activity from 1874 on to the present. He interpreted his data as time-macroscopic signatures of heliogeophysics. We subsequently could validate in a time-microscopic analysis, that he had presented data, documenting the biological decade and double decade, i.e., circaundecennian and circavigintunennian changes in human morphology, modulated by yet longer cycles, Figure 4 (Nikityuk et al., 1998a-c).

The Scope of Boris Nikityuk's Contributions

Boris' unique serial population data, covering 112 years (Figure 4), exceeded in length what many others had published, such as Düll and Düll (1934, 1935) and, through a lifetime, Chizhevsky (1940, 1968; cf. Dubrov, 1978; Sothern and Halberg, 1989; Halberg et al., 1991; Gamburtsev et al. 1994; Breus et al., 1995; Gheonjian, 1996; Khomeriki et al., 1998; Sothern et al., 1998). Boris' data time-macroscopically but persuasively showed that measurements on the human newborn may be associated with non-photic effects from the sun (Tarquini et al., 1997). Time plots of neonatal height, weight and the circumference of the head, chest and abdomen reveal changes apparent to the unaided eye, as recurring with periods corresponding at least numerically to sunspot (Wolf) number-gauged solar activity or to geomagnetic disturbance gauged by the index Kp (Figure 5), invisible on earth, yet not less tangible than light or temperature, leading to associations summarized elsewhere (Halberg et al., 2000).

With the publication of data covering over a century, Boris documented his love for and his dedication to the study of human physiology, "frozen" in the form of population statistics of neonatal anatomy (Nikityuk and Alpatov, 1984). The secular trends in human population growth and development he associated with solar activity cycles, led him to the concept of a modern integrative anthropology. He defined this field in another paper (Nikityuk 1996), including in the meaning of his integrative anthropology the "individual, constitutional, professional, regional

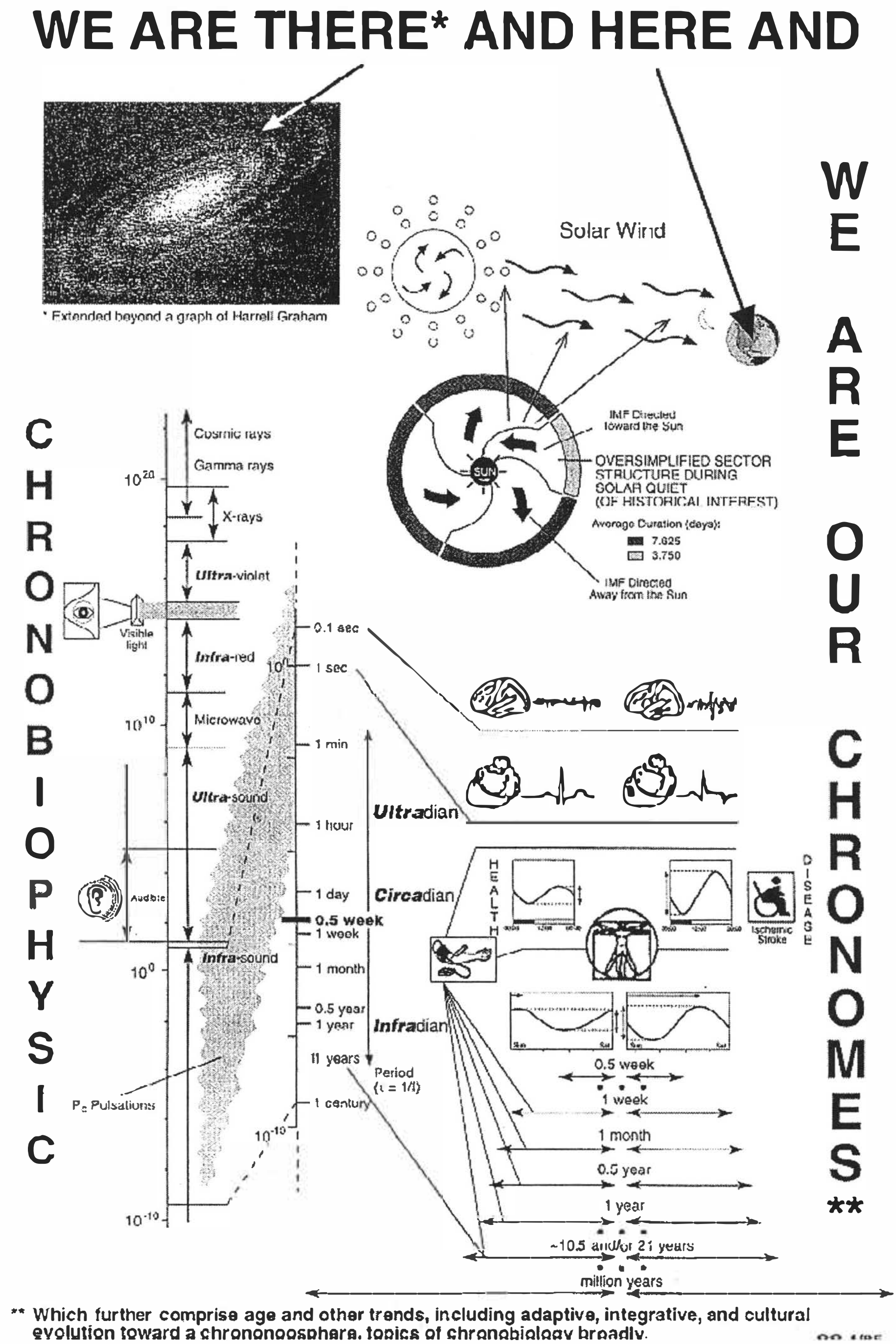

Fig. 1. The chronomes in us, that came about as adaptations to chronomes around us, and also as integrations of chronomes within us, to be eventually coded genetically, await further exploration for matching patterns in physiology and physics. Immediate applications in health care for stroke prevention complement basic topics, including the search for life's origins, all dividends of coordinated physical and physiological monitoring.

