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Light Rhythms

How and when we are exposed to light can affect our bodies in some surprising (and not always beneficial) ways. Here's what you need to know about your body's built-in responses to cycles of light and dark - and how you can make the most of them for better health.

By Karen Olson June 2009

Since the advent of the light bulb, we've been able to brighten our world with the flick of a switch. And what a breakthrough that has been: Artificial light has given us more time to read and learn, work and play. But the ability to keep lights burning 24/7 has also come with a dark side.

Our body's natural rhythms are connected to and affected by the natural cycles of light and dark. For millennia, humans stayed awake when the sun was up (to hunt for food and protect themselves from enemies), and slept when it set. So, today, while artificially extending our exposure to "daylight" means we can accomplish more, it also puts us out of sync with natural cycles of light and dark — the very cycles the human body got used to during centuries without manmade sources of illumination.

"Our bodies evolved to expect 12 hours of light and 12 hours of dark," says University of Connecticut epidemiologist Richard Stevens, PhD. "Since the advent of electricity, we haven't been exposed to enough darkness." Meanwhile, by spending most of our waking hours indoors and away from *natural* sunlight, we're also often underexposed to the wavelengths of light that stimulate our natural rhythms.

That might not seem like such a big deal, but research has shown otherwise. A study published in the December 2005 issue of *Cancer Research* showed that open-eye exposure to artificial light at night stimulated the growth of breast tumors. Stevens and colleagues first observed the relationship between breast cancer and aperiodic (irregular) exposure to natural cycles of light and dark in 2001, when a study he conducted found that the incidence of breast cancer in night-shift nurses was 30 percent higher than in the general population. "Artificial light erodes the night," he says, and that has long-term health consequences.

Stevens and Itai Kloog, an environmental epidemiologist at the University of Haifa in Israel, also found a correlation between excessive environmental-light exposure and prostate cancer in men. Their study, published in the January 2009 issue of *Chronobiology International*, looked at nighttime global-satellite images of 164 countries and noted that the incidence of prostate cancer was nearly double the average rate in areas exposed to the most light at night (LAN).

Evidence linking LAN with certain cancers is now considered so conclusive that the World Health Organization has classified night-shift work as a probable carcinogen.

Studies also show that exposure to aperiodic light and disrupted natural rhythms can affect our sleep patterns, mood, weight and susceptibility to other "lifestyle" illnesses. And the damage can happen early. Researchers at Vanderbilt University, in Nashville, Tenn., have found that excessive exposure to bright light early in life — such as in neonatal intensive care units — may contribute to depression and other mood disorders in adults.

By better understanding our bodies' natural rhythms and their relationship to natural cycles of light and dark, we can make more health-promoting and health-sustaining decisions. We can use what we know about our natural, biological rhythms to improve our sleep, bolster our mood, regulate our metabolism and reduce our risk for chronic diseases.

Life Rhythms

All living things have natural internal rhythms that regulate cellular functions and physiological processes. These rhythmic cycles act as a type of clock that dictates when and how our bodies do almost everything — crave food, get thirsty, generate energy, stay alert, fall asleep, regulate mood, maintain body temperature and more.

In humans, the most prominent internal cycles are circadian rhythms. These rhythms are internally generated, but they are triggered and influenced by external stimuli, such as variations in temperature or travel across time zones. (Jet lag is what you experience while your circadian rhythms are realigning themselves.) The most powerful external influence on

circadian rhythms, however, is exposure to light and dark.

As light fluctuates over the course of 24 hours, the brain tracks it through the retina's ganglion cells in the back of the eye. When a photosensitive pigment in those cells, called melanopsin, detects light, those ganglion cells send information about the duration and brightness of that light to clusters of nerve cells, called the suprachiasmatic nucleus (SCN), in the brain's hypothalamus.

The SCN is the master pacemaker of circadian rhythms, or, simply, the "master clock." Among its other duties, it determines the daily rise and fall in body temperature (which is ˙ lowest around 5 a.m.) and blood pressure (which is often 20 percent higher in the late afternoon than it is in the morning). The master clock also tells the brain's pineal gland when to produce melatonin, a sleep-promoting hormone with powerful antioxidant properties.

