Understand the Brain Clock to Cultivate Healthy Sleeping, Eating, and Activity Behaviors

"Nothing gets invented for it is written in nature first;
Originality consists of returning to the origins!!"
- Antoni Gaudi (renowned architect, Barcelona, Spain)

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What Is the Brain Clock and Its 24-Hour Circadian Rhythm?

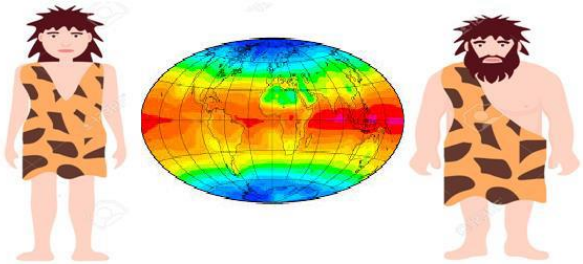
In October 2017, three medical Physiologists—Drs. Hill, Young, and Rosbash received Nobel Prize for their noteworthy discovery on "Molecular mechanisms controlling the Circadian Rhythms." This discovery gave the world profound insights into the internal timing systems of living beings and how these control their survival behaviors. From plants to the tiniest living organisms, such as bacteria to complex living species such as humans, each has coordinated biologic routines or rhythms for survival. These rhythms are called the Circadian Rhythms, and these are under the control of the master clock located in the brain. The timer resets itself daily to the 24-hour cycle of the earth's rotation on its axis. The three essential survival behaviors of humans under the influence of the circadian brain clock are:

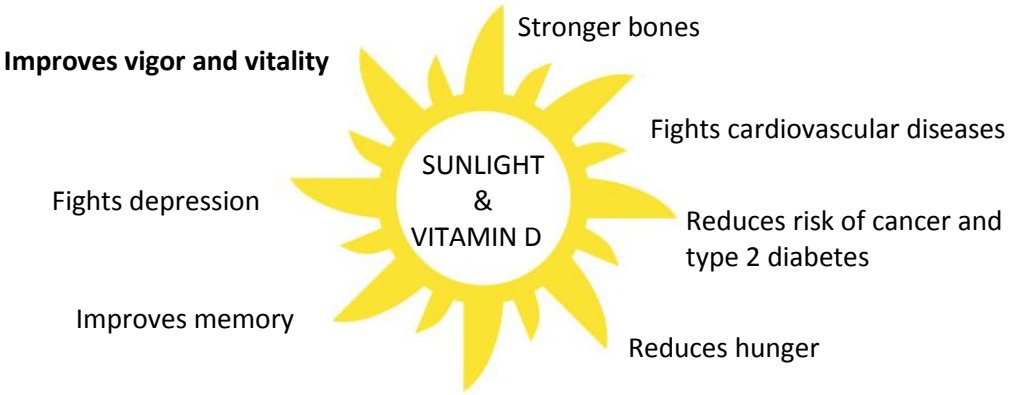
1. ***Sleep-Wake Cycle***
2. ***Fasting—Feeding Cycle***
3. ***Activity—Rest Cycle***

The sleep-wake cycle is the core survival behavior which regulates the other two cycles. If the sleep cycle gets disrupted, the other two survival behaviors invariably will get upset, causing loss of vitality and disease.

Humans feel sleepy during the night and hungry around lunchtime naturally because of the built-in circadian 24-hour rhythms. The natural 24-hour cycle of day and night as the earth rotates around its axis is the most fantastic feature of the planet earth. To adapt to the daily changes of the dark and light cycles of the environment, all living beings on Earth have developed an internal timing system. The word circadian comes from the Latin word "*circa*," which means round, and "*Diem*," which means the day. The daily changes in behavior, as well as the physiological activities of living beings, remain under the control of the internal clock system. Every organ in the human body such as heart, liver, digestive tract, kidneys, immune system, hormonal systems, functions at its peak during the daylight hours. The dark hours of the night are for rest, repair, and rejuvenation. Living in harmony with the natural circadian rhythms is critical to the health, well-being, and survival of all living beings.

The human race evolved near the equator, the region of planet earth where the intensity and the bioenergy of the sun are the strongest. As the humans moved away from the equator to higher latitudes, the human body adapted to capture the maximum energy of the sun and the daylight. This adaptation consisted of the skin, as well as the eye pigment, becoming lighter. The preindustrial humans lived close to nature, mostly in the outdoor setting, in harmony with the natural sunlight and daylight. There was no artificial light or blue light from digital devices and television screens. Preindustrial humans fasted/ fed, slept/woke up, and moved about according to the natural circadian rhythms in harmony with the cues (signals) of daylight and darkness.