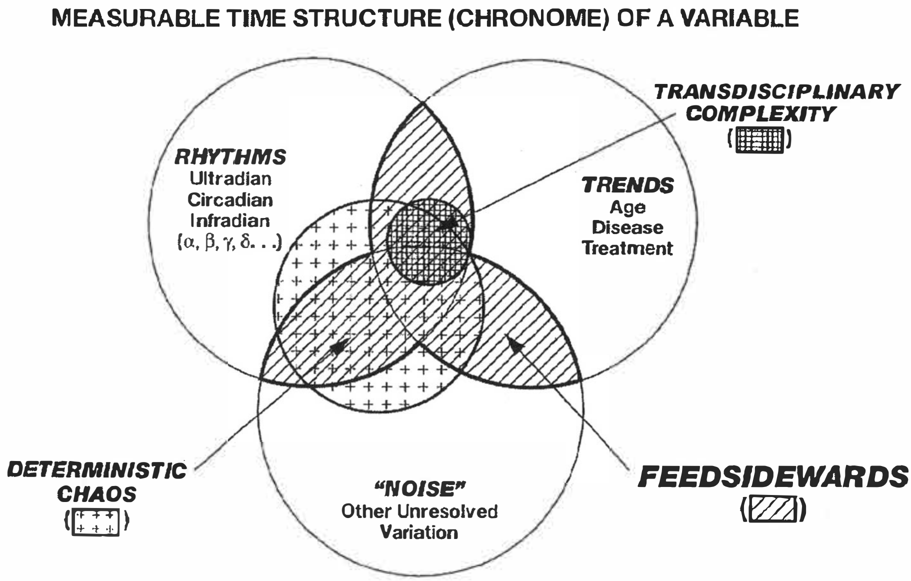

Fig. 2. More and more components in the spectrum of physiological variation are found to have physical numerical counterparts and, vice versa, numerical counterparts have been found for some unusual physiological cycles, believed to be purely societal, such as the week. These physical and biological spectra with irregular chaotic and complex variations and with trends in endpoints of rhythms, chaos and complexity constitute time structures, chronomes. The mapping of physical and biological chronomes proceeds as yet opportunistically in a project on the BIOsphere and the COSmos (BIOCOS), with a systematic Asian Chronome Ecologic Study of Heart Rate Variability (ACEHRV), now extended to an International project (ICEHRV), focusing on the human electrocardiogram. A data base of reference values thus accumulates with a target length of at least 7 days beat-to-beat for the electrocardiogram and again for at least 7 days at intervals from 15–60 minutes, in the case of human blood pressure. Such mapping is critical for a quantification of health in the range of the otherwise neglected physiological variation. Chronome maps are the invaluable and indispensable reference values for the detection of disease risk syndromes. "Measure what is measurable and render meaningfully measurable in time [as time series] what as yet is not" is what chronomes are all about.

or ethnic departures from the general scheme rather than the construction of the body proper".

Anthropometric Studies in Moscow

Neonatal Body Length

Body length at birth was recorded from random samples of 25-150 babies in Moscow, Russia, during the span from 1874 to 1985, separately for boys and girls. Such long time series lend themselves to the study of secular trends and of environmental influences. Each data series was analyzed by linear and nonlinear rhythmometry (Halberg, 1980). An about-50-year cycle, prominent for both boys and girls, may be numerically associated with tropospheric temperature variations.

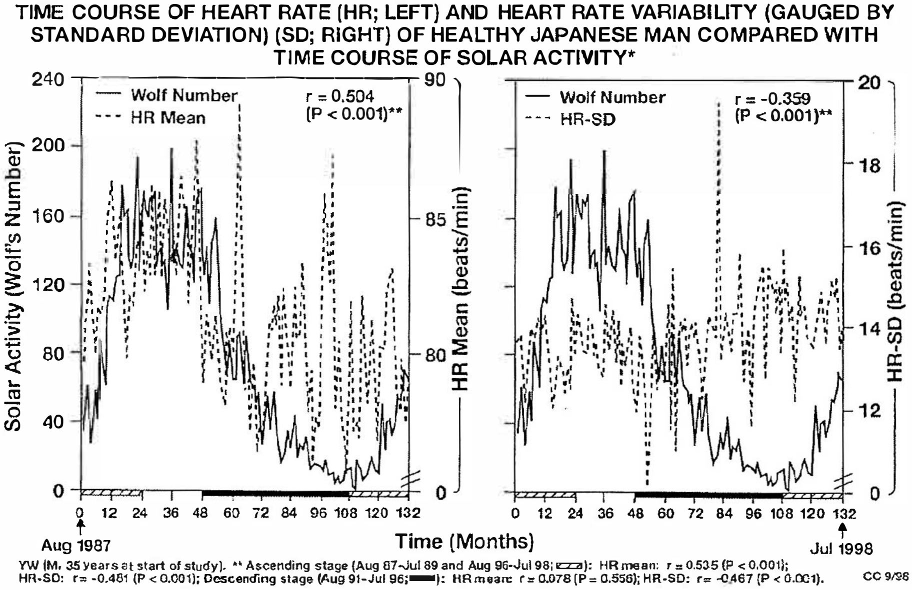

Fig. 3. Half-hourly around-the-clock heart rate measurements taken automatically about every 30 minutes for 11 years show associations with the about 10.5-year sunspot cycle. Whereas heart rate appears to vary in phase with solar activity, gauged by Wolf's number, heart rate variability, assessed by the monthly standard deviation, correlates negatively with solar activity.

A secondary peak at a frequency of one cycle in about 22 years is also observed. Moreover, a plot of the data as a function of time reveals a slight decreasing trend. A model consisting of a first-order polynomial and two cosine curves with trial periods of 50 and 22 years was thus fitted nonlinearly. All three components were found to be statistically significant, as attested by the non-overlap of zero by the respective 95% confidence intervals (CI) for the slope of the linear trend and for the amplitudes of the two periodic components.

Specifically, for the boys the slope was -0.018 (95% CI: -0.026; -0.011) cm/year, and for the girls it was -0.017 (95% CI: -0.024; -0.009) cm/year. The longest infradian period (in years) was 52.72 (95% CI: 46.97; 58.47) for boys and 51.15 (95% CI: 44.84; 57.46) for girls. Its double amplitude (in cm) was 1.64 (95% CI: 0.98; 2.30) for boys and 1.52 (95% CI: 0.80; 2.24) for girls. The other infradian component had a period (in years) of 20.28 (95% CI 18.76; 21.86) for boys and 20.76 (95% CI: 19.05; 22.78) for girls. Its double amplitude (in cm) was 0.84 (95% CI: 0.22; 1.46) for boys and 0.84 (95% CI: 0.16; 1.52) for girls. A smaller peak in the least squares spectrum around one cycle in 7 years was not validated nonlinearly.

A very close agreement between boys and girls for the point and interval estimates of the slope and of the period lengths and double amplitudes of the two periodic components indicates that changes in body length at birth follow a very similar pattern in both genders. Girls are on the average smaller than boys, as documented by the non-overlap of the 95% CIs of the MESOR for girls (51.57; 95% CI: 51.33; 51.81 cm) and for boys (52.21; 95% CI: 51.98-52.43 cm).