Melatonin production begins about two hours before you feel the urge to sleep at night and continues until shortly before you awake in the morning, says Michael Terman, PhD, director of the Center for Light Treatment and Biological Rhythms at Columbia University Medical Center. Whether you're a night owl (you don't feel drowsy until late at night) or a morning lark (you naturally wake up early) is a matter of genetics. "The way the clock adjusts to day and night is largely genetically determined," says Terman, "and lark and owl chronotypes are at the extremes."

Melatonin, explains Mark Rea, PhD, director of the Lighting Research Center at Rensselaer Polytechnic Institute in Troy, N.Y., "acts as messenger" between the master clock and several other peripheral circadian clocks in the body, such as those in the pancreas, skin and several internal organs, including the liver. "Each system in the body has its own rhythm that is coordinated by the master clock."

Coordination between the master clock and peripheral clocks (crucial for letting us know what to do and when to do it) is dependent on the natural 24-hour light-dark cycle. If our exposure to light and dark becomes aperiodic, the master clock can lose control of the timing of the peripheral circadian clocks. Our internal rhythms become out of sync with each other, and it's this internal rhythmic discord that causes trouble.

Mixed Signals

It doesn't take much to disrupt our circadian cycles, and the effects can be dramatic. "Aperiodic light exposure will sometimes send signals to the SCN telling it to move earlier, and at other times telling it to move later. This can happen within one night, causing chrono-chaos," says Terman. "Essentially, we're talking about inducing mini- or full jet lags from day to day, preventing the system from stabilizing in sync with external day and night."

It's easy to demonize a single aspect of aperiodic exposure to light and dark (such as LAN or too little exposure to natural sunlight during the day) as the prime troublemaker, but it's the systemwide rhythmic disturbances that have the biggest effect.

"We are careful not to say that it's only 'light' or 'light at night'" that is causing problems," says Rea. "What we are pursuing is the idea that it is the breakdown of the regular rhythm of light and dark. The rhythm is the foundation of our sleep cycle, immune system, body temperature and more. We think it's probably an oversimplification to say that it's 'light' or 'light at night' that causes health problems."

And Terman adds that chalking up circadian-related health issues solely to melatonin suppression "is simplistic and often hyped." He says that other possible contributing factors include "work stress, chaotic meal timing and diet, overall sleep loss, and frequent shifting of the circadian clock forward and backward."

Clearly, sorting out the precise mechanisms by which aperiodic exposure to light and dark affects circadian rhythms will require further study.

Two decades ago, funding for additional studies likely would not have materialized. In the 1980s, when Stevens first proposed the hypothesis that exposure to natural cycles of light and dark affected health, it was met with academic skepticism. Today, however, the landscape of circadian studies has shifted dramatically.

Stevens says scholarly interest in circadian cycles is skyrocketing because of reliable data pointing to a direct link to human health. Arrhythmic biological rhythms, it is now widely believed, can set us up to face a range of health problems, including sleep disorders, mood disruptions, weight gain, digestive problems, eating disorders, early- onset diabetes, specific cancers and more.

When Your Clock Is Off

The amount and intensity of light required to get the SCN to send "awake" signals to the body is about 500 billion photons per second per square centimeter of blue wavelength light — equivalent to the amount and type of light that reaches the eye at sunrise. But much of the artificial light we use today, including high-intensity discharge lamps (often used in streetlights) and fluorescent lamps (in offices everywhere), also contain blue wavelength light. This tricks our SCN into thinking it's perpetually sunrise — and, hence, that it's always time to be awake and alert. Conversely, if we are not exposed to enough blue wavelength light, we don't get the proper wake-up cue.

Overexposure to sun-mimicking light is also believed to play a role in the increase of insulin resistance, type 2 diabetes and obesity in developed countries (where round-the-clock illumination is more prevalent). Some research also shows that too much sun-mimicking light ups our craving for carbohydrates.

Before humans started cultivating grains, carbohydrate energy was available only from spring to fall. In response, our bodies evolved to stock up on carbohydrates during the growing season to prepare for winter, when no carbohydrates were available. In turn, we didn't crave carbohydrates in the winter. All that changed with the light bulb, write T. S. Wiley and Bent Formby, PhD, in Lights Out: Sleep, Sugar and Survival (Atria, 2001).

