

Neurobiology of Circadian Cycle: A Contemplative Approach

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Abstract

This paper is a part of D.Litt research work. Keeping in view of present pandemic situation the paper is based on quasi experimental data on circadian cycle. The focus is to provide the evidences on neurobiological clock within the organism that mobilizes, energizes, manages, maintains and regulates most of the behaviors, known as circadian cycle. Besides the study also emphasized on a contemplation of Indian philosophy and modern innovative observations on circadian rhythmic processes. And how it will be effective in educational upliftment of the students by regulating their activity-arousal cycle that can have an important variable in the teaching-learning processes.

Keywords: *Neurobiology; Circadian Cycle; Covid-19*

Introduction

Pandemic Covid -19 has put the whole world in a dilemma and in conflicting situation in all respects for quite a while. Especially in health and education the impact is intense. The role of the heritage of a nation is to understand the student's need and their academic pursuits, and to explore in a valuable way ahead in this regard, as they are the future of the world. Social Scientists, psychologists, sociologists and several researchers are also now highlighting their researches more on the issues about how to improve the qualities of education in virtual teaching-learning system. On the other hand, the students are thinking (based on the 'on-line' teaching-learning system) if they have a mobile in hand and a laptop or a desktop with them then they got their academic achievements as well. But they are unaware that by these only they are getting information, not the knowledge. To convert the information into knowledge there is the need of a 'Guru'- 'The Teacher', who only can impart it. The matter does not end here. The knowledge has to change again into wisdom. To convert knowledge into wisdom is only possible by the guidance of a 'Guru'- 'The Teacher'. To achieve it, the teaching-learning system is to be enriched and to achieve the holistic approach of the teaching-learning system there is a need of application of indigenous approach of the system which was in India 5000 years ago that can make the mind creative, innovative, and self-regulative leading to self-realization and self-actualization.

The fact is recent day adolescents never give attention to their biological cycles which has a great contribution to their overall developments and regulative performance. Thus, this paper aims at creating awareness among the adolescents and among all young mass to be conscious about the automatic pilot (neurobiological cycles) within the body that mobilizes the physical and mental functioning and to prepare themselves in this regard. Further attempts has been made to focus on Indian philosophy which has established this fact about the circadian cycles, many many years ago in yoga sutras, Vedas, and Upanishads. This regulation of body, mind and soul have a great importance in teaching - learning process. Especially in this Covid pandemic situation when the process is going on through on-line teaching system, the effect of this activity - arousal cycle definitely help both the teachers and students in their academic pursuits.

Objective of the Study

- Based on the above ideas this paper aims at focusing on creating awareness on one important aspect of the teaching-learning mechanism that is to uplift the inner neurobiological system which regulates most of the behavioural manifestation, generally known as circadian cycle, the biological clock within the organism.
- To describe its effects on achieving the educational goals as well, for both students and teachers in regulating the biological cycles that can help in fostering learning, memory, thinking, perception, motivation and can regulate the emotion.
- To provide exploratory analysis of circadian rhythm in contemplating eastern and western perspectives that can add to their knowledge about the automatic pilot within the body that controls, manages and guides the human behaviour.

Exploratory description

This Neurobiological regulative cycle that controls, manages and maintains the whole physical and mental system of the organism is known as the circadian cycle. This cyclic mechanism (the automatic pilot of the body) in the bodily process has its far-reaching effects in the different cyclic processes of the body like, sleep-wake cycle, birth and death cycle, activity-arousal cycle, intradian cycle, ultradian cycle, circannual cycle, reproductive cycle, menstrual cycle, etc. Every organism in their life styles is susceptible to all these cycles.

Among those different cycles, one of the important cycles is the circadian cycle which occurs neurobiologically in the organism in a period of only of approximately 24 hours a day. The particular word 'circadian' is rhythm is derived from the word 'circa' having the meaning of 'about' and 'dics' refers to the meaning 'day' leading to the meaning 'around the day'.

