M.SC. 2ND SEMESTER STUDY MATERIAL (II)
SUBJECT: HUMAN PHYSIOLOGY

TOPIC : CHRONOBIOLOGY

PAPER   PHY 203

UNIT 18 (MODULE IV)

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What is Chronobiology?
(Chronos=Time, Bios=life, logos=science)

➢ A relatively new branch of science which deals with the study of biological rhythms and their underlying mechanisms.

➢ All level of biological integrations: ecosystem, population, group, individual, organ-system, organ, tissue, cell and subcellular structure exhibit rhythms with different frequencies.

➢ Among other major sub-specialities, chronobiology includes: **chronophysiology, chronopathology,** and **chronopharmacology**. In addition, chronopharmacology includes **chronotoxicology** and **chronotherapy** in its premise.

➢ Also, the study of problems associated with transcontinental travels (**jet lag**) and shift work falls in the domain of chronobiology.

Chronophysiology	**It focuses on temporal aspects of various physiological processes, namely of nervous, endocrine and metabolic systems and their interactions with the environment.**
Chronopathology	**It describes alterations in biological temporal characteristics of organisms attributed to pathological state, such as psychoses, cancers, endocrinopathies, ulcers and blood pressure disease.**
Chronopharmacology	**It evaluates harmful/undesired effects of drugs, poisons, pollutants and other agents as function of timing of their administration (Chronotoxicology). It also includes chronotherapy that concerns cure or prevention of disease with proper regard to timing of administration of various types of therapeutics.**

BIORHYTHM(BR)

❑ A biological rhythm is one or more biological events or functions that reoccur in time in a repeated order and with repeated interval between occurrences.

❑ TYPES: Generally, there are 3 types of BR, - external, exogenous and endogenous.

❑ External rhythms are actually rhythmic alteration in response to the external environment, like light, temperature etc.

❑ Exogenous rhythms are the responses that are developed due to physical change in the environment and they are not persistent when the conditions are constant. Another term for this type of BR is direct effect. An example of an exogenous BR is the hopping of sparrows on a perch when a light is turned on. Such rhythm are said to have a geophysical counterpart, in this case the presence of light.

❑Endogenous rhythmic alterations persist under constant condition in the body.

❑TYPES:

▪ 1. **Circadian rhythm**: When a biological parameter shows a rhythmic alteration in its level at the interval of about 24 hours, then it is known as circadian rhythm. EX- blood level of melatonin, body temperature alteration, cortisol secretion etc.

▪ 2. **Semilunar rhythm**: When a bioparameter shows a cyclic repeatation at the interval of about 15 days, then it is known as semilunar rhythm. Ex- degree of apatite in some animals.

▪ 3**. Lunar rhythm**: When a bioparameter shows a cyclic repeatation at the interval of about 1 month, then it is known as lunar rhythm. Ex- Uterine cycle for human(female).

▪ 4. **Circannual rhythm**: When a bioparameter shows a cyclic repeatation at the interval of about 1 year, then it is known as circannual rhythm. Ex- Hybernation.

▪ 5. **Biannual rhythm**: When a bioparameter shows a cyclic repeatation at the interval of about 2 years, then it is known as biannual rhythm. It can be seen in some lower vertebrates.

The most important rhythm in chronobiology is the circadian rhythm, a 24 hour cycle. It can be further broken down into routine cycles during 24 hour day-

- **Diurnal:** which describes organisms active during daytime (eagle)

- **Nocturnal:** which describes organisms active during night time, (owl)

- **Crepuscular:** which describes organisms active primarily during the dawn and dusk hours (white tailed deer, bat)

Some other cycles include-

- **Infradian:** cycles longer than a day, such as the annual migration or reproduction cycles found in certain animals or the human menstrual cycle.