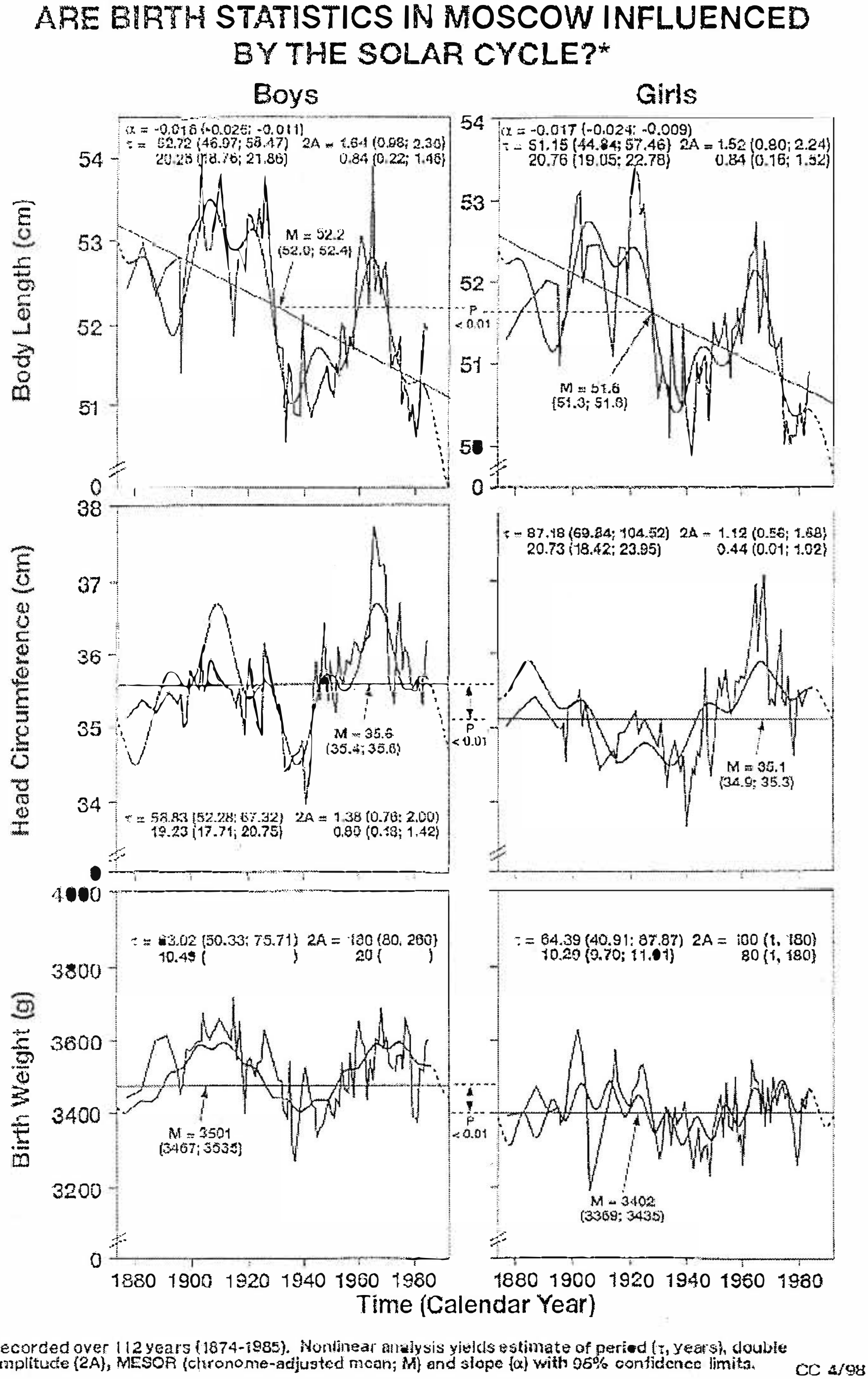

Fig. 4. "Secular" trends in body length, head circumference and weight at birth in Moscow (Russia) measured between 1874 and 1985 (112 years) include about 10.5- and/or 21.0-year cycles, which are in keeping with a possible modulation of human morphology by the solar activity cycle.

The great similarity between boys and girls in the time course of body length at birth is supported by a high correlation coefficient ($r=0.849$). A relation between body length and birth weight is statistically significant for boys and girls (boys: $r=0.589$; $P<0.001$; girls: $r=0.521$; $P<0.001$). The about 20.5-year cycle is hence also in keeping with a possible modulation of body length at birth by the solar activity cycle.

Head Circumference

Another anthropological measure, neonatal head circumference, was also recorded and available from Boris as yearly averages from the random samples of 25-150 babies of each gender between 1874 and 1985, providing the neonatal body length. As in the case of body length at birth, head circumference at birth is smaller for girls (35.13; 95% CI: 34.93; 35.34 cm) than for boys (35.59; 95% CI: 35.38; 35.80 cm) ($P<0.01$).

Least squares spectra reveal a prominent component with a period of about 60 years for boys and about 80 years for girls. In addition, an about 20-year component constitutes a secondary peak in the respective least-squares spectra. A model including these two components was further tested and validated nonlinearly for boys and girls, as shown by the non-overlap of zero by the 95% CIs for the amplitude of each tested component. For boys, the model resolved nonlinearly consists of an infradian component with a period of 58.83 (95% CI: 52.28; 67.32) years and a double amplitude of 1.38 (95% CI: 0.76; 2.00) cm, and of another infradian component with a period of 19.23 (95% CI: 17.71; 20.75) years and a double amplitude of 0.80 (95% CI: 0.18; 1.42) cm. For girls, the corresponding model is characterized by an infradian component with a period of 87.18 (95% CI: 69.94; 104.52) years, with a double amplitude of 1.12, (95% CI: 0.56; 1.68) cm, and another infradian component with a period of 20.73 (95% CI: 18.42; 23.95) years, with a double amplitude of 0.44 (95% CI: 0.001; 1.02) cm.

With the data available, the 95% CI of both periodic components are quite broad. Nevertheless, the nonlinear results indicate that the about 87.2-year cycle resolved nonlinearly for the girls may be longer than the about 58.8-year cycle resolved for the boys, as observed by the non-overlap of their 95% CIs. A plot of the data as a function of time reveals, however, that, contrary to body length at birth, in the case of neonatal head circumference, the second cycle has a much larger amplitude than the first cycle of the longest infradian component. Moreover, the first cycle, while dampened for the boys, is practically absent for the girls. This discrepancy between boys and girls may account, at least in part, for the difference in the estimated period length. A correlation analysis of neonatal head circumference between boys and girls shows a relatively close association ($r=0.842$; $P<0.001$), supporting the proposition that differences in period length may in fact result from an asymmetry between the first and second cycle of the about 60-year component in the case of neonatal head circumference.