Sun for Health and creating Vitamin D

What Moved Humans Away from Natural Circadian Rhythms

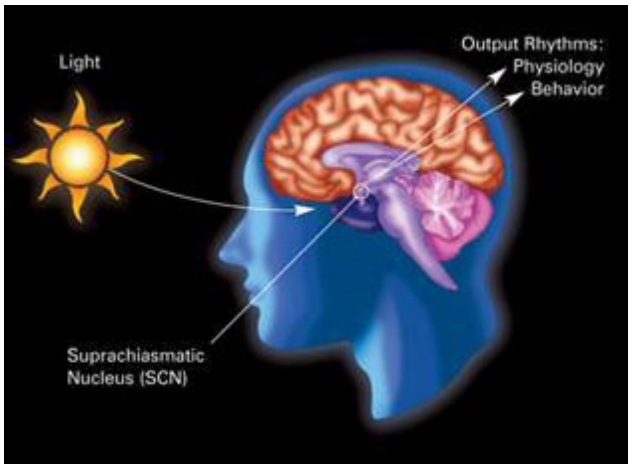
Over the past century, humans have experienced four life-changing revolutions: **Industrial**, **Agricultural**, **Economic**, and **Digital**. These revolutions have lifted human beings from poverty and

starvation. However, slowly and stealthily, these revolutions have also moved humans away from nature and its prime source of bioenergy—the SUN. Modern urban humans are spending their days mostly indoors, apart from the natural cues of light and darkness, and into the world of artificial lights as well as the blue light of digital devices. These artificial lights have extended the days and shortened the nights, leaving little or no time for the health-preserving activities of Rest, Repair, and Rejuvenation.

Additionally, the urban human has moved away from Plant-based foods grown under the energy of the sun. Plant foods are the richest sources of vitamins, minerals, and disease-fighting, immune-boosting elements called micronutrients and antioxidants. Commercial diets and animal foods lack these elements.

The Brain Clock and the Internal Clock System in the Body

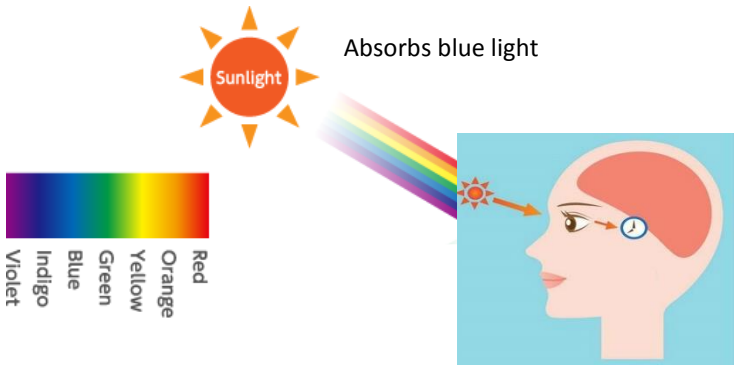
The concept of the internal clock and circadian rhythms has been around for a long time. However, research on the effects of these rhythms on human behavior and physiology, and their role in health and disease have received considerable attention only in the past few years. The science of circadian physiology is so vital to health and disease that a Nobel prize was awarded for research in this field in 2017. The recent medical research supports that the disruption of circadian rhythms concerning the three essential behaviors of Sleep-Wake, Fasting-Feeding, and Activity-Rest have contributed to the global epidemics of obesity, type 2 diabetes, metabolic syndrome, heart disease, cancer, insomnia, stress disorders, depression, and many more.



The Brain Clock—The Master Controller (Illustration Credit: NIGMS. nih.gov)

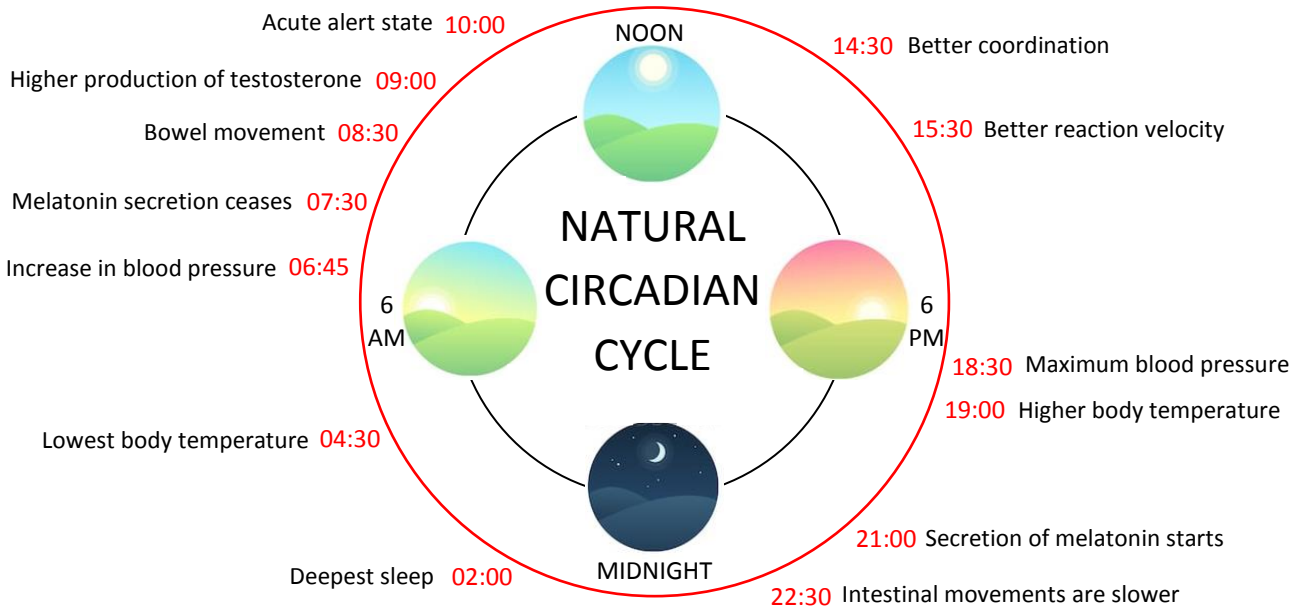
In highly evolved mammals and humans, the brain clock comprises of about 20,000 highly specialized nerve cells collectively known as the suprachiasmatic nucleus or SCN. The SCN lies in the area of the brain called the hypothalamus. The hypothalamus is the principal center for controlling all the essential hormones in the body. It lies in the brain right behind the middle of the forehead. A unique nerve pathway connects the retinal membrane of the eyes to the brain clock (SCN). The retinal layer of the eyes is the seat of vision. It has a particular light-sensing protein called melanopsin. The white light of the sun or the bright daylight both have seven colors, which on blending create white color. These seven colors (VIBGYOR) of white light show up in the rainbow. Of the seven colors, only the blue light stimulates the melanopsin protein of the retinal layer. The blue light (photic) signal from the eye travels

