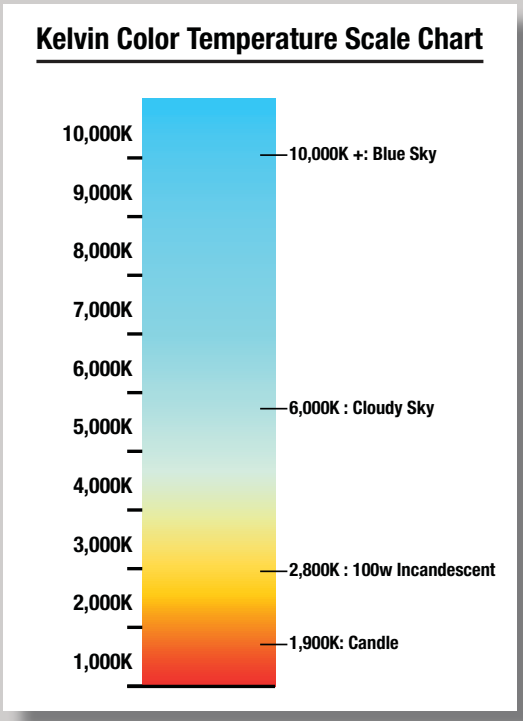
SIGMA LUMINOUS™

ENERGY SAVINGS THROUGH INNOVATION

SIGMA LUMINOUS COLOR TUNING TECHNOLOGY

Getting You Back In Rhythm

Today, humans spend 90% of their time indoors with artificial lighting.



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Until 200 years ago, humans spent much of their time outside. Today, humans spend 90% of their time indoors with artificial lighting. We will discuss the body's natural clock - the circadian rhythm, the various forms of light that humans have been exposed to over the past 300 years and its effect on the circadian rhythm, and how lighting methods like an adaptive, tuneable system are better for the working and learning environment.

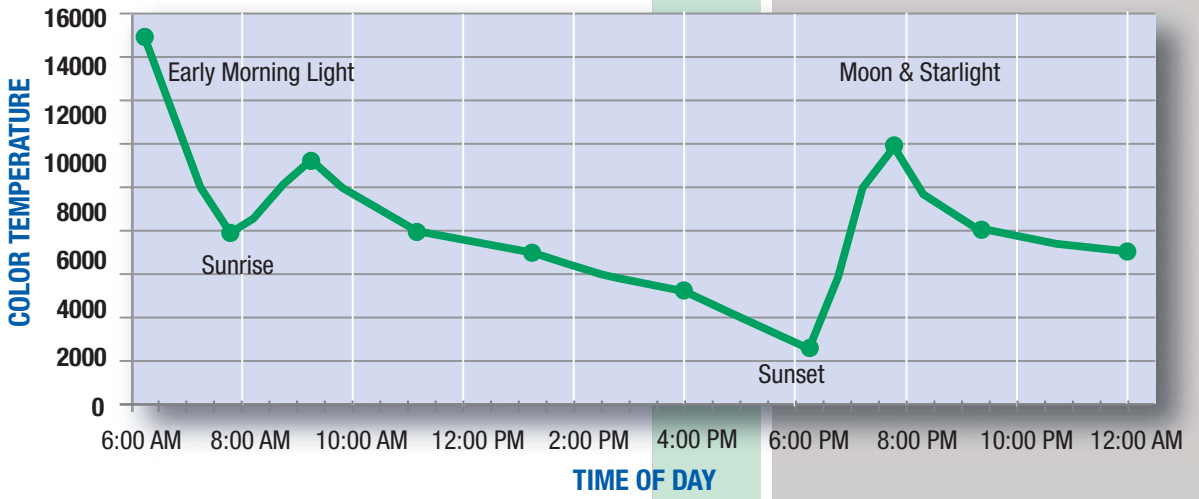
CIRCADIAN RHYTHM

The circadian rhythm sets the body's natural clock and regulates the sleep/wake cycle. The hormone melatonin is primarily responsible for setting the clock every day[1]. When the pineal gland in the brain secretes this hormone in the late evening hours, it prepares the body for sleep. Melatonin is one of the body's natural antioxidants, which acts to prevent cellular damage created during the stressful activities of daily life[1]. Melatonin levels peak around 10 pm, as the body increases its internal metabolic activities to restore the body. If a person is awake during this process, they feel it as the "second wind" phenomena, except their body will not restore itself as expected[1]. If people also experience external stimuli that affect the production of melatonin, they will feel fatigued and sleepy in the morning.