Ultradian: cycles shorter than 24 hours, such as 90 min REM sleep , 4 hour nasal cycles or 3 hour cycle of GH production

Tidal: mainly observed in marine life, which follow roughly 12 hour transition from high to low tide and back

**Gene oscillations:** Some of the genes are expressed more during certain hours of the day than during other hours.

❖*Within each cycle the time period during which the process is more active is called acrophase. When it is less active, the cycle is known as bathyphase or trough phase. The particular moment of highest activity is the maximum or peak; the lowest point is nadir. How high or low the process gets is measured by the amplitude.*

ZEITGEBER (Time Giver)

A zeitgeber is an external cue which infuences the operations of the internal clock in an organism. The classical example of a zeitgeber is light, which leads some organisms to wake up, while others go to sleep. An interruption in such cues can confuse an organism potentislly causing health problems and functional difficulties.

The term was coined in 1954 by Jurgen Aschoff, a German biologist who studied circadian rhythms.

One can consider a zeigeber to be like a natural alarm clock, triggering some sort of change in an organism's internal clock, like a hint to wake up, eat, or engage in various activities.
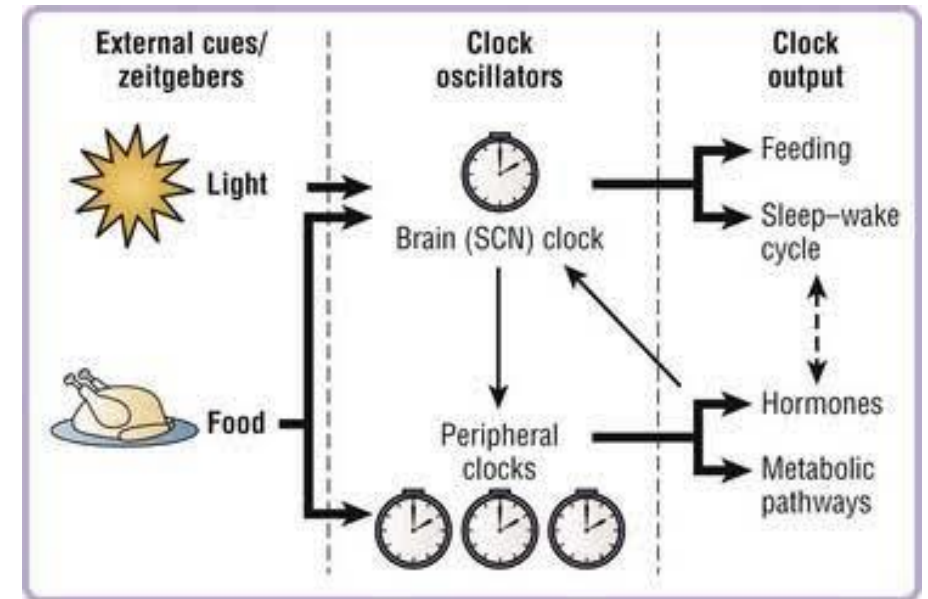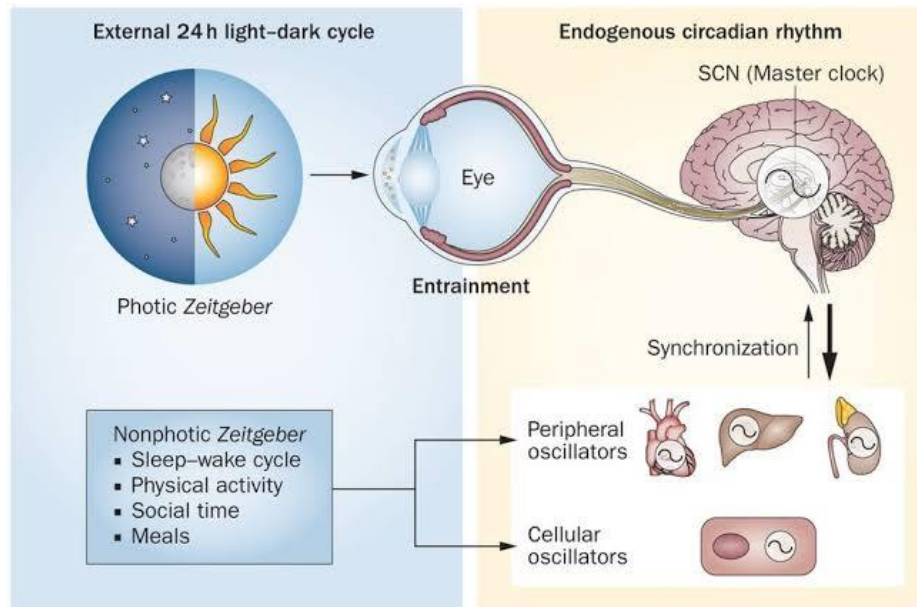
Biological Clock

* Biological clocks are an organism's innate timing device. They are composed of specific molecular proteins that interact in cells throughout the body.