Although statistically significant, the correlation between neonatal head circumference and birth weight (boys: $r=0.386$, $P<0.01$; girls: 0.289; $P=0.01$) or body length at birth (boys: $r=0.309$, $P<0.01$; girls: $r=0.317$, $P<0.01$) is much less pronounced, a result suggesting the presence of secular trends not only in one or the other anthropologic measure of birth statistics, but also in their inter-relationships.

Birth Weight

A major component of variation common to boys and girls is an about 63-year cycle, validated nonlinearly. Girls, but not boys, displayed an about 10.2-year cycle (P=0.010), also validated nonlinearly. Other components found in the least squares spectra were not anticipated and differed between boys and girls.

Although the data series are still limited for an investigation of changes along such long time scales, one component that seems to remain consistent for the different indices available (neonatal body length and head circumference and also birth weight) relates to the about 20-year component and its second harmonic with a period of about 10.2-years, which are in keeping with a possible modulation of human neonatal morphology by the solar activity cycle.

A Non-photic "Switch": Heliogeomagnetics?

A 10.2-year component had been reported for the Ap and aa indices of magnetic disturbance during a 103-year span starting in 1868 (Delouis et al., 1975), thus approximately matching the observation span of Boris' investigation. Although not necessarily causal, this numerical association warrants further study of possible environmental effects beyond light and temperature on neonatal morphology. This is the more pertinent since neonatal blood pressure and heart rate have been reported to be resonant with about 7-day cycles in the local geomagnetic index K in Moscow (Syutkina et al., 1997) and to undergo changes matching the solar activity cycle (Syutkina et al., 1996), whereas their endogenicity has been documented by free-running in adulthood (Halberg et al., 1965). Whereas more work is needed to understand why girls and not boys exhibit an about 10.2-year cycle in birth weight, there are precedents for anthropological differences between boys and girls (Grande et al., 1994).

Body weight, and more generally growth, also undergo rhythmic changes along the scales of the day, the month and the year (Garcia Alonso et al., 1993; Otsuka et al., 1993). In humans, body weight is usually higher in winter than in summer. Human growth during the first few years of life also shows a circannual component that is determined not only by the seasons but also as an endogenous feature of growth synchronized by the time of birth (Garcia Alonso et al., 1993). Variations along the scale of the week have also been demonstrated for variables related to growth and regeneration (Hübner, 1967; Cornélissen and Halberg, 1994; Halberg and Cornélissen, 1994; Cornélissen et al., 1996), with similar features reported in fossil records (Kaiser et al., 1990).

The Biological Decade and Double Decade

We can also turn to the degree of generality of chronome components such as the about 10.5- or about 21.0-year cycles in additional data on the circumference of chest and abdomen at birth in Moscow (Russia), as well as in data on weight, height and head, chest and abdomen circumference at birth of Russian and Kazak babies born in Alma-Ata (Kazakstan). The extent of synchronization of these two components with periods of about 10.5 and 21 years can be examined among variables in different populations living in the same or in different geographic and geomagnetic locations.

After detrending, estimates of the amplitude and phase of the 21-year Hale and the 10.5-year Schwabe-like cycles were obtained by the least-squares fit of cosine curves with trial periods of 21.4 and 10.2 years, respectively (corresponding to spectral peaks of Wolf's number estimated since 1749 and of Kp, recorded since 1932). Results were summarized by population-mean cosinor (Halberg, 1969) to examine the extent of synchronization of these two components among the different data series.

The about 21.4-year component was found to be statistically significant for height and head circumference in Moscow, as well as for chest circumference in Moscow and for weight and height in Alma-Ata (and incidentally also for neonatal weight in Minnesota). The about 10.2-year component was detected with statistical significance only for the weight of girls in Moscow and for the height of boys in Alma-Ata. The phases of both components show a tendency to cluster when summarizing results from all data series (21.4-year component: $P=0.056$; 10.2-year component: $P=0.055$), peaking, respectively, about 13.7 and 9.0 years after the reference time (January 1874) with recurrence every 21.4 and 10.2 years, respectively. A summary of all birth statistics recorded in Alma-Ata (20 series) reached statistical significance in the case of a 21.4-year component ($P=0.003$), peaking about 16.6 years after the reference time, and borderline statistical significance in the case of the 10.2-year component ($P=0.094$), peaking 7.5 years from the reference time. By comparison, birth statistics in Moscow showed a similar pattern both in the case of the 21.4-year component ($P<0.001$) peaking 8.7 years from the reference time and in the case of the 10.2-year component ($P=0.005$) peaking 0.3 year from the reference time. The 7.9-year difference in phase of the 21.4-year component assessed in Alma-Ata vs. Moscow is statistically significant, as attested by the non-overlap of their 95% confidence intervals.

The above-mentioned clustering of phases suggests some degree of synchronization of the Hale and Schwabe cycles among different birth statistics recorded in different geographic locations and thus a planetary effect. Separate analyses in Moscow and Alma-Ata, however, reveal a difference in phase for the 21.4-year component. Several limitations should be considered in interpreting the results of this study. First, any magnetic disturbance effects on birth statistics constitute at best one among several environmental influences. Second, some of the data series cover at best two cycles of the Hale component, thus rendering the estimation very difficult. In other words, both the amplitude and phase estimates are associated with a relatively large uncertainty. This is the more so since the presence of even longer-term trends in some of the data series required them to be detrended prior to analysis. Even a limited second-order polynomial trend may have affected the estimation of the two components of interest herein, i.e., of a biological decade and double decade.

An influence of geomagnetic disturbance on birth statistics is further supported by cross-spectral coherence (CSC). CSCs have in common with correlation coefficients that they describe the relation between two variables. They are less unspecific in that they describe the relationship at a certain frequency. To avoid listing spurious associations, only CSC coefficients away from spectral peaks are listed here. CSC is found between Kp (and to a lesser extent between Wolf's number) and several of the neonatal indices in Moscow over 112 years at a frequency of one cycle in 7 years ($P=0.004$ for birth weight of boys; $P=0.012$ for body length at birth of boys; and $P=0.007$ for head circumference at birth of girls). This component had been singled out earlier as possibly being associated with cosmic influences (for review see Cornélissen et al., 1998). Moreover, the results of the transverse analyses carried out herein are in keeping with results obtained longitudinally over 31 years, found by Sothern et al. (1998). Specifically, the blood pressure of a clinically healthy man was found to cross-correlate positively ($P<0.05$) with several planetary indices of magnetic activity peaking at a lag of 1 month while his heart rate cross-correlated negatively ($P<0.05$), the strongest association occurring at lag 0.