What controls melatonin levels? It is not the passage of time, but rather the correlated color temperature (CCT) of light[1]. Specific receptors in the eye are particularly responsive to the blue light we experience early in the morning. Exposure to even low levels of this 6000K+ light prevents secretion of melatonin. Conversely, this high color temperature light promotes the secretion of hormones like cortisol, dopamine, and serotonin to increase alertness, stress response, pleasure, and carbohydrate and impulse control. Throughout the day, the light gets brighter, but also the color temperature decreases, to more a more white light at noon, to a warmer less intense light before sunset.

The following chart shows the color temperature of light throughout a normal day, 6 am to midnight. The large spikes right before and right after sunset is due to the reflection of ambient light in the atmosphere. The color temperature at night is the same as noon light since the light comes from the reflection of the sun's light on the moon and stars, but because the light levels are low people do not perceive it as noon light.

Chart 1:
Color Temperatures Experienced During the Day



Not all exposure to light results in changes in melatonin levels. A study was conducted exploring melatonin changes in the evening when exposed to different color temperatures of light. They exposed three groups of subjects to light from 9:00 pm to 2:00 am, using 3000K, 6500K, and 3000K as a control at a much lower illumination level of 50 lux. The group exposed to the 6500K light had 50% and 70% less melatonin in their system than the 3000K and 3000K control groups. Additionally individuals in the 6500K group woke up groggy and did not sleep well compared to the other two groups .

ARTIFICIAL LIGHTING THROUGH TIME

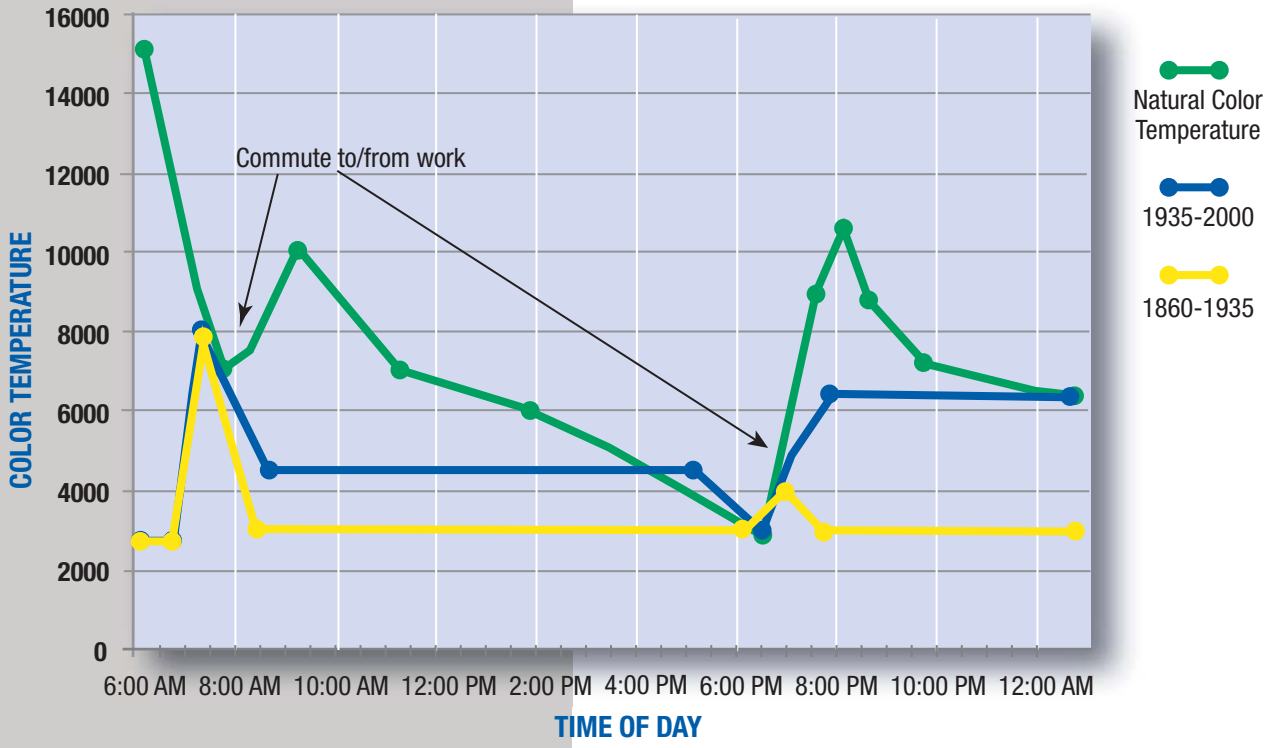
Up until about 200 years ago humans spent most of the day outside exposed to natural light, then relying on candlelight or fires at night for additional light. Candle light and fire have very warm color temperatures of under 2700K so they did not affect the human circadian rhythm when used. However, with the invention of the light bulb and the industrial revolution, people began to work indoors in often-windowless offices