In 1800 Charles Darwin has noticed the cyclic effect in leaf movements and concluded its biological rhythmicity [10]. Further it is found that this rhythmicity is also available in birds, mammals and in human beings as an endogenous biological clock [20,40,41]. According to Baron (2002, 2) circadian cycle is a biological process which influence our waking state of consciousness in a cyclic way. Research findings indicate this neurobiological rhythmicity not only affect the physical functioning but also influences higher mental processes like attention level, intelligence and other cognitive abilities [28-35]. Daniel and Patasova, (1989, 9) opined that depending on the nature and complexity of tasks the cycle activates in its strength [47].

Near about 4th BC the existence of Circadian cycle was noticed [4]. Further in 1729 French scientist Jean-Jacques d'Ortois de Mairan distinguish an endogenous clock from responses to daily stimuli [12,14].

In 1896, Patrick and Gilbert, in 1918, J.S. Szymanski, and in 1971 Konopka and Benzer, located the external cues in mammalian clock, which is accepted afterwards by Vitaterna, *et al.* (1994) and Dijk and Archer (2010). In 1959 while doing blood count Franz Halberg, a scientist at the University of Minnesota, published for the first time interpreted human circadian rhythm.

These four important points are mainly the basic characteristics of circadian cycle. Number one is - the rhythms repeat once a day (they have 24 hours). To keep track of the time of day, a clock must be at the same point at the same time each day, i.e. repeat every 24 hours. Number two is - the rhythms persist in the absence of external cues (endogenously). It persists in constant conditions for a period of about 24 hours. Number 3 is - the rhythms can be adjusted to match the local time (entrainable). Number 4 is - the rhythms maintain circadian periodicity over a range of physiological temperatures (exhibit temperature compensation).

Circadian Rhythms are also found in mammals [39], birds, fungi, insects, etc. Although the clocks do not function the same way in all species, yet they are very similar. In the case of *Drosophila*, the activating cycle is more as the day increases and in the middle of the night. But in the case of mammals, the process is more complex and less understood at this time. In the case of human beings, there is a disease called Familial Advanced Sleep - Phase System (Fasps) which causes people to have sleep schedules that move ahead by about 4 hours. In other words, they wake up around four hours earlier than they would otherwise [16,24-26,36,44,45]. It is suggested by the maintenance (heritability) of circadian rhythms in fruit flies after several hundred generations in constant laboratory conditions [47] as well as

in creatures in constant darkness in the wild, and by the experimental elimination of behavioural output but not physiological circadian rhythms in quail [18,52].

The simplest known circadian clock is that of the prokaryotic cyanobacteria. Recent research has demonstrated that the circadian clock of *Synechococcus elongatus* can be reconstituted *in vitro* with just the three proteins of their central oscillator. This clock has been shown to sustain a 22-hour rhythm over several days upon the addition of ATP. Previous explanations of the prokaryotic circadian time-keeper were dependent upon a DNA transcription/translation feedback mechanism.

This biological clock in mammals is located in the suprachiasmatic nucleus (or nuclei) (SCN), of hypothalamus. Destruction of the SCN results in the complete absence of a regular sleep-wake rhythm. The SCN receives information about illumination through the eyes. The retina of the eye contains “classical” photoreceptors (“rods” and “cones”), which are used for conventional vision. But the retina also contains specialized ganglion cells which are directly photosensitive, and project directly to the SCN where they help in the entrainment of this master circadian clock. Researchers at Harvard have recently shown that human subjects can at least be entrained to a 23.5-hour cycle and a 24.65-hour cycle [45].