For heart rate, a statistically significant spectral coherence was also found at a frequency of one cycle in 0.493 year ($P<0.001$). Associations between geomagnetic disturbance and heart rate had been noted earlier (Cornélissen et al., 1996, 1999; Baevsky et al., 1997) and may have a bearing on the increased incidence of myocardial infarctions observed on the day following a southward turn of the vertical component of the interplanetary magnetic field induction vector (Halberg et al., 1991; Breus et al., 1995; Roederer, 1995). Geomagnetic disturbance indices are characterized by a prominent half-yearly component (Grafe, 1958; Fraser-Smith, 1972) that may account for infradian changes in circulating melatonin with a pattern that varies with latitude (Martikainen et al., 1985; Tarquini et al., 1997). Using a linked cross-sectional (hybrid) approach, associations between the local geomagnetic disturbance index, K, in Moscow and neonatal heart rate and blood pressure have also been shown (Syutkina et al., 1997). These results involved components with a period of about 7 days, which are very prominent in early extrauterine life and may have their counterpart in the fourth harmonic of the solar rotation (Halberg et al., 1990a, 1991).

The foregoing time series analyses (time-microscopy) revealed that different body features of the same population of babies may be differentially influenced by effects from the sun other than those mediated by visible light. The 10.5-year Schwabe cycle in sunspot numbers was reflected in the body weight of girls, but not in that of boys. Neonatal length and head circumference showed numerical equivalents of the 21-year Hale cycle in Moscow at 55°N geographic and 50.76°N geomagnetic latitude. Furthermore, since Boris had extended his data collection to Kazakstan, comparing Russians and Kazaks in the same geomagnetic and geographical location in Alma-Ata at 43.19°N geographic and 33.67°N geomagnetic latitude, additional differences are found, Figures 5 and 6. Body weight in Alma-Ata showed for Russians an about 17-year periodicity in both boys and girls, whereas in Moscow a 10.3-year periodicity was found in girls-only. Kazak girls and boys in Alma-Ata show a circavigintunennian period which in boys is nearly double in amplitude, as compared to that of girls, Figure 6. By contrast with the differences in neonatal weight, the dynamics of body length are more similar at different latitudes, with a prominent about 20-year periodicity resolved by non-linear least-squares in data from each of the sites investigated (including Minnesota). Clearly, the about 10.5-year Schwabe cycle and the about 21-year double-polarity

Hale cycle have numerical associations in neonatal biology and also in adults, Figure 7.

Boris' succinct descriptions of the results were an expression of more than scientific curiosity. His interpretations of our analyses showed his active mind better than the results themselves. We were, as Boris put it, discussing the "bottom floor" of life in the cosmos. A non-photic set of influences from the sun and from beyond is a basic "mover", Table 1. This non-photic solar effect of corpuscular emission, geomagnetics, gravitation, etc., although more difficult to discern than the sun's shining and warming effects, is not trivial, even when compared with the all-pervasive effect of light and heat from the sun. As suggested in the context of birth statistics by Randall (1990), at middle latitudes, the photic influence dominates on the surface of the earth by day, yet, what is new in melatoninology, helio-geomagnetics may take over by night (Tarquini et al., 1997) and heliogeomagnetics may play their role around the clock near the poles (Martikainen et al., 1985) and probably at the bottom of the sea (Halberg et al., 1991; Cornélissen et al., 1999). (Randall and Randall [1991] also deserve credit for detecting a circasemiannual periodicity in hallucinations, which, as they point out, occur as a typical symptom in epilepsy, also characterized by a half-yearly pattern in the distribution of over 50,000 cases [Halberg et al., 1991].)

The cycles in Boris' data are the sum, or rather the product, of effects occurring both in our lifetimes and over the much longer spans of an external Darwinian (1859) as well as an internal integrative (Halberg et al., 1990b) evolution. The question whether the rhythmic element of chronomes is endogenous or exogenous, a topic of heated debates in newspapers as well as at symposia, is ill-posed. The proposition of many Soviet investigators that earthly life is an echo of the sun pays homage to Pavlov while ignoring Mendel. The sun's photic and nonphotic effects eventually entered our genome and thus rendered us responsive to several latitude-dependent master-switches at selected frequencies. A scenario of our "adapting" to internal needs by temporal interactions within us as well as by adaptation to external stimuli is offered by the study of the ontogenies of humans (Halberg et al., 1990b), pigs (Thaela et al., 1997), rats (Diez-Noguera et al., 1996) and crayfish (Fanjul-Moles et al., 1998) in a broad phylogenetic perspective (Halberg et al., 1991; Cornélissen et al., 1999). Boris' point of view was that "the bottom floor" is the sun acting via space and terrestrial weather, via pandemics (Ertel, 1993, 1994), economics (droughts) and political upheavals. Physiological associations are reinforced by morphologic effects upon newborns, noted elsewhere. At middle latitudes on earth, the primary synchronizing effects of visible light and temperature are reinforced, not confounded, by those of secondary synchronizers, in the last analysis also cosmic in origin (Tarquini et al., 1977).

We use herein the word "cosmic" advisedly, in Boris' sense, by accepting the testability that there may be effects from beyond the solar system that bring about storms of the interplanetary magnetic field rather than the latter originating exclusively in the solar system. This would be an answer to the observation that a rise in systolic, mean and diastolic blood pressure may precede a magnetic storm in space, the latter gauged by a southward turn of the vertical component of the interplanetary magnetic field, Bz, an effect detected by superimposed epochs (Halberg et al., 1991).

