Biological Rhythms
The Clock Ticks Away....

A biological rhythm is any cyclic change in the level of a bodily chemical or function. Biological rhythms can be: – Internal (endogenous) - controlled by the internal biological clock e.g. body temperature cycle – External (exogenous) - controlled by synchronizing internal cycles with external stimuli e.g. sleep/wakefulness and day/night. These stimuli are called zeitgaber -- from the German meaning "time givers". These stimuli include environmental time cues such as sunlight, food, noise, or social interaction. Zeitgaber help to reset the biological clock to a 24-hour day.

The daily changes in sleep and wakefulness, annual bird migration, and the tidal variations in behavior of coastal animals: these are all examples of biological rhythms. The field of **chronobiology** studies these rhythms in living organisms and how they are tuned by cues from the outside world.

Circadian rhythms (rhythms that repeat approximately every 24 hours) are the most prominent biological rhythms. Not only sleep and wakefulness are influenced by circadian rhythms, also many other bodily functions show a circadian rhythm, such as body temperature, the secretion of hormones, and metabolism, and organ function. These rhythms allow organisms to anticipate and adapt to cyclic changes in the environment that are caused by the daily rotation of the Earth on its axis.

In humans and other mammals, circadian rhythms in the body are synchronized to the environment by a master clock that is located in the suprachiasmatic nuclei (SCN), a tiny brain region that is located just above the crossing of the optic nerves. The SCN receive information about light and darkness directly from the eyes, integrates this input, and relays it to cellular circadian clocks located throughout the rest of the body. In this way, circadian rhythms in behavior and physiology are synchronized to the external light-dark cycle.

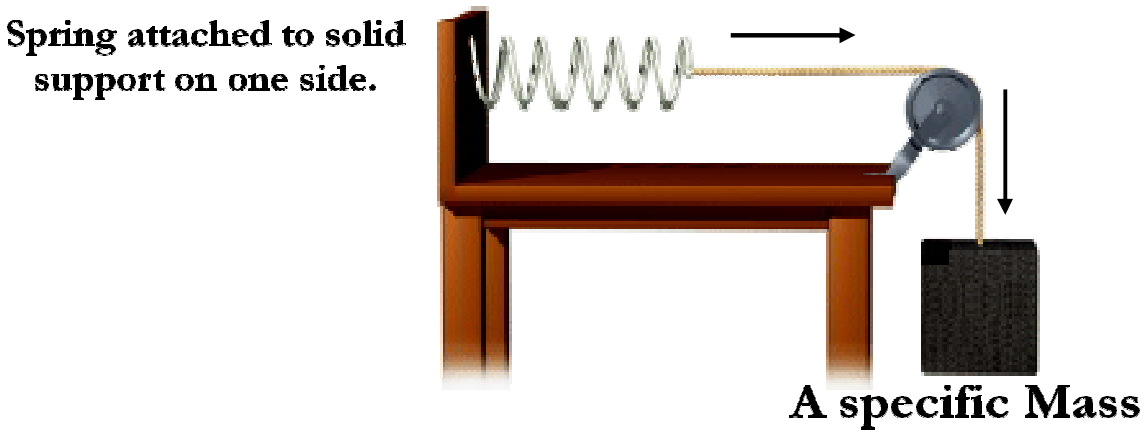
Although circadian rhythms require input (such as light) from the environment to synchronize to the 24-h day, a key feature of these rhythms are that they are self-sustained, meaning that they continue to cycle with a period of approximately 24 hours in the absence of any time-giving cues from the environment. Thus, even in constant darkness under controlled laboratory conditions, many bodily functions