More recent research has shown that adults have a built-in day, and most people attain their best-quality sleep during their chronotype-determined sleep periods. Czeisler, *et al.* at Harvard found the range for normal, healthy adults of all ages to be quite narrow: 24 hours and 11 minutes \pm 16 minutes. The “clock” resets itself daily to the 24-hour cycle of the Earth’s rotation [8]. Biological markers for measuring the timing of a mammal’s circadian rhythm are: melatonin secretion by the pineal gland, core body temperature [5], and the plasma level of cortisol [21]. For temperature studies, subjects must remain awake but calm and semi-reclined in near darkness while their rectal temperatures are taken continuously. The average human adult’s temperature reaches its minimum at about 05:00 (5 a.m.), about two hours before habitual wake time [citation needed], though variation is great among normal chronotypes. Melatonin is absent from the system or undetectably low during the daytime. Its onset in dim light, dim-light melatonin onset (DLMO), at about 21:00 (9 p.m.) can be measured in the blood or the saliva. Its major metabolite can also be measured in the morning urine. But it needs further research on the fact. Glass (2001) [7], Hofman (1988) [19] and Kunz (2003) [23] opined that most of the physical activities are cyclically associated to the organism. They show different cycles: circadian cycles (lasts approximately 24 hours), ultradian cycles (shorter than 24 hours/a day, such as the REM cycle of sleep), and infradian cycles (longer than 24 hours, such as the menstruation cycle), Diurnal cycles (25.4 hrs cycle without cyclical cues provided by natural light, occur during the waking day), Circannual Rhythm (a period of about a year such as hibernation/activity cycle), etc. (1)) and interact mutually as well as with the outside fluctuating environment (41) under the control of feedback systems. Circadian rhythms have been described in the human foetus [13,24,39,51] and have been attributed either to the maternal environment or to the maturation of the foetal nervous system [3,13,24,47,49]. Some studies showed that circadian rhythms are predominant in preterm neonates [27,28,44,50,53] while others showed ultradian rhythms to be dominant in preterm neonates.

Recent studies on circadian rhythm reveals the idea that melatonin onset can be made in adolescents within a 6-h sampling window Crowley, *et al.* (2016), prediction can be made on circadian misalignment in shift workers [48], and as per the Nobel prize winner Jeffrey C. Hall, Michael Rosbash, and Michael W. Young, 2017, on circadian rhythm, the changes to our body cycle can be possible if there will be a change in mutation of circadian genes, Jet lag or Shift work, and the light from electronic devices at night if will be continuously used [19].

Indigenisation of the fact

A regulated rhythmicity can uplift the power of physical and mental state of a person [11]. All the ideas described above are there in our Indian philosophy from thousands and thousands of years ago. In Srimad Bhagawat Gita, in Veda, in Vedanta, in Upanisad, in Sankhya Darsana, in Ramayana, in Mahabharata, and Maharshi Patanjali’s Yoga sutra, the awakening of body, mind and soul are very well described, analysed and explained for the health and wellbeing of the individual.

From among them focus is here only on Maharshi Patanjali’s Yoga sutra and how, much before, in our Indian philosophy, the neurobiological analysis has been made on activity arousal cycle, i.e., the so-called circadian cycle of the recent era.

The Yoga sutra of Maharshi Patanjali is very well translated, explained and analysed by Satguru Bodhinatha veylanswami from sutra 1.1 to sutra 4.34. Patanjali was a Saivite Natha Siddha (ca 200 BCE) who codified the ancient yoga philosophy which outlines the path to enlightenment through purification, control and transcendence of the mind. His system is one of the six classical philosophical systems (darshans) of Hinduism and is known as Yoga Darshana.

It is clearly stated that in Hindu scripture, the earliest usage of the term “yoga” as applied to spiritual endeavour has the meaning of “the control of the mind and senses.” That is the sense in which the term “yoga” is used in Patanjali’s Yoga Sutras. Yoga is the restraint of mental activities and can regulate the physical and mental condition of the individual. They knew the importance of activity and arousal cycle and accordingly, they have designed their daily routine works from early morning to night. The morning was started with ‘Surya Namaskar’ and the day is to end with meditation. This system helps in activating the biological clock following nature. As the morning starts we became active and as night comes there is a need to take rest and to re-energise the body for the next day. In this way, regulation of the mind and body will occur and the person concern can able to have peace in body mind and soul.

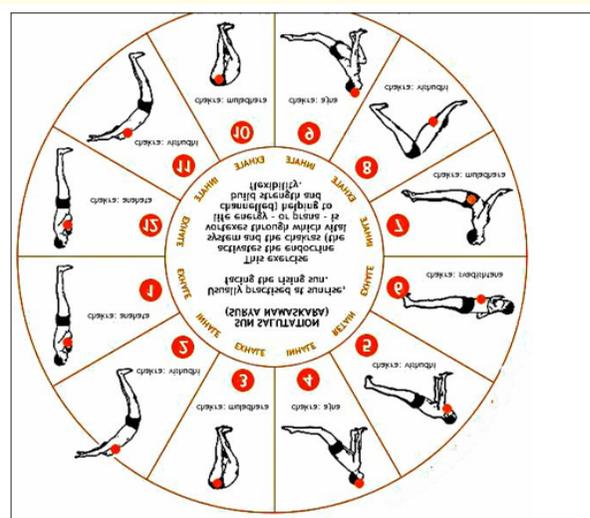


Figure 1: Showing the different posture of Surya Namaskar given by Leonardo Da Vinci (15 April 1452 – 2 May 1519, who was an Italian polymath of the High Renaissance).