via the unique nerve pathway to the brain clock (SCN). The stimulation of the brain clock sets in motion all the physiological functions in the body, including hormonal release, digestion, and metabolism.

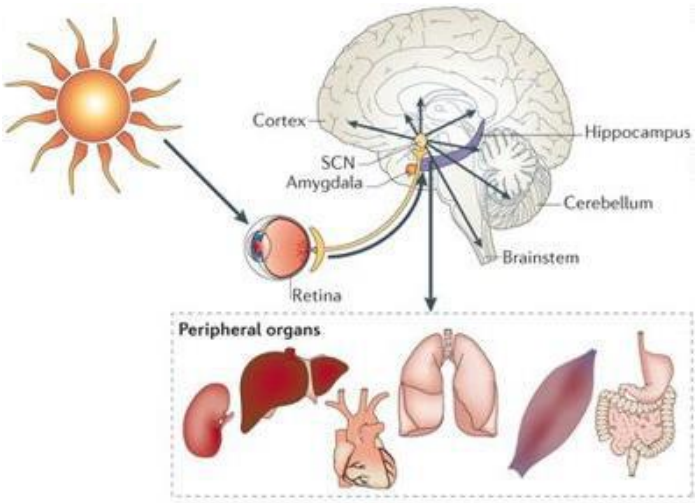


The colors of the Light Spectrum (seen in the rainbow)

In addition to the central brain clock, every organ in the body has its specific peripheral clock. Although the brain clock (SCN) is the master controller, the organs in the body can function independently of the brain clock in response to other cues (signals) such as artificial light, food, exercise, and social interaction. A good example is a digestive tract, which will start working any time the food gets into the mouth, even in the middle of the night. Digestion gets initiated although the natural brain clock has determined that the digestive tract must slow down by 10 PM for the process of rest, repair, and rejuvenation. The signals other than natural light are under human control. The modern epidemics of the food and lifestyle diseases are the result of the disruption in natural circadian rhythm harmony brought about by the irregular signals controlled by humans.



Natural Daily Circadian Rhythms Controlled by the Brain Clock



Peripheral Clocks in Every Organ and Body Tissues
(Illustration: Nature Reviews/Neuroscience)

Circadian Rhythms—The Natural Versus Artificial Light Signals

When an individual enters the room lit by bright artificial light, the brain clock perceives this as daylight. The blue light from digital and television screens also gets seen as daylight. The red and orange lights, on the other hand, get perceived by the eyes and the brain clock as the darkness of the night. Most mammals in the universe obey the light and dark signals of their natural environment to regulate the three survival behaviors of eating, sleeping, and activity in harmony with the natural 24-hour circadian rhythms of the brain clock. The modern urban human, on the other hand, spends time mostly indoors subjected to bright artificial light signals and blue light signals from digital tools. The brain clock perceives these unnatural signals as daylight. The perpetual indoor lifestyle adversely affects sleeping and eating behaviors.

Can the Brain Clock System Work without the Light Signal?