The circadian rhythm sets the body's natural clock and regulates the sleep/wake cycle.

during the day and companies began using shift work to increase production. These all limited people's exposure to the higher color temperature light during the day.

Companies began using fluorescent lighting in the middle 1930s, and still do to this day. These lights have a cooler color temperature, most commonly between 4000K and 6000K. During this time, more jobs shifted towards to the white-collar service industry and work hours increased, with many people working into the night. The following chart shows the color temperatures individuals experienced until the year 2000. The green line represents natural light; the blue line represents the color temperatures experienced until about 1935, the yellow line represents the color temperatures experienced from 1935 to 2000, with individuals only going outdoors for their commute to work.

Chart 2:
Color Temperatures Experienced ~1885 – 2000



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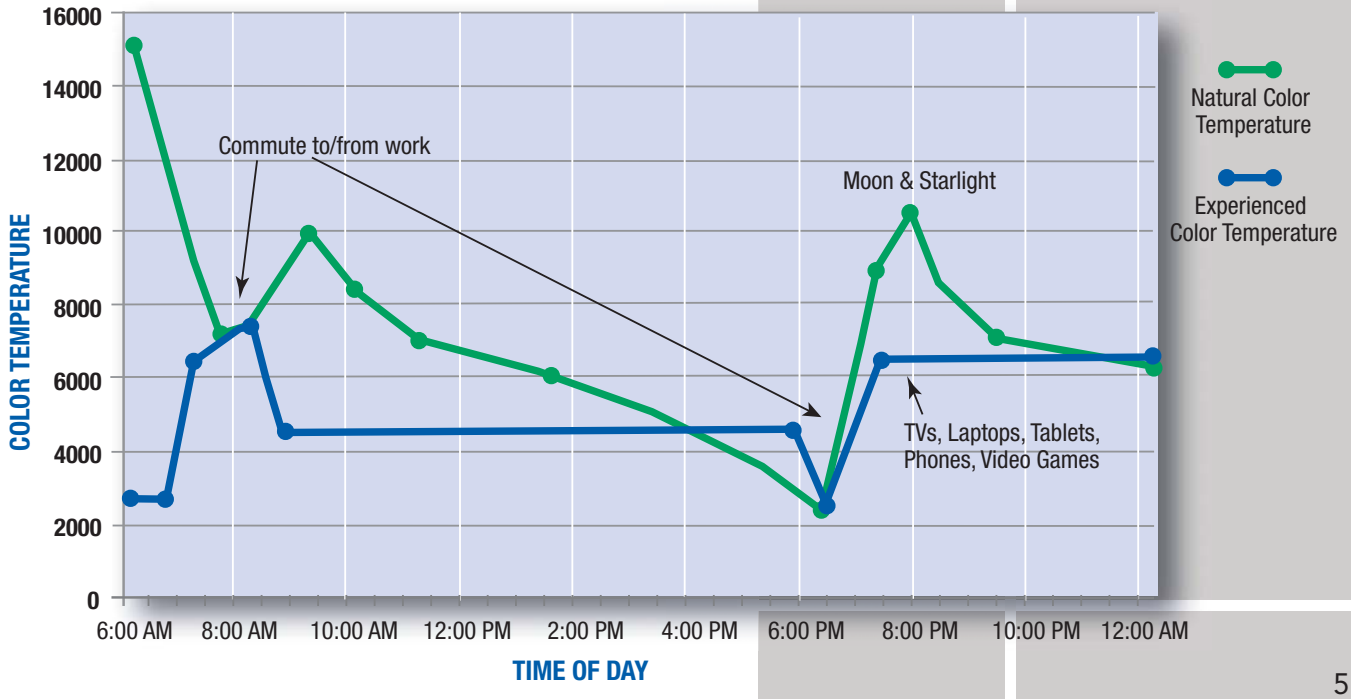
LIGHTING IN THE COMPUTER AGE

