PHILIPS

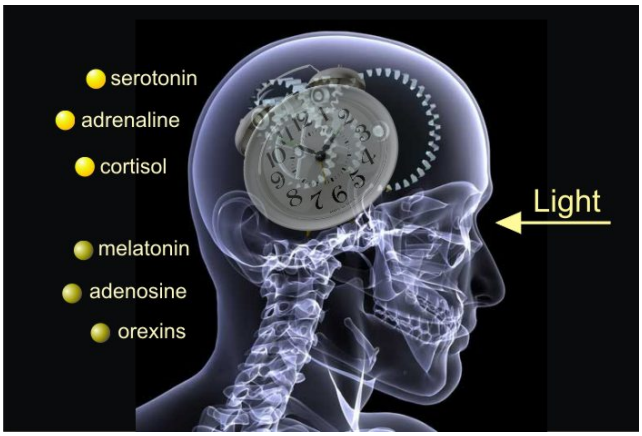
Physiological Effects of Light: *How light regulates sleep, mood and energy*

October 2009

Sunrise, sunset

For eons of time, we have arisen and gone to sleep with the rising and setting of the sun. Our body clocks have adapted to these daily light and dark signals and use these cues to regulate our sleep and energy cycles. These cycles are called circadian rhythms (Latin = around a day). These cycles also regulate our mood and energy. We feel exhilarated in the sunlight and pull back and withdraw in the dark.

This process is more than just psychological. Our eyes transmit light to a center in the hypothalamus of the brain called the Suprachiasmatic Nucleus (SCN) or body clock. This is how active hormones like serotonin are produced. And when the eyes perceive darkness, the brain produces the nighttime hormones such as melatonin, adenosine and orexins.

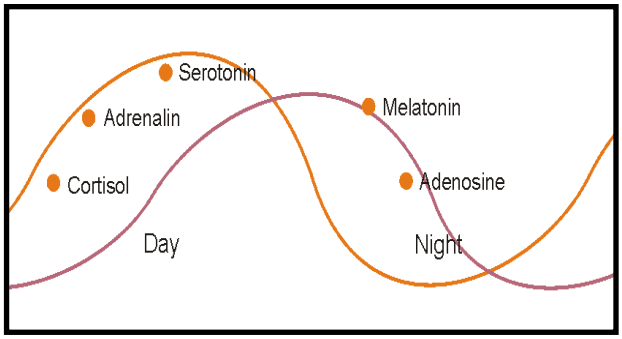


Light regulates our internal body clock, which produces active hormones during the day (serotonin) and sleep hormones during the night (melatonin).

Flipping a switch

We think we should be able to wake up or fall asleep as easily as flipping a light switch on or off, but our bodies don't work that way. It takes time to transition from wakefulness to sleep; we have active, energetic hormones that need to be washed out and replaced by the nighttime sleep hormones.

This happens when our eyes sense lower light levels in the evening sky, and signal the body clock to stop the production of active hormones. And it takes time; which is why we usually get tired and want to go to sleep a couple of hours after sunset. During this transition phase the body begins to break down hormones like serotonin into the nighttime hormone melatonin. This also triggers the release of other sleep hormones such as adenosine and orexins.



Circadian rhythms rise and fall like a wave during the 24 hour day. Misaligned rhythms (shown in purple) may cause the body clock to regulate the wrong hormones at the wrong time of day.

In nature, as darkness fades to twilight and then to dawn, the body clock stops producing melatonin and begins producing serotonin, adrenaline and cortisol. Over the next couple of hours, these chemical levels build, causing us to awaken feeling alert and energetic. This is why it is so much easier to wake up with the sun rather than with an alarm clock. Alarm clocks short change (bypass) this essential function, which may be why so many people have a difficult time getting up with just the alarm clock in the morning.

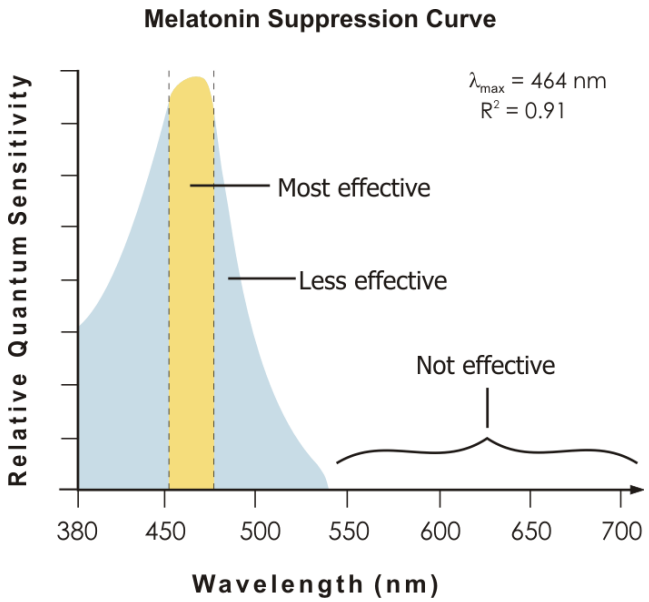
Mood and energy

The discovery that we depend on sunlight arose in the early 80's at the National Institutes of Health (NIH), where researchers discovered that the lack of light caused mood problems in the winter. As they

increased the level of light, people responded better, and morning light worked best of all.