There are many geographic areas of the world where sunlight and bright daylight are scarce. When there is no natural light, the brain clock system and circadian rhythms depend on signals other than the natural light. The light signal (natural and artificial) is called a photic signal. The signals other than light are called nonphotic signals or the *zeitgeber*—a German term for a signal. These nonphotic signals are:

- Social cues – such as noise, conversation
- Food intake – the food entering the mouth activates the process of digestion, metabolism, and energy production at any time of the day or night
- Exercise / Activity

Circadian Rhythms and Body Physiology

Most of the physiological processes in the body are cyclic and under the influence of circadian rhythms controlled by the internal clock system.

a) ***Energy metabolism.*** During daylight, the body is expected to be physically active, so there is an enhanced need for energy. Glucose is the primary source of energy for body cells. That means the body uses up glucose more efficiently for making energy during the day time. The hormone which moves glucose into cells for producing energy is insulin, so the body is more sensitive to insulin during the daytime. During the night, the body is physically inactive and does not require much energy from glucose, so it becomes insulin-resistant. Therefore, the glucose absorbed from a meal eaten late at night does not get used for making immediate energy for activity. Instead, it gets converted into the reserve energy as fat. For this reason, a meal consumed late at night will invariably lead to obesity, even if one were to eat the healthiest holistic meal.

Therefore, for keeping a lean and disease-free body, when to eat is as critical as what to eat.

b) ***Hunger and Satiation***. No one gets hungry at night when they are sleeping. However, staying up late at night causes intense food cravings and overeating. The perception of being awake is a signal to the body that energy is needed. Typically, the food craving at night is for sugary foods to get instant energy. Late eaters usually, end up consuming convenient, readily available sugary junk foods and are likely to suffer from obesity, and associated diseases.

c) ***Cellular repair is cyclic in harmony with the natural circadian cycle.*** During the daylight hours, the cells are actively working to produce energy for survival and growth. The night time is for rest, repair, and rejuvenation. The digestive tract, which gets overworked for 14-15 hours from frequent meals or meals eaten late into the night, suffers from acid reflux disease, indigestion, bloating, and gas because there is no time for rest, repair, and rejuvenation. Once an individual adopts two or three meals a day routine with no food after 8 PM, all these problems disappear.

d) ***Hormonal balance is circadian.*** The hormones in the body rise and fall with circadian rhythms of the brain clock in response to the natural light and dark cues. The release of several essential hormones in the body is in synchrony with the Sleep-Wake cycle. Activation of brain clock by morning light sends the signal to the hypothalamus to release stimulating factors for all the essential hormones needed by the body:

- Insulin (glucose utilization hormone). As explained above, the body is sensitive to insulin during the daylight hours and resistant during the night.
- Cortisol-stimulating hormone
- Thyroid-stimulating hormone- Hypothyroidism has become an epidemic amongst city dwellers because of the disruption of natural circadian rhythms and unhealthy foods.
- Growth hormone. Deep rejuvenating sleep is critical to the optimal level of growth hormone in the body. The children who need more growth hormone get profound sleep and are hard to wake up.
- Melatonin. The brain clock on exposure to sunlight or bright daylight sends the signal to the pineal gland (the third eye) to synthesize and store the sleep hormone melatonin. It then gets released during the darkness of night to bring about deep, rejuvenating sleep. The artificial bright light and blue light from the digital screens at night inhibit the regular release of melatonin from the pineal gland at the dark hours of the night.

Harmony with the body's internal clock system and its circadian rhythms is critical to normal body physiology to ensure the preservation of health and prevention of disease.

Circadian Rhythm Disruption and the Modern Diseases

In 1997 a study of workers in Japan drew attention to the adverse effects of night shift work. The epidemiological studies on the night shift workers, showed that long-term disruption of the Sleep-Wake and Fasting-Feeding cycles cause metabolic diseases such as obesity, type 2 diabetes, heart disease, and cancers. These diseases are fast becoming epidemics among young urban adults who have work and social life schedule similar to that of a night shift worker. The following groups of people are susceptible to circadian disruption metabolic diseases:

- Night shift workers
- Jetlagged / long-term frequent fliers crossing time zones
- Social and digital jetlag—The young adults who eat late, sleep late, and are perpetually indoors in the midst of artificial light, digital blue light, and noise.

The night shift workers, who make up almost 20% of the workforce in the urban population globally, were the first group of individuals who got studied for circadian rhythm diseases. These individuals were found to have a high incidence of several metabolic disorders, such as:

1. Abdominal obesity
2. High blood pressure
3. High blood sugar
4. Type 2 diabetes
5. Heart disease
6. Gastrointestinal disorders
7. Depression and mood disorders
8. High risk of developing cancers

Many epidemiological studies have shown an increased incidence of breast, colorectal, and prostate cancer in night shift workers. A 1996 report suggested a higher rate of breast cancer in Norwegian radio and telegraph operators. The World Health Organization (WHO) recommended a set of health risks, as outlined above, linked to night shift work.

The hypothesis of "Light at Night" (LAN) suggests that the lack of the sleep hormone melatonin is at the root of the cancer disease process. The sleep hormone melatonin is a powerful antioxidant which removes cancer-producing free oxygen radicals from the body tissues during the sleep. The epidemiological support for the LAN hypothesis and breast cancer connection is robust.