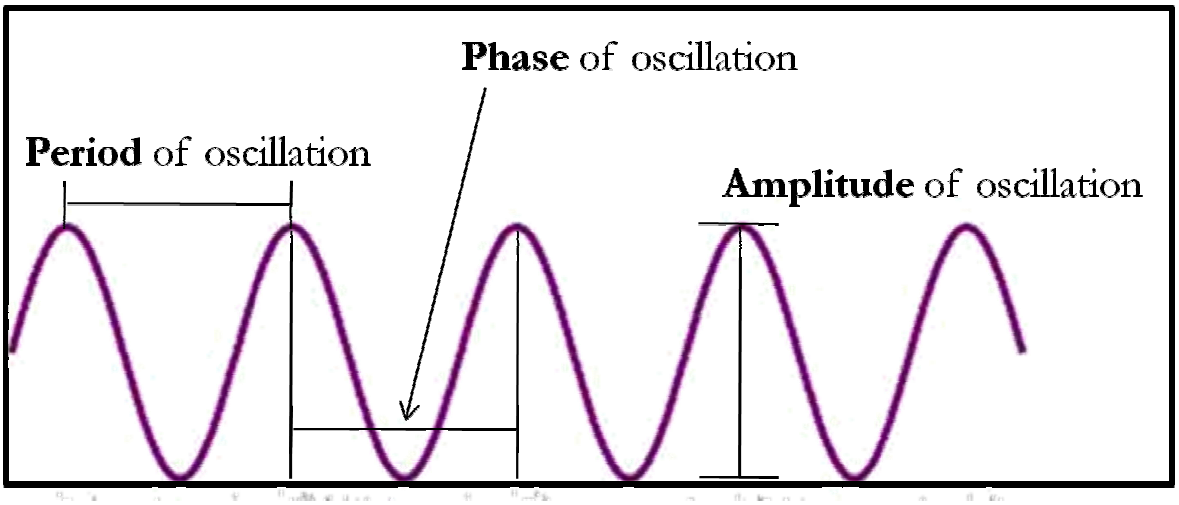
continue to show an approximately 24-h rhythm. In humans, the intrinsic circadian period is on average 24.2 h, ranging from about 23.5 to 24.6 in the healthy population. This variation in circadian period explains why some people are early birds and others are night owls.

On a molecular level, circadian rhythms are generated by a feedback mechanism involving cyclic changes in the expression of certain genes. The proteins encoded by two of these genes, called CLOCK and BMAL1 switch on the activity of other genes, called Per and Cry. In turn, PER and CRY proteins turn down the activity of CLOCK and BMAL1 proteins, creating a recurring loop of genes being switched on and switched off that repeats approximately every 24 hours. This molecular feedback mechanism is present in virtually every cell in the body – from the cells in your liver to the cells in your skin. Ultimately, it drives the circadian rhythms in cellular processes, metabolism, physiology, and behavior, ensuring all these functions are occurring at the right place at the right time of day.

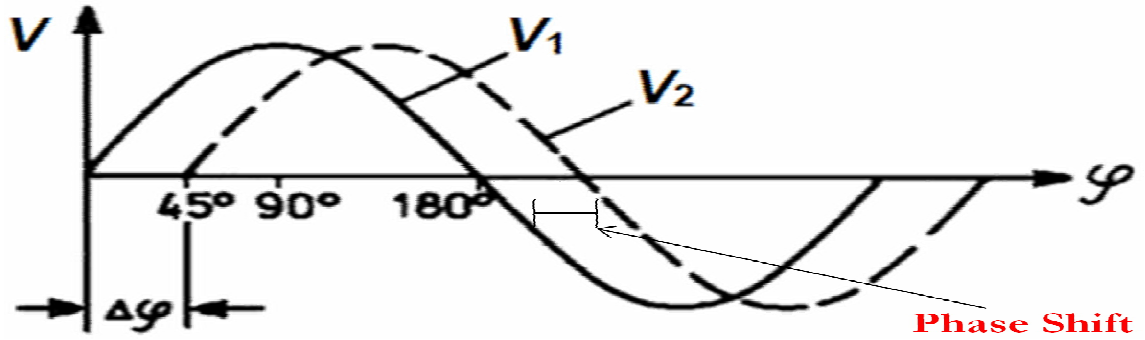
Disruption to the circadian clock may contribute to health problems. This occurs for example during night shift work or jet lag, in which there is a mismatch between light exposure, food intake, and other cues from the external environment with the timing of the circadian rhythms in the body. In the long term, repeated loss of coordination between the circadian rhythms and environmental cues may increase the risk for a range of diseases such as diabetes, heart disease, and certain types of cancer. Getting in tune with your internal clock may be key to health and wellbeing.