The great ‘Guru’ Patanjali has emphasized on function of the mind also. According to him “Our minds are generally busy in one type of mental activity or another. We are remembering events from the past, thinking about current tasks or theorizing about possible future events. The practices of yoga are designed to enable us to eliminate these mental activities”.

Then awareness abides in its essential form. According to Maharshi Patanjali, when mental activity is restrained, then the soul’s faculty that witnesses thoughts are naturally ‘turns in’ on itself. And it remains temporarily aware only of itself until thoughts again arise. At other times awareness takes on the form of mental activities.

Patanjali also focuses a lot on consciousness. It is the nature of the witness consciousness of the soul that does not only observe the mental activity but also identified with those activities. A simple example is the feeling of happiness which is purely personal. And the awareness is taken as a form of happiness of the person concern.

There are five types of mental activities and they are either detrimental or conducive to the practice of Yoga. They are correct knowledge, misconception, imagination, sleep and memory. This fivefold division of mental activity provides a useful categorization system for analyzing and subsequently restricting one's thoughts. That can be best explained by 'Yoga'- the "Chitta vritti Nirodha".

Yoga is all about supporting the body's inherent biorhythms. It is a form of meditative movement that combines alternatives and focused on breathing with physical exercise. The practice has its place from 3000 years ago in Indian philosophy. The Yogic lifestyle is always aimed at the evolution of the mind which takes the journey from gross to subtle, that is, from existential world to celestial world. It is the Yoga and spirituality through which we can able to achieve the 'four Bargas' of Indian philosophy (Sanatan Dharma), i.e. *Dharma, Artha, Kama and Moksha* which are the basic rudiments of human life. Yoga is that process where the consciousness aroused by the power of 'Petty self' is uplifted to combine itself with the higher 'Universal self' of its mental maturity that helps one to concentrate and meditate upon the transcendental 'Atman' which is the main source of knowledge, intelligence and bliss (Swami Avedananda). Yoga is the only way of 'God-consciousness in the ways and means of 'Chitta Vritti Nirodha' (as stated in Sanskrit).

In a two days of training programme on Yoga by Rashtriya Madhyamik Sshiksha Abhyan, Kerala, it is stated about origin of Yoga that:

- There is no exact evidence about the origin of Yoga. Hence the Yoga has come from times immemorial.
- Yoga is one of the disciplines of Spirituality.
- Yoga is universal and not a religion.
- It is because of the contribution of the great sages of India that made Yoga a science of living.

Indian Yogis for centuries have charted their biorhythms via the movement of the stars, ocean tides and sun-moon cycles. Chinese Medicine has long mapped the phases of metabolic activity for all the internal organs. The idea that not only do organs have internal clocks, but every cell in the body has its timing, is profound. In states of meditation and *yoga Nidra* (yogic sleep), yogis aim to support the inherent cycles of activity and rest in all tissues of their body to generate optimal health. Yogis sensed long ago that the body's circadian rhythms are governed by the minuscule master glands-the pituitary and pineal glands-set deep within the skull. Perhaps the experience of timelessness celebrated in states of meditation suggests a state where all the cells in the body operate via a unified field of time.

The study of sculpture sattvic thoughts is an example of thoughts that are conducive to the practice of Yoga. Thoughts of attraction to the worldly object, a rajasic thought are detrimental to the practice of Yoga.

According to Pandit Ravi Sankar when the mind becomes inactive the body becomes active and when the body becomes inactive the mind becomes active. Always there is debate whether a body is existing within the mind or the mind is existing within the body. But it is a fact that there is no existence of one without the other.