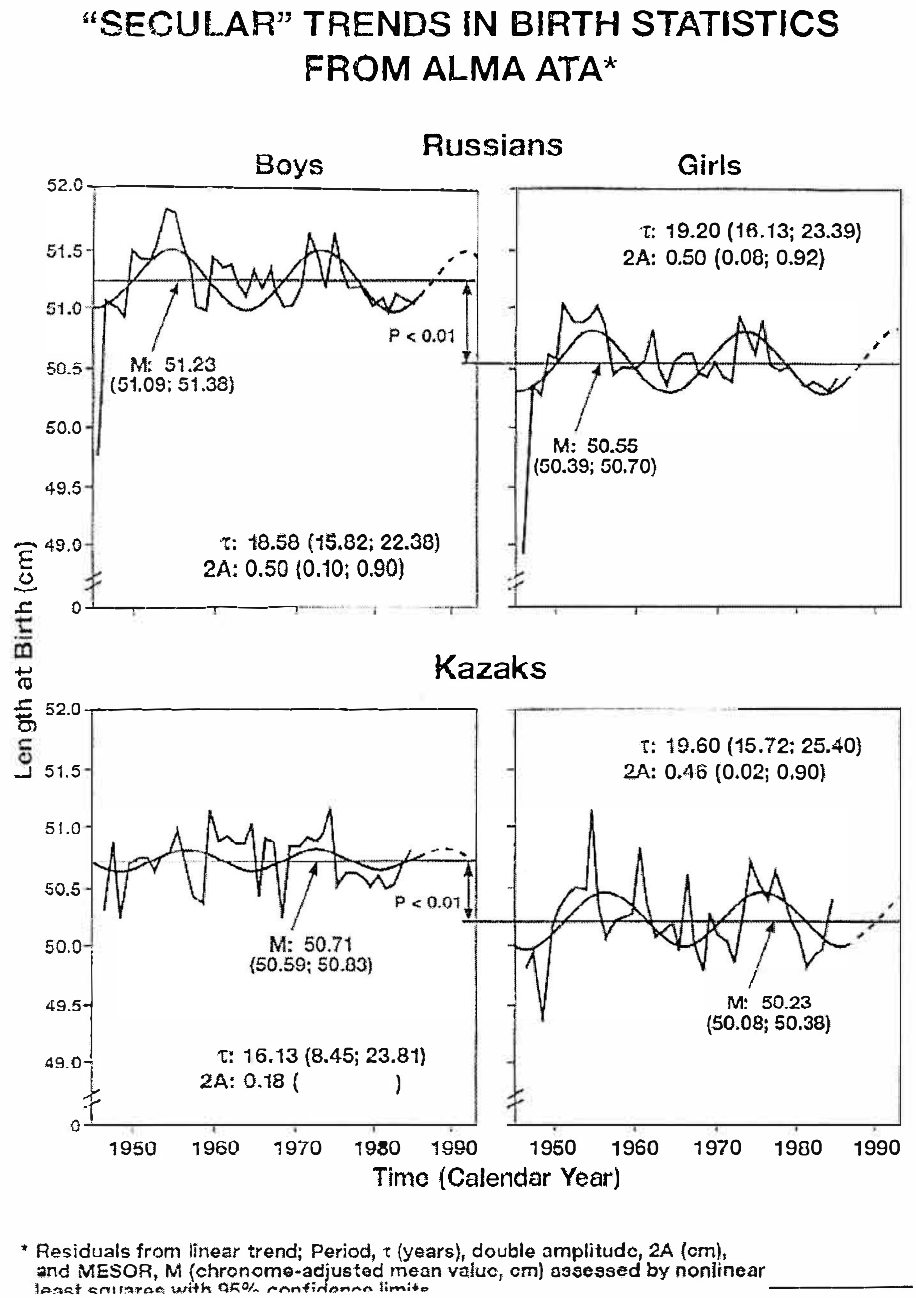

Fig. 5. An about 21.0-year Hale cycle is also detected in shorter series of body length at birth in Russian and Kazak babies in Alma-Ata, in data collected between 1946 and 1985.

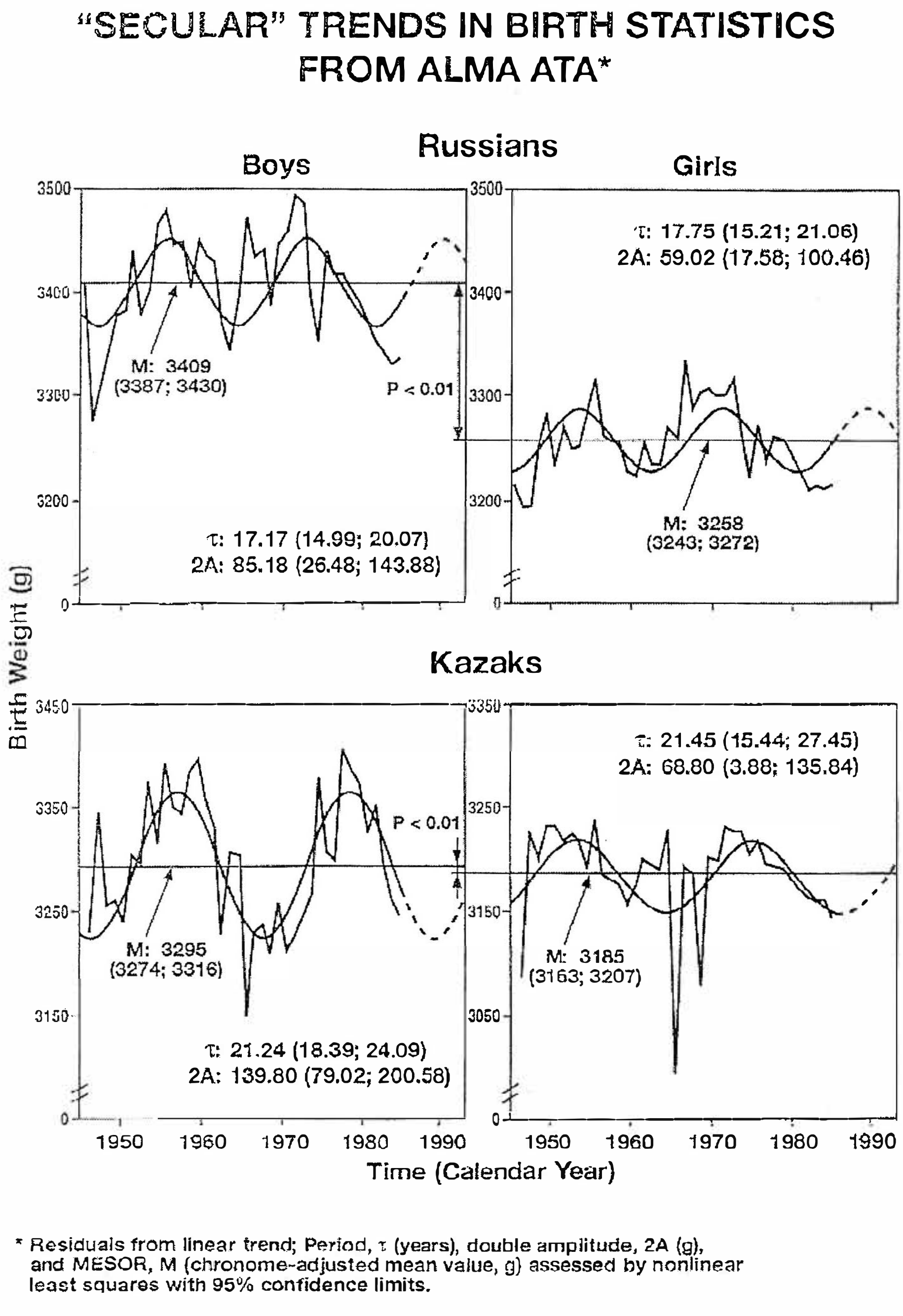

Fig. 6. An about 21.0-year Hale cycle is also detected in shorter series of birth weight in Russian and Kazak babies in Alma-Ata, in data collected between 1946 and 1985.