Over the past 10 years, there has been an explosion in the use of portable electronic devices, especially into the evening. People take their work home with them and look at their laptop screens late into the night. People also use their tablets, smartphones, portable gaming devices, as well as watch on their ever-growing televisions at night. What is wrong here? All these screens have a CCT of 6500K, which means that when individuals look at these screens, they are tricking their brain into thinking that they are seeing the early morning blue light that stops melatonin production, when their melatonin levels should be increasing to prepare for sleep[1].

A recent study had volunteers use iPads for 2 hours before bed and they found that nighttime melatonin levels dropped 22%. People are shifting their melatonin production later into the night, have more trouble sleeping, and wake up tired as a result. This is a contributing factor of the growth of the sleep aid market, which increases 29% annually since 2000. The following chart shows the color temperatures experienced in this modern time. The green line represents the natural color temperature; the blue line represents the experienced color temperature. Keep in mind that the blue line, while a high CCT, is at a very low illumination level and too low to alter melatonin release.

A study examining errors due to flickering fluorescent lights found an increase in errors of 50% and a decrease in reading speed. Quality, consistent light is important!

Chart 3:
Color Temperatures Experienced 2000 - Present



High color temperature 6000K+ light suppresses melatonin production and promotes alertness and pleasure, while warmer color temperatures allow the body to prepare for rest.

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INTRODUCING COLOR TUNE TECHNOLOGY FROM SIGMA LUMINOUS

What is wrong with current lighting technologies? They emit light at a fixed color temperature! If you've looked at any chart throughout this discussion, you've probably noticed that the natural light color temperature is anything but fixed. This means that while your body and hormones operate to react to a changing light curve, traditional lighting has prevented this from happening, essentially hacking your Circadian Rhythm. Sigma Luminous developed color tune technology with the Circadian Rhythm in mind to help you get back in tune with your rhythm and lead a more enjoyable life!

High color temperature 6000K+ light suppresses melatonin production and promotes the release of hormones that promote alertness and pleasure, while warmer color temperatures allow the body to prepare for rest. The Troffer and Panel lights with this technology can change color temperature from a cool 6500K to a warm 3000K. An individual can select the preset Circadian Setting on the controller to set the color temperature in their commercial space to 6500K first thing in the morning to suppress melatonin production, wake up employees, and make them more alert and attentive. It will then gradually lower the color temperature throughout the day until they leave in the afternoon relaxed and ready to rest at home.