Another important feature in Sanskrit is found which is a clear depiction of the sample of how circadian rhythm was understood much before by Indian 'Rishis' and 'Munis', that is - *Dinacharya*. It is a Sanskrit word made up of '*Dina*,' meaning day, and '*acharya*,' meaning activity. So *Dinacharya* is a daily routine designed to maintain and connect us to our circadian rhythms or internal body clocks. While 'Ayurveda' has emphasized the importance of a connection with nature for millennia, western scientists are only now beginning to understand exactly how important it is for the body to stay connected to the rhythms of nature. Disconnection from circadian rhythms is called chrono disruption. It is linked to a host of health concerns, including poor cognitive function, mood and sleep disorders, daytime sleepiness, reduced school performance, substance abuse, heart disease, diabetes, obesity, and some cancers.

Dinacharya makes us understand the best time for our daily routines, such as walking, exercise, bathing, meditation, prayer, meals, study, work, relaxation, and sleeping. This is necessary to maintain a healthy body with a healthy mind. The benefits of *Dinacharya* conveys the idea that it helps in balancing '*DOSHAS*', helps in digestion, indicates discipline, promotes peace, integrity and happiness.

Daily 'dosha' cycles according to Ayurveda

First cycle (sunrise-sunset):

- 6 am to 10 am - *Kapha*
- 10 am to 2 pm - *Pitta*
- 2 pm to 6 pm - *Vata*.

Second cycle (sunset- sunrise):

- 6 pm to 10 pm - *Kapha*
- 10 pm to 2 am - *Pitta*
- 2 am to 6 am - *Vata*.

Based on the above *dosha* cycles is an ideal daily schedule that needs to be inculcated into our daily routine.

Near about pre-2nd century CE, 'The *Charaka Saṃhitā*' or '*Compendium of Charaka*' (the text consists of eight books and one hundred and twenty chapters) developed Ayurveda treatment system which tells us that on any given day, there are two cycles of change that exist - the sun cycle and the moon cycle - and they're connected with the *Ayurveda* body type, our *doshic* constitution (*Vata*, *pitta* or *Kapha*).



Figure 2: Showing Dinacharya idea of 'Sun cycle' and the 'moon cycle'. Cited by Ganesh Puttur | Posted: March 14, 2019 in <https://www.artofliving.org> › in-en › ayurveda-dinacha.

Conclusion

Indian sculpture, Indian philosophy, indigenous knowledge, Indian religion, 'The Sanatana Dharma', always have been giving importance to the regulation of physical and mental wellbeing in all of its domain. A regulative body can give a regulative mind. A regulative mind can give regulative knowledge. A regulative knowledge can lead to enhance wisdom. And all these are essential for each individual to sustain their livelihood effectively. And all these said facts very much essential for the students and teachers in a teaching-learning system.

Whether it is eastern or western, the development of knowledge is unique and contemplated. And the two sources of knowledge, Science and spirituality, starting from the pre-Vedic period till today, aim at the positive wellbeing of mankind at large to reach the perfection in all respects. Especially for the student mass this awareness of Neurobiological mechanism (internal biological clock) can foster their academic pursuit to reach their life goal. The point is to ignite their inner ability, strength, and energizing force to switch on their real capacity and to show the real path of salvation, as their 'real self' (the 'petty self') can merge with the 'cosmic self' (The 'Universal Self').

'Life is running through faith and belief'

Upanisada.