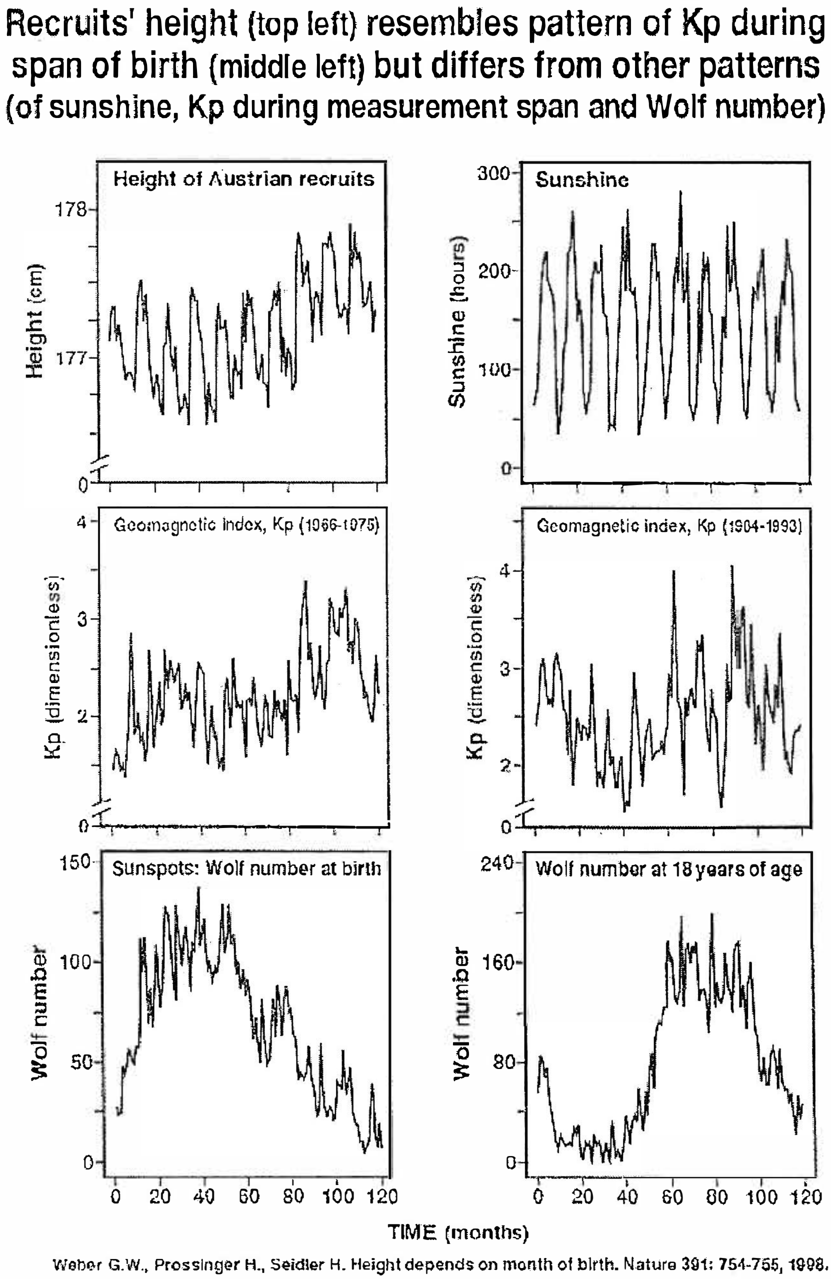

Fig. 7. About-yearly changes in body height at 18 years of age, assessed transversely in Austrian recruits, are modulated by an about 11-year cycle, as is apparent by the naked eye and also documented by analyses of the original authors, who refrain, however, from comments about associations with non-photic effects from the sun, referring only to sunshine. The same association was also missed by the editors and referees of the journal Nature. These human morphological data also show in our analyses a cross-spectral coherence with the geomagnetic index, Kp, at a frequency of one cycle in 5.45 months.

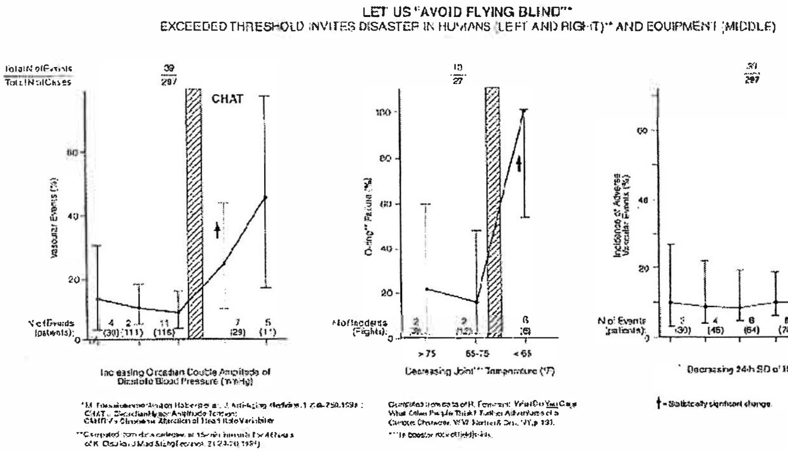

Fig. 8. The editor (Fossel, 1998) of a journal in which some of us published a recent paper (Halberg et al., 1998b) inserted the following note: "Talking about 'blood pressure' as a single figure is similar to knowing the average height of a mountain range: an interesting statistic, but completely useless to a pilot trying to make it through a mountain pass alive. Realistically, we need to consider not merely the mean stress on an aging vascular endothelial cell, but the 'peaks' that it has to 'fly over' as well. Aging vessels are-to an extent-the end result of such stresses. Halberg et al. suggest that many patients may be apparently normotensive, yet (because of circadian peaks in blood pressure) have the catastrophic risks of any other severely hypertensive patient. They recommend that [medical practitioners] avoid 'flying blind' and begin to measure peak pressures more accurately if we are to avoid disaster." The evidence supporting his foregoing warning is aligned with a result of Feynman's (1988) probe into the Challenger disaster, uncovering the limits of acceptability for equipment, just as there are limits to acceptable physiological variability. Too much blood pressure or too little heart rate variability can lead to a massive stroke or heart attack. These in turn lead to infirmity which can jeopardize a mission to Mars or beyond, while they also constitute major cripplers on earth.

In Vinnitsa, Boris told one of us (OS) that a chronobiologist's wish is his command. Likewise, his wish for an integrative anthropology based on chronobiology is our command. An integrated chronophysiology and chronomedicine were to be incorporated into the statutes of his International Academy of Integrative Anthropology. Chronobiology adds substance to concerns about health and human development in a broad perspective, to the extent that it resolves ubiquitous rhythms in and around us that otherwise remain in a neglected range of normal values of our physiology.