"Your body translates long hours of artificial light into summertime," they explain, "and you begin to crave carbohydrates so you can store fat for a time when food is scarce and you should be hibernating." Being aware of this seasonal effect can help you trump carb cravings.

And, if you don't get enough sleep, your body is at even higher risk for gaining weight. That's because a lack of sleep reduces your body's ability to process glucose, reduces thyroid function, and elevates levels of cortisol, a stress hormone that tends to work against weight-loss efforts.

Excessive light at night sends our SCN confusing signals, and these can prove particularly troublesome when it comes to getting a good night's sleep. If your bedroom is filled with ambient or artificial light, your SCN thinks it's daytime, making it harder to fall asleep and stay asleep. What's more, it doesn't take much light to disrupt your bedtime. One study revealed that nighttime exposure to just one low-level incandescent bulb for only 39 minutes reduced melatonin levels by 50 percent. And sleep loss and disruption can affect our health, emotional state and ability to perform.

"Early indicators [of not getting adequate sleep] are depressed mood, feeling flat, running out of motivation, more negativity," says Adam Fletcher, PhD, an organizational psychologist and managing director of Integrated Safety Support (www.integratedsafety.com.au), a Melbourne, Australia–based firm that helps companies deal with the risks of fatigue and sleep loss. "If it progresses, we start seeing quite significant impairments in communication. After that, people start making errors and forgetting things. At quite late stages, people start unintentionally falling asleep. They physically shut down." (For more on sleep deprivation, read "Sleep Deficit: The Hidden Debt That's Hurting Us All" in the November 2008 archives.)

While too much light can disrupt quality sleep, too little exposure to the right kind of light can affect mood ˙ and trigger mood disorders such as Seasonal Affective Disorder (SAD).

Though the exact mechanisms by which lack of light affects mood remain unknown, the link between light and mood seems almost certain. Studies have shown that exposure to 30 to 90 minutes of blue wavelength light each day is as effective as pharmaceutical antidepressants in treating several forms of depression, including SAD. People in northern latitudes, where winter days are shorter, are more susceptible to SAD, as are people on the western edges of time zones, where it is dark later into the morning than it is on the eastern edge of the same time zone.

Even more worrisome, research has suggested that circadian rhythm disruption can increase the risk of certain cancers. A 2005 study published in the *Journal of Circadian Rhythms* found that the total plasma antioxidant capacity of shift workers after completing a night shift was significantly reduced. The study concluded, "shift work can act as an oxidative stressor and may induce many medical disorders."

Interestingly, the study also found that age and obesity in shift workers made them more sensitive to this hazardous effect.
The full mechanisms by which night-shift work and inverted circadian cycles contribute to increased cancer incidence remain a mystery, but melatonin suppression is strongly suspected to play a role. Melatonin is a powerful, protective neuroendocrine substance that has shown the ability to inhibit tumor growth and bolster anticancer immune defenses.

Resetting Your System
Getting your body in line with natural cycles has numerous benefits and can ward off a host of potential problems. Because everyone has slight differences in their internal clocks, there's no single formula for resetting your body's clock. But we can all follow some helpful guidelines for embracing the natural light-dark cycle.

Get up at the same time every day.
"This tactic will anchor your biological clock at the desired time," write Michael Smolensky and Lynne Lamberg in The Body Clock Guide to Better Health (Holt, 2001). "If you go to sleep late one night, don't sleep in the next morning. Compensate for missed sleep with a 20-minute midafternoon nap, unless you find naps leave you foggy. In that case, go to bed 15 minutes earlier the next night."

Plan your exposure to bright light.
"Light can have a different effect on your body depending on when, in your circadian rhythm, you're exposed to it," says Fletcher. Let's say you rise at 8 a.m. and go to sleep at 11 p.m. If, for several days in a row, you get bright light from 6 to 8 a.m., your brain will reprogram and you will begin waking up earlier and getting sleepy earlier. If you get bright light in your last two hours of wakefulness, Fletcher adds, your brain gets the signal to stay up later and sleep later in the morning. "The same two-hour burst of light can have the opposite effect, depending on the time you get it."