Bibliography

1. Antoine D. "Important dates 1900-1919". HKU-Pasteur Research Centre (Paris) (2008).
2. Baron RA. "Psychology (3rd Edition)". Prentice - Hall of India Privat-e Limited, New Delhi (2002): 11001.
3. Begum EA., *et al.* "Emergence of physiological rhythmicity in term and preterm neonates in a neonatal intensive care unit". *Journal of Circadian Rhythms* 4 (2006): 11.
4. Bretzl H. "Botanische Forschungen des Alexanderzuges". (Leipzig, Germany: B.G. Teubner) (1903).
5. Benloucif S., *et al.* "Stability of melatonin and temperature as circadian phase markers and their relation to sleep times in humans". *Journal of Biological Rhythms* 20.2 (2005): 178-188.
6. Cheng P., *et al.* "Predicting circadian misalignment with wearable technology: validation of wrist-worn actigraphy and photometry in night shift workers". *Sleep* 44.2 (2021): zsa180.
7. Crowley SJ., *et al.* "Estimating the dim light melatonin onset of adolescents within a 6-h sampling window: the impact of sampling rate and threshold method". *Sleep Medicine* 20 (2016): 59-66.
8. Czeisler CA., *et al.* "Rotating Shift Work Schedules that Disrupt Sleep are improved by appl" (1982).
9. Daniel J and Potasova A. "Oral Temperature and performance in 8 - hour and 12 - hour shifts". *Ergonomics* 32 (1989): 689-696.
10. Darwin C and Darwin F. "The power of movements in plants". John Murray; London (1880).
11. David Hartman MSW and Diane Zimberoff MA. "Heart-Centered Therapies Association 75 Healing the Body-Mind in Heart-Centered Therapies". *Journal of Heart-Centered Therapies* 9.2 (2006): 75-137.
12. De Mairan J. "Observation botanique". *Histoire de l'Academie Royale des Sciences* (1729): 35-36.
13. D'Souza SW., *et al.* "Skin temperature and heart rate rhythms in infants of extreme prematurity". *Archives of Disease in Childhood* 67 (1992): 784-788.
14. Dijk DJ and Archer SN. "PERIOD3, circadian phenotypes, and sleep homeostasis". *Sleep Medicine Reviews* 14 (2010): 151-160.
15. Gardner MJ., *et al.* "Circadian regulation of Ca²⁺" signalling". *Annual Review of Plant Biology* 21 (2005): 191-210.
16. Gelder R., *et al.* "Reduced Pupillary Light Response in Mice Lacking Cryptochromes". *Science* 299.5604 (2003): 222.
17. Glass L. "Synchronization and rhythmic process in physiology". *Nature* 410 (2001): 277-284.
18. Guyomarc'h C., *et al.* "Circadian rhythm of activity in Japanese quail in constant darkness: variability of clarity and possibility of selection". *Chronobiology International* 15.3 (1998): 219-230.
19. Hall J., *et al.* The Nobel Prize in Physiology (2017).
20. Hofman MA., *et al.* "Morphometric analysis of the suprachiasmatic and paraventricular nuclei in the human brain: Sex differences and age dependent changes". *Journal of Anatomy* 160 (1988): 127143.
21. Johnson MS. "Effect of continuous light on periodic spontaneous activity of white-footed mice (*Peromyscus*)". *Journal of Experimental Zoology* 82 (1939): 315-328.