The regulation of circadian rhythms in other organisms, ranging from cyanobacteria to fungi and from plants to insects, all follow the same general principles. Indeed, it was the discovery of the molecular feedback mechanism in fruit flies that led to the Nobel Prize in Physiology or Medicine in 2017. Plants can use their circadian clocks to time flowers to the correct season.





Time required to complete one cycle – **Period**. A particular recognizable point in a cycle – **Phase**. Maximum Displacement of mass from the zero position – **Amplitude**.



The displacement of the rhythm without altering the basic character of the oscillation is called **Phase Shift**.

The Salient Features

- **Rhythms are temperature-compensated.**
- **Unaffected by metabolic poisons or inhibitors**
- **Occur with approximately the same frequency as some environmental feature**
- **Self-sustaining – maintain cyclicity in absence of cues**
- **Can be entrained by environmental cues**

Types

Epicycles (Ultradian) Rhythms

cycles of repeated activity that are less than 24 hours
E.g. *Arenicola marina* - feed on surface every 6 -8 mins

Lunar Rhythms

cycles of repeated activity that are synchronized with lunar cycles
E.g. Spawning of California grunion(10pm -4am before full moon night)

Tidal Rhythms

cycles of repeated activity that are synchronized with tidal flow
E.g. Fiddler crab - times activity cycles to match tidal flow

Circadian Rhythms

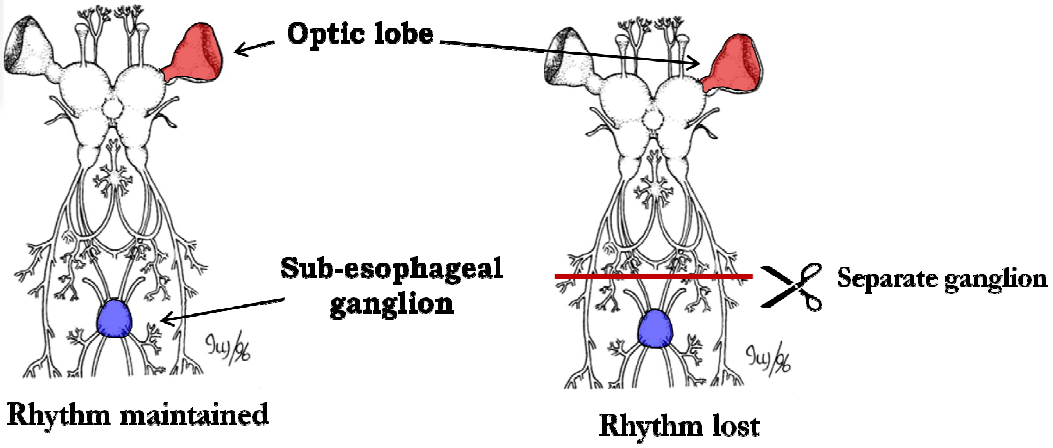
cycles of activity that are repeated approximately every 24 hours

Circannual Rhythms

rhythms that are approximately 1 year long
E.g. Hibernation

The TIME KEEPERS

Cricket Calling Rhythm- Maintained by the Optic lobe(perception of light) an the sub-esophageal ganglion.



Male crickets calls due to the perception of photic information that is decoded by the TIME-KEEPER- sub-esophageal ganglion.

The ablation of the connectivity between perception and time-keeper disrupts the rhythmicity in the calling. The dark period is pursued by optic lobe but the synchrony is not maintained that leads to loss of the rhythmic calling.