Exposure to bright natural light is best, but sitting for 30 to 90 minutes a day in front of full-spectrum lights, often used to treat SAD and other circadian-related mood and sleep disorders, is also effective.

Get outside during the day.

If you don't get enough light during your day, take small steps to increase your exposure. Try parking your car at the far end of the parking lot at work or the grocery store, so you have to walk some distance each time you come and go. Or take your lunchtime workout outside and go for a short walk or jog. This small exposure to sunlight can help increase alertness and concentration, and increases vitamin D absorption.

Sleep longer.
The advent of electric light around 120 years ago shortened our nights considerably, and while it might not be feasible in today's world to return to these extended 12-hour sleep sessions, epidemiologist Stevens says most of us would do well to seek more sleep than we're currently getting: "We can certainly handle more than seven."

Keep lights off at night.
"If you are going to get up in the middle of the night, it is better to use lights that are not overly bright," says Fletcher. That's because turning a bright light on even briefly may stop melatonin secretion, which may not start up again for up to 20 minutes after the light is turned off. "It may not reset your body clock, but it could get in the way of you getting back to sleep quickly."

The eyes are photosensitive even when we sleep — ganglion cells in our retinas can absorb light photons through our eyelids (though they absorb less than when eyes are open). In short, if there's a light burning somewhere, our bodies know it, even deep in sleep. To reduce light exposure when sleeping, remove electronics from the bedroom. If your alarm clock is bright, turn it around so it's not facing you. If there are streetlights outside your window, shut the drapes. Still too much light? You might consider investing in blackout drapes.

Yet, even when we set out to correct the imbalances in our artificially lit world, we can run into challenges. Light pollution, or light from poorly designed lighting systems that send light skyward (where it is unneeded and unwanted), occludes natural darkness in densely inhabited areas and thwarts our efforts to experience daily doses of darkness. The International Dark-Sky Association (IDA), an advocacy group in Tucson, Ariz., dedicated to fighting light pollution, has labeled light pollution a public health risk. "Physiologically, humans need darkness," says IDA managing director Pete Strasser. "As much as we want to live in a 24-hour day, we evolved with daily light and dark periods, and our circadian cycles are a constant reminder of this fact."

Get outside at night, too.
Light pollution also robs us of experiencing unfettered moonlight and starlight. While there's very little research on the human health effects of exposure to it, and the research so far shows no quantifiable connection between exposure to celestial light and our natural rhythms, the psycho-emotional benefit of experiencing that light is hard to deny.

"In a bright city, you can see about nine stars," says Strasser, who with the IDA helped pass light ordinances in Tucson that restrict unnecessary ambient light. "You can see the Milky Way within Tucson city limits [because of the ordinances], but two-thirds of Americans under 18 have never seen the Milky Way. They have no inkling what they're missing."

Our brighter world comes with many advantages — including gains in convenience, productivity, comfort and safety. We can leverage these benefits best, however, when we understand how our bodies work in connection with natural cycles of light and dark, and when we know when to turn lights off as well as on.

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Sunlight and Vitamin D
Sunlight doesn't just help set your internal clock, it actually nourishes your body by helping it create vitamin D. Classified as a water-soluble vitamin, vitamin D acts more like a hormone, working with the parathyroid hormone to balance calcium in the blood and build strong bones. It also maintains healthy cellular growth and regulates the immune system, which prevents excessive inflammation that can lead to autoimmune diseases like rheumatoid arthritis, diabetes, periodontal disease, multiple sclerosis and irritable-bowel diseases.

The Institute of Medicine of the National Academies currently calls for 200 international units (IU) of vitamin D per day for people younger than 50, 400 IU for those 51 to 70, and 600 IU for people 71 and older. But organizations like the American Medical Association and the American Academy of Pediatrics have called on the government to raise those numbers to between 1,000 to 2,000 IU daily.

Recent studies in North America and Europe indicate that a staggering 95 percent of people are vitamin D deficient — not surprising given how much time we spend inside. To counteract this, the National Institutes of Health recommends spending 10 to 15 minutes outside, without sunscreen, three times per week. People with darker skin may need additional sun exposure. Expose arms, legs and hands. Avoid overexposing your face, which tends to be more prone to sun damage.