22. Klerman EB, *et al.* "Comparisons of the variability of three markers of the human circadian pacemaker". *Journal of Biological Rhythms* 17 (2002): 181-193.
23. Konopka RJ and Benzer S. "Clock Mutants of *Drosophila melanogaster*". *Proceedings of the National Academy of Sciences of the United States of America* 1971 68.9 (1971): 2112-2116.
24. Kunz H. "Simulation of circadian rhythm generation in the suprachiasmatic nucleus with locally coupled self-sustained oscillators". *Journal of Theoretical Biology* 224-17 (2003): 63-78.
25. Lunshof S, *et al.* "Fetal and maternal diurnal rhythms during the third trimester of normal pregnancy: outcomes of computerized analysis of continuous twenty-four-hour fetal heart rate recordings". *American Journal of Obstetrics and Gynecology* 178 (1998): 247-254.
26. Lucas R, *et al.* "Diminished Pupillary Light Reflex at high Irradiances in Melanospin - knockout Mice". *Science* 299 (2003).
27. Marcia Baringa. "How the Brains's clock Gets Daily Enlightenment". *Science* 295.5557 (2002): 955.
28. Menakar M. "Circadian Photoreception". *Science* 299.5604 (2003): 213-214.
29. Mirmiran M and Kok JH. "Circadian rhythms in early human development". *Early Human Development* 26 (1991): 121-128.
30. Misra S. "Effect of Circadian Cycle and Acculturation on Span of Attention". *Behavioral Scientist* 5 (2004).
31. Misra S. "Circadian Cycle and Intelligence". Presented in NAOP (Department of Humanities and Social Sciences , IIT , Kharagpur (2004).
32. Misra S. "Effect of Yoga Practice And Circadian Cycle On the Span of Attention of The Subject". Presented in NAOP (Department of Humanities and Social Science, IIT, Bombay) (2006).
33. Misra S. "Circadian Cycle and Adolescents' Behaviour". 3rd International Conference on life skills education, enabling competencies of adolescents and youth: a life skills approach (2011).
34. Misra S. "Circadian Cycle of mother and the arousal Level of the Fetus". *Indian Women: Past and Present* (2012).
35. Misra S. "Circadian Rhythms in cognitive performance: Evidence on Tribal Adolescents' Nonverbal Intelligence". *Research Journal of Arts, Management and Social Sciences* (2013).
36. Misra S. "Physiological correlates of circadian rhythm between mother and fetus". *Journal of Arts, Management and Social Sciences* 2 (2013).
37. Misra S. "Effects of Mothers' Stress on the Circadian Rates of the Fetus". *Journal Gerontology Rennsc, Japan* 2.1 (2013).
38. Panda S. "Melanospin (opn4) Requirement for normal light - Induced Circadian phase shifting". *Science* 298.5601 (2002): 2213-2215.
39. Patrick J. "Influence of maternal heart rate and gross fetal movements on the daily pattern of pattern of fetal heart rate near term". *American Journal of Obstetrics and Gynecology* (1982): 533-538.
40. Patrick J, *et al.* "Patterns of gross fetal body movements over 24-hour observation intervals during the last 10 weeks of pregnancy". *American Journal of Obstetrics and Gynecology* 142 (1982): 363-371.
41. Poletini MO, *et al.* "Central clock regulates the cervically stimulated prolactin surges by modulation of dopamine and vasoactive intestinal polypeptide release in ovariectomized rats". *Neuroendocrinology* 91.2 (2010): 179-188.
42. Ralph E, *et al.* "Social influences on mammalian circadian rhythms: animal and human studies". *Biological Reviews* 79.3 (2007): 533-556.
43. Reppert SM and Weaver DR. "Coordination of circadian timing in mammals". *Nature* 418 (2002): 935-941.

44. Richter CP. "Biological Clocks in Medicine and Psychiatry". Thomas; Springfield (1965).
45. Roizen J., *et al.* "Oxytocin in the Circadian Timing of Birth". *PLoS ONE* 2.9 (2007): e922.
46. Ruby N., *et al.* "Role of Melanospin in Circadian Responses to light". *Science* 298.5601 (2002): 2211-2213.
47. Schibler U and P Sassone - Corsi. "A web of Circadian Pacemakers". *Cell* (2002): 919-922.
48. Seron-Ferre M., *et al.* "Circadian rhythms during pregnancy". *Endocrine Reviews* 14 (1993): 594-609.
49. Shang X., *et al.* "The association between vision impairment and incidence of dementia and cognitive impairment: a systematic review and meta-analysis". *Ophthalmology* 128 (2021): 1135-1149.
50. Shibata S and Moore RY. "Development of neuronal activity in the rat suprachiasmatic nucleus". *Developmental Brain Research* 34 (1987): 311-315.
51. Spiegel K., *et al.* "Effect of sleep deprivation on response to immunization". *JAMA: The Journal of the American Medical Association* 288 (2002): 1.
52. Thomas KA. "Biological rhythm development in preterm infants: Does health status influence body temperature circadian rhythm". Article first published online: 18 JUL (2001).
53. Updike PA., *et al.* "Physiologic circadian rhythmicity in preterm infants". *Nursing Research* 34 (1985): 160-163.
54. Visser GH., *et al.* "Diurnal and other cyclic variations in human fetal heart rate near term". *American Journal of Obstetrics and Gynecology* 142 (1982): 535-544.
55. Vitaterna MH., *et al.* "Mutagenesis and mapping of a mouse gene, Clock, essential for circadian behavior". *Science* 264.5159 (1994): 719-725.
56. Zivkovic BD., *et al.* "Formal properties of the circadian and photoperiodic systems of Japanese quail: phase response curve and effects of T-cycles". *Journal of Biological Rhythms* 14.5 (1999): 378-390.

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