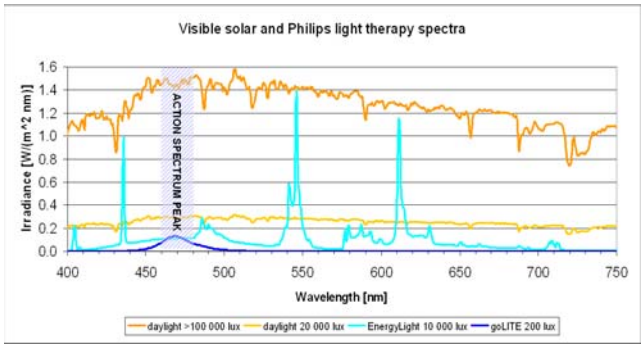
These discoveries led scientists to ask the question: Is all light the same, or are specific wavelengths or colors important? Researchers knew that we see light through different rod and cone receptors in the eye, and each responds to a different spectrum or color band of light. If selective colors were responsible, then they could design more effective lighting and perhaps reduce the intensity to more comfortable levels.

In answering this question, scientists knew that light stopped the production of melatonin, and melatonin production is a good indication of how the body clock responds to light. If one wavelength is better than another, it should suppress melatonin more effectively. After several experiments, a team led by Dr. George Brainard at Thomas Jefferson University discovered that a specific color of blue light (light blue ~470 nm) suppressed melatonin much better than other colors. In fact, warmer colors such as yellow, amber and red didn't suppress melatonin. Because light blue was so superior, scientists termed it the, "action spectrum" of light.



In 2001, Dr. Brainard and colleagues identified the action spectrum of light as most effective from 447 – 476 nm. Subsequent studies have updated this region to ~460 – 485.

Several studies now confirm that this blue light is mainly responsible for regulating our body clocks. For example, very low levels of blue light produce an equivalent or greater body clock response than high levels of white light, despite the fact that the white light contains blue.



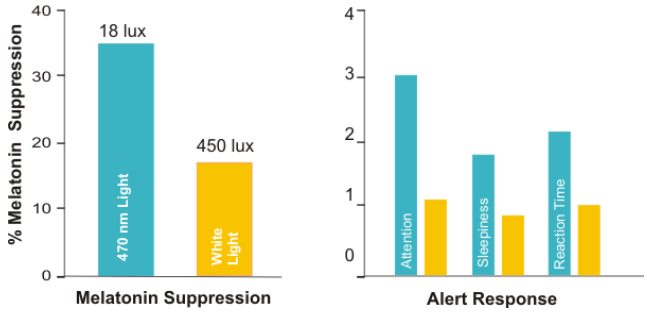
The peak of the physiological action spectrum of light is in the light-blue region of the visible spectrum. It is this part of the solar spectrum and of the traditional bright light therapy spectrum such as e.g. Philips EnergyLight that is essential for our wellbeing, and provided by the Philips goLITE device.

Surprisingly, this color of light didn't match any of the rod and cone photoreceptors in our eyes, and subsequent studies confirmed that rods and cones were not primarily responsible for regulating our body clock. This led to one of the most important ocular discoveries in hundreds of years: If rods and cones aren't responsible, there must be an undiscovered photoreceptor in the eye.

Melanopsin Discovery

In 2002, David Berson at Brown University discovered the missing link: The ganglion cells in the inner retina (in front of the rods and cones) contained a photopigment called *melanopsin*. This newly discovered receptor matched perfectly with the 'action spectrum' of blue light. Now that scientists identified melanopsin, they were able to trace its projections via the retinohypothalamic tract to the SCN in the hypothalamus and other areas in the brain.

This discovery meant that the eyes also transmit light through a non-visual system, and studies comparing the visual against the non visual system show that the blue-light melanopsin pathway was not only responsible for regulating our circadian system, but the alerting system as well. Memory, attention span, reaction times, alertness, learning ability and cognitive processes all perform much better under blue light. In fact, a study by Dr. Lehrl and colleagues in Germany showed an immediate improvement in learning process equivalent to a 5 point increase in I.Q.



In the first illustration, Low levels of blue produced nearly twice the body clock response compared to much higher levels of white light. The second illustration shows a dramatic increase in alertness when the blue, non visual system is stimulated vs. the visual system.