*Biological clocks are found in nearly every tissue and organ. Researchers have identified similar genes in people, fruit flies, mice, fungi and several other organisms that are responsible for making the clock's component.

*Biological clocks produce circadian rhythms and regulate their timings.

*A 'MASTER-CLOCK' in the brain coordinates all the biological clocks in a living thing, keeping the clocks in sync. In vertebrate animals, including humans, the mater clock is a group of about 20,000 neurons that form a structure called the suprachiasmatic nucleus or SCN. The SCN is located in a part of brain called the hypothalamus and receives direct input from the eyes.
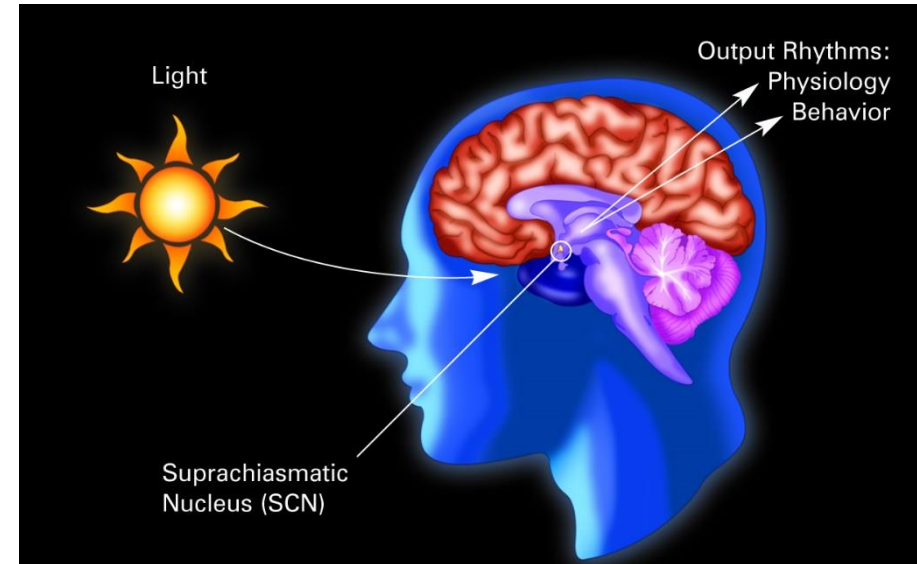
INTERNAL BIOLOGICAL CLOCK:

Leaves of mimosa plants open towards the sun during daytime and close at dusk. Jean Jacques d'Ortous de Mairan placed a mimosa plant in constant dark and found that the leaves continued to follow their daily rhythm for several days. This suggested that mimosa plants have a cell autonomous clock that can maintain the biological rhythm even under constant conditions.
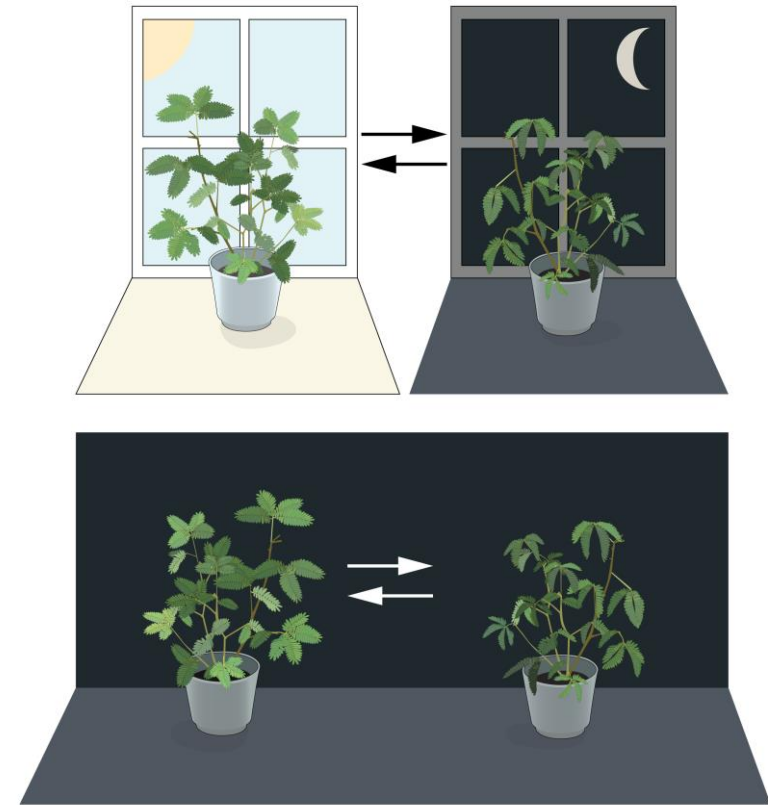
Circadian biology and human health:

Chronobiology has an impact on many aspects of our physiology. For example, circadian clocks help to regulate sleep patterns, feeding behavior, hormone release, blood pressure and body temperature. Molecular clocks also play critical roles locally in many tissues. Ablation of clock genes in animal models results in arrhythmic production of hormones, such as corticosterone and insulin. Clock genes also exert a profound influence on metabolism through the control of gluconeogenesis, insulin sensitivity and systemic oscillation of blood glucose.

Sleep is vital for normal brain function and circadian dysfunction has been linked to sleep disorders, as well as depression, bipolar disorder, cognitive function, memory formation and some neurological diseases. In rare cases, sleep phase disorders are due to mutations in circadian clock genes resulting in advanced or delayed sleep-wake cycles .Studies have indicated that chronic misalignment between our lifestyle and the rhythm dictated by our endogenous circadian clock may be associated with increased risk for various diseases including cancer, neurodegenerative diseases, metabolic disorder and inflammation. Efforts are underway to develop approaches in chronobiology and pharmacology to modify the period, phase or amplitude of circadian clocks to improve human health.
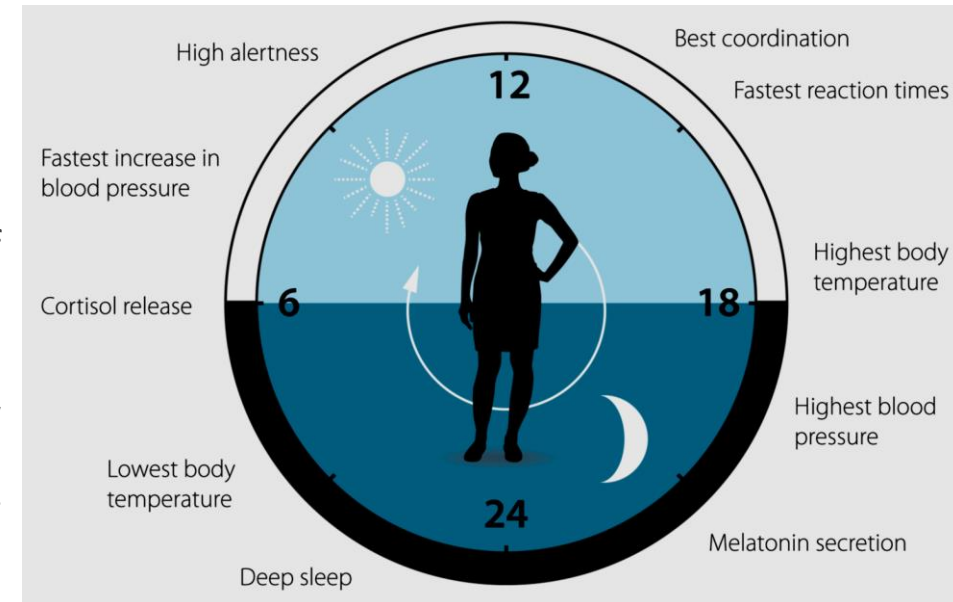
The circadian clock has an impact on many aspects of our physiology

Home Assignment:

Prepare a note on significance of circadian rhythm on human .