Habitual late-night social life, commonly called social jet lag is universal in the young city dwellers. Social jet lag carries the risk of the same diseases as the night shift worker and additionally, the risk of addictive behaviors such as alcohol and nicotine use.

How to Live in Harmony with Circadian Rhythms

The light (photic) signal from the sunlight/daylight is the primary signal for the body's internal clock system and the circadian rhythms generated by it. These rhythms control the three survival behaviors of Sleep-Wake, Fasting-Feeding, and Activity-Rest. Humans control nonphotic signals such as mealtime, exercise, social interaction, and temperature change. In the preindustrial outdoor human, the original photic message of the sunlight was the dominant signal for the natural rhythmic lifestyle. In the postindustrial human, artificial light and the nonphotic signals are getting to be more significant. Being aware of and living in harmony with the natural circadian cycle is about:

- Getting the right amount of rejuvenating sleep
- Eating healthy holistic food at the right time, so the digestion and metabolism of the food remain most effective.
- Activity and exercise during the daylight hours

The natural photic signals from sunlight and bright daylight have a consistent pattern. However, artificial light and nonphotic signals are entirely under human control and may not have regularity. To re-establish circadian balance; modern humans need the discipline to control the artificial light and nonphotic signals under his/ her supervision. That harmony is critical to the preservation of health and prevention of disease.

Human Circadian Rhythms and Sleep-Wake Cycle

Knowledge about the process of normal sleep will help in cultivating healthy sleep-wake behavior. Every living being has an innate desire to sleep as their survival depends on it. There are two types of sleep:

1. ***Circadian sleep.*** It is the rejuvenating sleep brought about by hormone melatonin. Light (photic) signals from sunlight/daylight stimulate the brain clock, which in turn sends a message to the pineal gland located near it. The mood-elevating hormone serotonin gets synthesized in the pineal gland first in response to the brain clock signal. Melatonin, in turn, is manufactured from the serotonin. Since the sleep hormone melatonin and mood-elevating chemical serotonin are interrelated, poor sleep leads to depression, and the depression, in turn, leads to insomnia.

2. ***Deficit sleep.*** The desire for sleep which gets built up at the end of a day's activity is called sleep deficit or sleep debt. The metabolic activity during the wakeful state produces accumulation of a chemical substance called adenosine in the brain. Adenosine is the chemical driver of the sleep. The longer the body is awake and active, the more will be the accumulation of adenosine, and the more intense will be the drive for rest and sleep.

How the Circadian and Deficit Sleep Work Together to Regulate Normal Sleep

The first and foremost function of the brain clock is to keep the body awake during the daylight hours. The deficit sleep drive of adenosine keeps building the sleep drive with each accumulating awake hour. As the dark of night approaches, the awake signal from the brain clock dampens, and the sleep driver (adenosine) takes over to initiate the process of sleep. Rejuvenating sleep follows the deficit

sleep. Melatonin hormone release from the pineal gland starts at around 9 PM and is responsible for the rejuvenating sleep. Two hours before morning wake up time, the brain clock begins with the alert signals, and the melatonin release from the pineal gland stops. Cessation of the melatonin secretion coincides with a fully awake state of the morning.

"It must be noted that the normal wake up process which follows the rejuvenating sleep in an individual is a spontaneous phenomenon. It does not require an alarm clock. The need for an alarm clock daily to wake up in the morning is an indicator that the sleep-wake cycle is not in natural harmony, and there is residual sleep debt."

How Much Sleep Does a Human Need?

Sleep needs change over the lifetime of the human. Infants under one year need up to 16-18 hours of sleep. Seep hours then decrease steadily as the child grows. For optimal health, an adult needs 7-8 hours of sleep. Of these 7-8 hours:

- The first 20-30 minutes get spent in the process of falling asleep. The sleep onset time longer than 30 minutes suggests insomnia.
- First four hours of the sleep go towards paying back sleep debt or sleep deficit created during the day's activity.
- The final 3 hours of the daily sleep cycle are rejuvenating sleep, which is under the control of the sleep hormone melatonin. The rejuvenating sleep is a critically important part of the sleep process as creativity, memory consolidation, repair of body tissues, and the hormone secretion occurs during this phase.

For the majority of the adults, 7 hours of sleep is a good guideline. The sleep duration of fewer than 7 hours creates sleep debt. There are, however, exceptions to this rule. If someone sleeps little less than this duration but feels refreshed, not tired or sleepy during the day, and does not require an alarm clock to wake up daily, he/she can be considered to be getting required hours of sleep.

Health Problems Associated with Perpetual Sleep Debt

Perpetual sleep debt day after day is also called the state of chronic sleep deprivation. The sleep debt is the amount of sleep one needs, minus the amount of sleep one gets.