Chronoastrobiology

Gabriel A. Tikhov wrote two popularizing booklets, on astrobotany (1949) and on astrophysiology (1953; cf. Cowing, 1999). Explicitly about astrobiology (Bunk, 1998; Zubrin, 1996), Hubertus Strughold wrote in 1953:

Early man studied the heavens first for guidance in computing the seasons as an aid to agriculture, and later for assistance in navigation, and still later to enlarge his knowledge of the cosmos. Now, as the time approaches when we may be able to travel to some of our neighbors in space, we search the stars for an answer to another question: Is there life elsewhere in the universe ?

"Up to the middle of the nineteenth century," Percival Lowell [1908, 1909] once wrote, "astronomy was busied with motions. The wanderings of the planets in their courses attracted attention ... to the practical exclusion of all else concerning them. ... But when the century that has gone was halfway through its course, a change came over the spirit of the investigation; with the advance in physics, celestial searchers began to concern themselves with matter, too. Gravitational astronomy had regarded the planets from the point of view of how they act; physical astronomy is intent upon what they are."

To Lowell's definitions there should perhaps be added a third, which might be called astrobiology, as distinguished from astrophysics. It is the investigation of the planets with regard to their habilitability for life [italics added]. From the known facts of what the planets are, it proceeds to ask: Can they support living beings-and, if so, of what kind?

After pointing to progress made by the time of his writing, Strughold (1953) continued:

Ecology is that science which treats of the physical environment of a place or region, with regard to its fitness as a site for the existence and development of living things. This field is known as physical ecology. The science deals also with the adaptive reactions or responses of living things to their environment, in order to make their existence easier wherever they may be; and this is known as physiological ecology.

As a branch of biology, ecology embraces both the biological kingdoms: animals and plants, in the form of human ecology, animal ecology, and plant ecology. Until now, ecology has been applied only to the earth as an environment, often under the name, ecological geography. Extending it to other planets, we enter a field which may be called planetary ecology.

In 1974, by the invitation of one of us, Strughold wrote about "Cyclobiology", a position hardly surprising, since he had been interested in rhythms in the 1920s (Hoffman and Strughold, 1927) and maintained that interest when he published a book in 1971. Strughold's lunar medicine (1967) is no longer utopian. A new astrobiology leads to a comprehensive environmental perspective (Reiter, 1953), which sees us as more than a link in a terrestrial food chain.

Seeking our past and future in the context of the stars sounds poetic and utopian, but it is the raison d'être of a virtual co-laboratory (Bunk, 1998; Cady, 1998; Lawler, 1998) now including a burgeoning chronoastrobiology within an ongoing project on the BIOsphere and the COSmos, BIOCOS (Halberg et al., 1991, 1998; Halberg, 1997). If astrobiology includes the use of humans and robots in space exploration (Soffen, 1997), then the screening of disease risk syndromes by the monitoring of physiological functions is an aspect of astrobiology, aimed at reducing disease risk (Halberg et al., 1998; Otsuka, 1998). Chronobiologic instrumentation and analyses are affordable and are needed on earth as well as most urgently en route to Mars (Figure 8). They are a good investment, serving to change a health care based on spotchecks to one based on time series. The same chronoastrobiological approach also serves to define physiological functions in the range where they occur, and thus can define health positively rather than as the absence of disease. By splitting the range of physiological variation into deterministic chaos and rhythms and by separating physiological trends from those associated with disease risk elevation and eventually with pathology, good science and preventive health care can both be achieved. Our memorial directed to Boris will be to strive for his goal with analyses such as those formulated for a budding chronoastrobiology (Halberg et al., 1996, 1998a-c).

The preceding thoughts and data were expressed and Boris' data were shown in opening two meetings in China, one on chronobiology and chronomedicine in Kunming (Halberg and Cornélissen, 1998), and another on rehabilitation in Chengdu. These meetings, and a conference of the Italian Society for Chronobiology in Chianciano Terme in November 1998, honored both Boris Nikityuk and Werner Menzel, who died on September 17, 1998 just short of his 90th birthday (*October 8, 1908). Werner Menzel preceded Boris' activities by attempting to introduce chronomedicine into health care practice, and was apparently first to introduce a pump for drug administration (Menzel, 1962). Both Boris and Werner looked at the dynamics of body function: Menzel sought their expression in our pathology, Nikityuk in our morphology. Boris died in the prime of his life, but was able to provide an invaluable legacy of anthropometry covering five morphological variables in two geographic locations on two ethnic groups, in some of them for 112 years.

An international study, leading to a new discipline of chronoastrobiology, is now collecting reference values for our physiology, to paraphrase Boris Nikityuk, at all "floors" that determine the quality of life, political, economic and health-related, concerned with necessities and utilities as well as amenities (Cornélissen et al., 1999). Boris, you are still with us in spirit, and we miss the daily exchanges with you, which we enjoyed as much as you welcomed the prompt numerical analyses of your archives.

Acknowledgement. We are indebted to Dr. Juan Roederer (Professor of Physics Emeritus, International STEP Coordinator, Geophysical Institute, University of Alaska, Fairbanks, Alaska), who advised concerning our distinction between photic and non-photic effects, and who wrote that he had not seen the distinction made earlier. The geophysicist among us liked the dichotomy; Dr. Roederer indicated that in any first reference to the dichotomy, we should amplify on photic effects as relating to electromagnetic radiation, notably in the visible domain, whereas non-photic effects refer to those of corpuscular emissions from the sun, and more broadly to heliogeomagnetics, ultraviolet flux, gravitational, and other effects. After giving such details once, it seemed appropriate to him to refer simply to "photic" vs. "non-photic" effects when addressing a broad readership such as that in the journal Science, wherein emphasis appears on light as a master switch, in the context of about 24-hour rhythms (Plautz et al., 1997; Pennisi, 1997). By the 1950s it was documented that the temporal placement along the 24-hour scale of light and darkness alternating at 12-hour intervals could change the temporal placement of rhythms in the formation of RNA and DNA, in phospholipid labeling, in glycogen content, and in cell division of mouse liver, and that it could further manipulate the mitotic rhythm in pinnal epidermis of mice at the cellular level (Halberg et al., 1958a), and also rhythms in circulating glucose and corticosterone of mice. At the level of the organism as a whole, rhythms in the response to audiogenic circulation, consisting of a change from no-effect to convulsions and death were shown to be a function of timing the noise stimulus (Halberg et al, 1955, 1958b). Herein and elsewhere, we emphasize the added role of heliogeomagnetics, a non-photic stimulus, in synchronizing at middle latitudes an about half-yearly change in human circulating melatonin by night (whereas sunshine synchronizes this hormone's concentration in blood by day), insofar as one can infer from 1 rather than 2 equinoctial peaks along the scale of

a year; at a very high latitude there is an about half-yearly rhythm in circulating melatonin at noon (Tarquini et al., 1997).

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