The great "Duh" moment in science

With the discovery of the action spectrum came another important observation; this color of blue was the same as the blue morning sky. After decades, and millions spent in research, the conclusion was inescapable—When it comes to sleep wake cycles and mood and energy, we respond best to the natural light cycles produced by the sun.

The problem with indoor light

The problem with artificial indoor lighting, whether halogen, incandescent, fluorescent or mercury, is that it doesn't produce very much of this essential color and intensity of light. Recently, Dr. Nancy Snyderman, NBC's medial expert on the Today Show announced that when Thomas Edison invented the light bulb, he also discovered insomnia. Because of artificial indoor lighting, we not only miss the essential colors of light, but we also miss the sunrise and sunset signals that set our sleep wake cycles. Now we get up before the sun and stay awake hours after dark, which plays havoc with our body clock. The effects of artificial lighting caused Dr. Till Ronnenberg, a noted Neuroscientist, to claim that our society suffers from perpetual jet lag. In fact, our sleep wake patterns are so disrupted that the National Sleep Foundation reports that half of all adults can't get up in the morning without an alarm clock.

Getting back to nature

We can't change our sleep schedules but we can use technology to make falling asleep and waking up more natural. Philips has developed a new lighting device that recreates sunrise and sunset in your bedroom. The Philips Wake-Up-Light (WUL) supports the body's natural transitions with sleep and wakefulness.

Phillips Wake Up Light creates a naturalistic sun-rise and sunset to help the body clock transition into wakefulness and sleep.

In the wakeup mode or sunrise, the WUL gradually turns on before you need to be awake, and increases just enough light to alert your body clock without causing you to awaken prematurely. The WUL reaches full brightness by the time you need to get up, allowing you to awaken refreshed in a well-light room, just as with a natural sunrise. Studies using the WUL show an improved ability to awaken with more energy for the day.

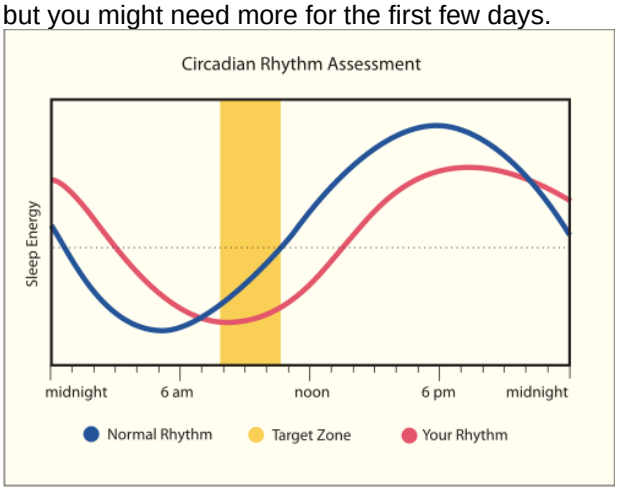
In the fall-asleep or sunset mode, the WUL gradually dims, alerting the body clock to the gradually dimmer levels of light. The sunset mode allows a more natural transition from wakefulness to sleep. As the room lighting diminishes, you may find it harder and harder to stay read or watch TV. The sunset mode gradually turns off the light and automatically resets for the sunrise sequence the next morning.

Daytime energy

Besides lacking natural sunrise and sunset, indoor lighting produces little of the natural blue sky light, or action spectrum that stimulates our body clocks and alertness. While everyone can get tired and fatigued at work, some may notice it more on cloudy days or especially in the fall and winter months. The Philips goLITE BLU (HF3330) recreates the color and intensity of light shown in research to improve mood and increase energy and alertness.

The BLU is portable with a rechargeable battery so it can be used anywhere. And because it only produces the action spectrum, it doesn't need to be as bright as traditional 10,000 lux bright white light boxes. By comparison, the goLITE BLU only produces 200 lux of light.

The BLU can be used anytime of day for an energy boost, but it may be that your body clock responds best to light at a certain time of day. Our body clocks can either slow down or speed up when they don't get the right light signals, and it's important to get the right type of light to help reset the body clock each day. Since every body clock is different, it is a good idea to take the online, circadian rhythm assessment, to see if a particular time is best for you. Usually 15 minutes a day helps keep the body clock in check, but you might need more for the first few days.



Philips provides a body clock assessment tool online to help goLITE users find the time of day to use their goLITE for the best response(www.lighttherapy.com)

The goLITE BLU Produces the wavelength and intensity shown to regulate the circadian and alerting systems.
Size = (14 X 14 cm)

Conclusion

Demands of modern work schedules and lifestyle have disrupted our exposure to natural sunrise, sunset and the essential blue light from the morning sky. As a result our sleep/wake and energy patterns can suffer, causing many to feel the negative effects of perpetual jet-lag. While it may be impossible to waken and fall asleep with the sun or receive enough beneficial morning light, technology from Philips is recreating nature as much as possible, in an effort to improve sleep, awakening and daytime energy.