For every hour one stays awake, he/she will accumulate sleep debt of 20-30 minutes. Over 16 hours of the awake cycle, the sleep debt of 7-8 hours gets accumulated. A state of the sleep debt is a significant problem in the modern urban population who stay perpetually engaged with work or social activities going late into the night. Two or three hours of sleep debt for a day or two is easy to catch up in the following few days. However, longer sleep debt accumulated day after day is hard to pay back. The perpetual sleep debt or sleep deprivation leads to many health problems, such as:

a) Headache, migraine
b) Mood disorders such as anxiety, irritability, anger, hostility, and depression
c) Lack of concentration—attention deficit disorder
d) Poor memory

e) A constant feeling of being tired and sleepy

How to Normalize Sleep-Wake Cycle in Harmony with Natural Circadian Rhythms

Taking all the above knowledge into consideration, the sensible guidelines on normalizing Sleep-Wake cycle are:

1. Plan 7-8 hours of sleep daily to avoid cumulative sleep debt, which is hard to pay back.
2. Keep in mind that a perfect indicator of optimal sleep duration is the pattern of the wake-up process. If one needs an alarm clock daily to wake up, that would mean that the individual is sleep-deprived. The wake-up process is always spontaneous for those who have had optimal sleep in both quality and duration. There is no harm in keeping an alarm, but in most cases, it should serve only as a backup tool.
3. The morning wake-up time naturally sets up the sleep onset time at night. If one gets up early between 5-7 AM, it will be easy for him/her to fall asleep by 10-11 PM. Rejuvenating sleep is critical to good health, so It is a good idea to stay in harmony with the melatonin secretion. The melatonin secretion by the pineal gland starts by 9 PM. That will be an excellent time to start winding down and prepare for sleep by disconnecting from digital devices and cellphones. These devices emit blue light which inhibits melatonin secretion from the pineal gland. There are red/orange circadian light apps for digital tools and mobile phone screens. Use these circadian screen apps to minimize blue light exposure.
4. Finish eating by 7-8 PM to be able to sleep by 10-11 PM. The food in stomach raises the core temperature by a degree, and for the good deep sleep, the core temperature needs to come down by a degree. “Late eaters are invariably poor sleepers both concerning the quality as well as the quantity of the sleep.”
5. Minimize external and internal sensory sleep disrupters. The external disrupters are easy to control and include noise, artificial bright light, the blue light of digital devices, and conversation. Internal inputs such as anxiety, stress, and negative thoughts are harder to fix, but the awareness of the problem helps one to seek the solution. In most cases, a “Let Go” attitude and building social support (positive vibrations) helps with the anxiety and stress situation. Ego and fear of being judged are the most significant culprits in ruining restful sleep.
6. Note that time to bed is not the same as the time to relax for sleep. Time to rest is the time when one disconnects from all the external disruptions. After shutting off from digital devices, it takes 1-2 hours to wind down for sleep.
7. Aerobic exercise late in the evening after 7 PM disrupts the sleep cycle. Exercise releases excitatory chemical adrenaline which inhibits sleep drive chemical adenosine, a critical chemical for initiating the sleep process.

8. Caffeine antagonizes the effect of adenosine, the natural sleep driver in the brain and is the most potent inhibitor of sleep. The caffeine can stay in the system for as long as 8 hours, especially when one consumes a strong caffeinated drink like coffee and caffeinated soda beverage. Always check the caffeine content of your beverages and judge for yourself what disrupts your sleep. For good restful sleep do not consume any caffeinated drinks after 2-3 PM.

9. The sleep time starts when one turns off external signals and closes the eyes. It usually takes 20-30 minutes for sleep initiation. If sleep fails to get initiated within 30 minutes, one should look into the cause which could be external or internal signals or certain medications (For more details on sleep, check the section of sleep).

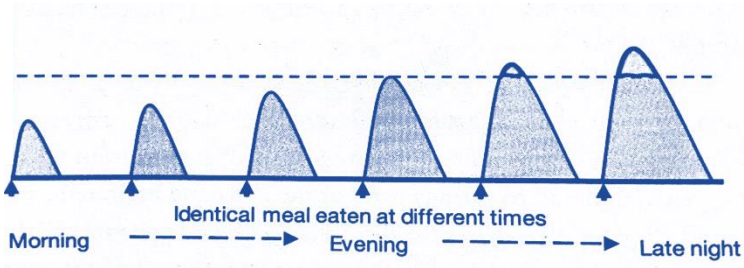
Human Circadian Rhythm and Fasting-Feeding Cycle

The circadian rhythms and the internal clock systems were designed by nature to enhance the survival of a living being by creating harmony in the three survival behaviors. The purpose of the circadian Fasting-Feeding cycle is to improve energy production for survival. Getting optimal energy from the food requires that:

- The food is holistic, primarily plant-based grown under the power of the sunlight.
- The food gets consumed at a time when digestion and metabolism are at the peak.

The digestion and metabolism of the food are at best only during the daylight hours. Artificial light has extended the day for the human beyond the daylight hours. The feeding times of modern humans have become long extending into the late-night hours. Before 1970, most populations around the globe ate only 2-3 meals a day. These meals got consumed within the 10-12 hours of daylight hours. There was no obesity or type 2 diabetes epidemic in the world before 1970.

The feeding time of the current generation of city dwellers has now extended to 14-15 hours going late into the night. When the identical meals get eaten at different times of the day, the blood glucose level is the lowest in the morning hours and highest at the late hour of the night (see the graph below on glucose blood levels versus meal times). The number of meals and snacks has also multiplied.



Glucose Blood Levels vs Meal Times
(from "The Circadian Code" by Satchin Panda, 2018)

The lack of knowledge on ***"<u>What</u> to Eat, <u>When</u> to eat, and <u>How often</u> to eat"*** is the primary reason behind the modern epidemics of obesity, and the associated multiple food and lifestyle diseases.

Risks of Late-Night Eating

A. ***Weight gain and metabolic diseases***. Overweight and obesity lead to type 2 diabetes, high blood pressure, metabolic syndrome, PCOS (Polycystic ovarian syndrome of young females), heart disease, and many more. Late-night eating will invariably lead to obesity, even if one eats the most holistic healthy meal for a reason outlined above.

B. ***Excessive hunger and overeating.*** Staying up late at night increases the level of hunger hormone ghrelin secreted by the stomach. That is a natural mechanism to get glucose for energy for an awake and active body. Late sleepers are invariably overeaters and obese for this reason.

C. ***Acid reflux disease and digestive problems***- As dictated by the natural circadian cycle, the intestinal muscles and secretion of digestive juices slow down after 10 PM. Meals consumed late at night do not get digested, causing bloating, gas, and acid reflux disease. A simple practice of eating meals early before 8 PM will eliminate all these digestive problems.

D. ***Poor sleep***. For good sleep there should be a time gap of 2-3 hours between the last meal of the day and the bedtime. Food in the digestive tract raises the core body temperature for 2-3 hours. To get good sleep, the core temperature of the body must come down by a degree. The late eaters are invariably poor sleepers.

When to Eat and How Often to Eat in Harmony with Circadian Rhythms

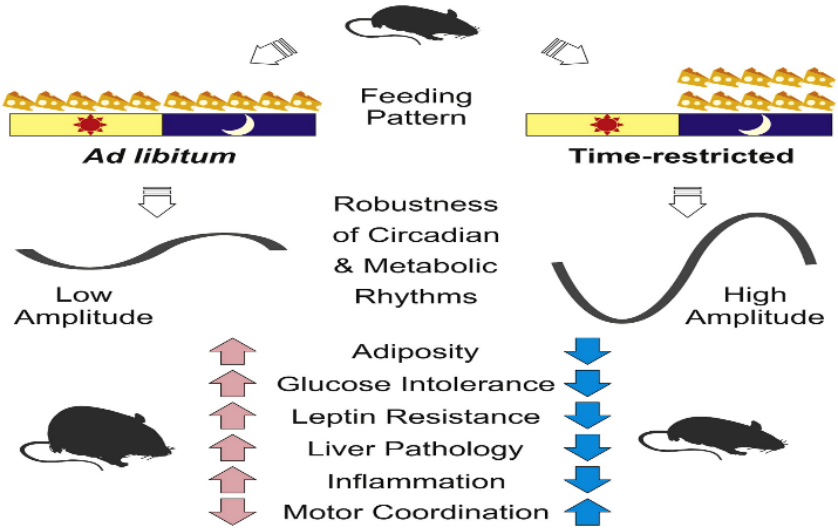
A groundbreaking experiment on mice by Dr. Sachin Panda and his associates at Salk Institute in San Diego, California, gave the world a revolutionary insight into "When to eat and how often to eat." The researchers looked at the effect of time and frequency of eating on body weight and health.

Two groups of mice born of the same parents got fed similar amounts of same type of food. One group of mice got free access to the diet for all 24 hours of the day. The second group was given access to the food only during the 8 hours of the standard eating time of the mice. The mice are nocturnal animals and eat at night. The mice seek food by the smell, so the mice who got exposed to food 24 hours fed randomly at all hours (*ad libitum*). Both groups consumed the same amount of food. However, after 12 weeks, the mice who fed ad libitum became obese and developed all the signs of metabolic syndrome:

- Obesity
- Fatty liver
- High blood glucose
- High blood fats
- Slow with poor muscle coordination
- Poor sleep because of perpetual food-seeking

The mice who ate in the restricted but natural time window of 8 hours during the standard feeding time for mice stayed lean and had no evidence of metabolic syndrome. Interestingly, when these mice in the ad libitum obese group were put back on the time-restricted eating cycle of 8 hours, both obesity and metabolic syndrome reversed.

The conclusions of the study were enlightening: ***"The time-restricted eating within the natural eating hours (in humans daylight) prevents obesity, reverses obesity as well as the associated metabolic disorders such as high blood sugar, high blood fats, and fatty liver."***



When to Eat

During the daylight hours, the body requires more energy for physical activity. Insulin is the hormone which helps the body use glucose for making energy. The body remains highly sensitive to insulin hormone during the daylight hours to boost energy production for physical activity. At night the physical activity slows down, the body is in the rest, repair and rejuvenate mode, so energy needs are minimal. Therefore, at night, the body shifts gears to become insulin hormone-resistant and convert glucose into the reserve energy fat for later use. Late-night eating, especially after 8 PM, leads to high blood glucose levels, and abnormal fat storage even when one eats holistic, healthy meals. Late-night dining also disrupts deep rejuvenating sleep, as outlined above. That adds to weight gain by increasing the level of the stress hormone cortisol.

How Often to Eat

Frequent eating every 2-3 hours keeps the digestive tract and metabolism in a constant working mode. A meal of any size, including a snack, provides 2-3 hours' worth of glucose for energy. After this time when no more glucose is coming from the digestive tract, the body has to fall back on the reserve energy from the glycogen and fat stores. When one eats every 2-3 hours, there is a constant supply of glucose coming from the digestive tract, so the body does not draw out of the stored reserves of glycogen and fat. Eating every 2-3 hours, therefore, takes away from this great benefit of using up fat stores. Using up the stored fat requires a separation of 12-14 hours (more extended period if someone is obese) between the dinner and next morning meal and 5-7 hours between the day meals. Only when there is no eating for several hours does the body switch to fat-burning mode. Even a healthy meal or a healthy snack, if eaten frequently, will lead to weight gain for this reason.

Human Circadian Rhythms and Activity-Rest Cycle

An active balanced lifestyle and exercise is the third survival behavior which must remain in synchrony or harmony with circadian rhythm to preserve health and prevent disease. Regular physical activity and exercise promote muscle and bone strength, heart and lung health, good sleep, good mood, and a happy spirit. When in synchrony with natural circadian rhythms, the body is most active physically in the morning, and the muscle coordination is best in the late afternoon and early evening hours (see the picture on natural daily circadian rhythms controlled by brain clock section 3- Brain Clock and Internal Clock System). The exercise timings for optimal health, therefore, are:

Aerobic exercise	The aerobic exercises increase the heart rate and are ideal for the morning, or early afternoon and late evening before 7 PM. Aerobic exercise late in the evening after 7 PM is not a good idea because adrenaline produced can interfere with sleep.
Strength and weight training	Muscle coordination is best in the late afternoon and early evening, so this time is best for competitive sports, strength, and weight training.
Stretching, brisk walking, yoga	These are the ideal exercises for the morning. Do these exercises outdoor under the morning sun to get the maximum benefit of sunlight for enhancing melatonin and serotonin synthesis in the pineal gland, and vitamin D synthesis in the skin. Additionally, the brisk morning walk on an empty stomach allows the body to use up stored fat.

Conclusions:

The health experts until now promoted that ***"How much we eat and how much we exercise"*** is the secret to keeping a lean body and good health. That old concept of "eat less and move more" has cost the global population billions of dollars year after year. However, the epidemics of diseases such as obesity, type 2 diabetes, high blood pressure, cancer, and heart disease have continued to multiply with each passing year.

The recent research on the science of the natural circadian rhythms has provided revolutionary insights into the cause of new food and lifestyle diseases. Every biological process in the body—digestion, metabolism, hormonal balance, sleep, activity, immunity, and gene expression follow a set rhythmic pattern called circadian rhythms. These are under the control of an internal clock system of the body, which is controlled by the brain clock. The clock system resets itself every 24 hours. To preserve health and prevent disease, it is critical that humans, like other living beings of the universe, live in harmony with the body's circadian rhythms concerning the three essential survival behaviors: Sleep-Wake, Fasting-Feeding, and Activity-Rest cycles.

The current scientific knowledge supports that ***"How much we eat and how much we move is not good enough."*** To preserve health and prevent disease, other parameters outlined below need a serious consideration. These parameters are:

- ***What we eat***
- ***How often we eat***
- ***What time we eat***

- ***When we wake up and when we sleep***
- ***What is meant by healthy activity and exercise***

Humans are born with robust circadian rhythms. However, when they lose harmony with natural rhythms concerning sleep, feeding, and activity behaviors, they end up with disease and disability. A good example is night shift workers who eat and sleep at ungodly hours and end up with obesity and metabolic diseases such as type 2 diabetes, heart disease, and cancer. The modern city dwellers in this respect are no different than the shift workers and therefore, suffer from similar conditions.

One may think that the first thing to do for fixing circadian rhythm harmony is to normalize the Fasting-Feeding Cycle. Interestingly, it is the Sleep-Wake cycle, which lies at the core of the three survival behaviors. Therefore, if one normalized the Sleep-Wake cycle, the other two survival behaviors of Fasting-Feeding and Activity-Exercise would get synchronized naturally.

"Sleep is the golden chain which binds health and body together."

- Thomas Dekker (English playwright, 1572-1632)

The best indicator of optimal rejuvenating sleep is a spontaneous refreshed wake up in the morning without any help from a screaming alarm clock. Our ancestors were wise when they declared that the early morning time is "*Amrit Vela*," which means the time or moment when one can taste the nectar to empower the self.

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