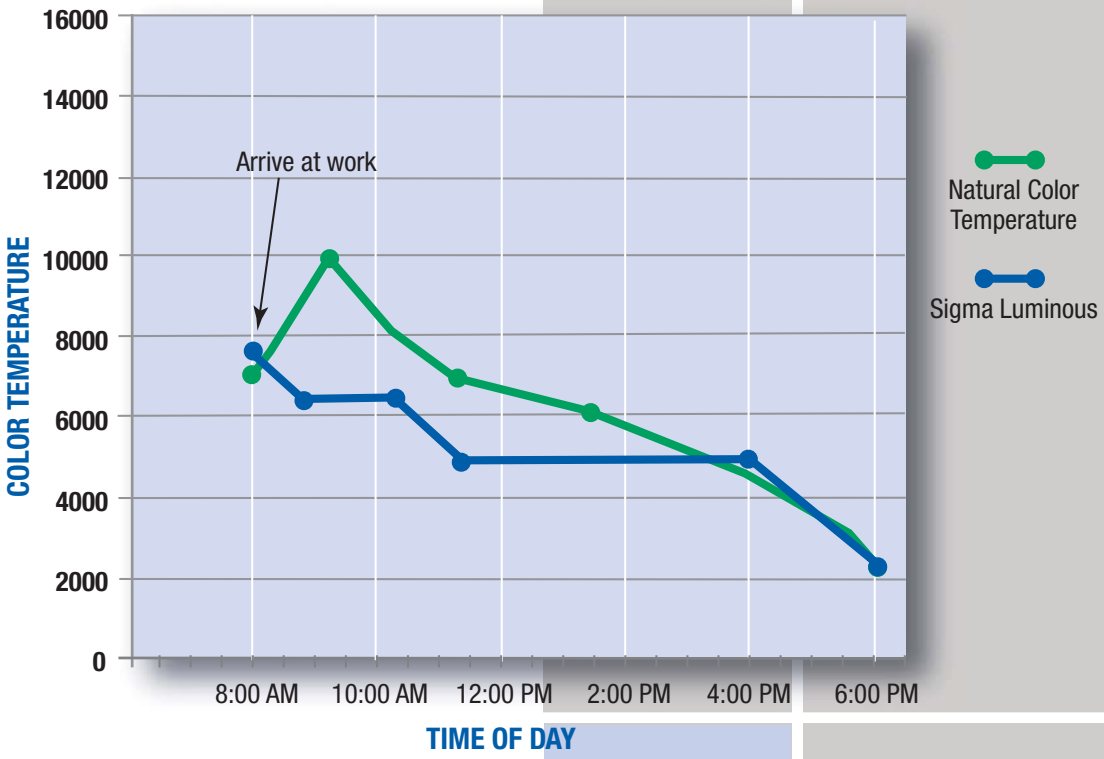
Here is how we came to those specific CCT settings - a recent study looked at brainwaves as well as subjective observation and feedback during exercise at different color temperatures. They found that individuals at 5000K showed the highest levels of motivation, performance, and concentration, while individuals at 3000K were more relaxed and had higher recovery rates.

A company can use the Office Setting on the controller to start the day at 6500K to wake employees up. After two hours, it gradually drops to 5000K, for optimal focus and alertness, where it will remain until an hour before the end of the workday. It will then gradually drop to 3000K, as the employees calm down and get ready to leave work relaxed and ready to rest before coming back to work refreshed. The

following chart shows how this setting corresponds to the natural color temperatures, with the green line being the natural color temperature, and the blue line being the light using Sigma Luminous color tune technology.

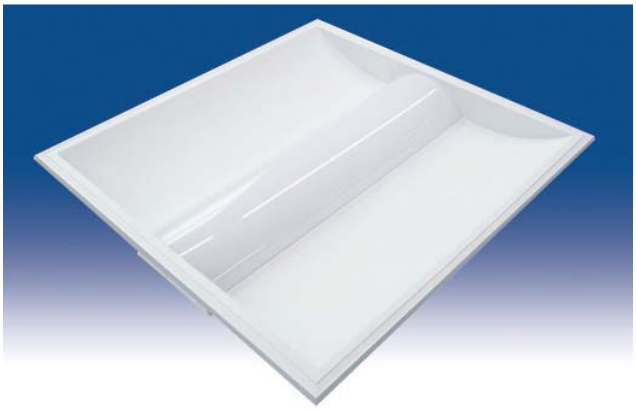
The Sigma Luminous Controller has other settings that are available for office, healthcare, or educational use. For School

Chart 4:
Color Temperatures Experienced Using Sigma Luminous Color Tune Technology - Office Setting



Settings, there is a "Morning" setting at 6500K to wake the students up, a "Math/Science" setting at 5500K for focused concentration, a "English/Social Science" setting at 4000K to for a more calm atmosphere, and a "after break" 3000K setting after lunch, recess, or other activities to calm the students down before getting back to learning. In a study conducted by Philips in Hamburg, Germany, they installed different color temperature light fixtures in the room and the teacher changed it based on activity. Student concentration improved, exam errors decreased, and hyperactivity decreased as well. Hospitals and health care settings can also specify different settings as well for shift workers or for the patient rooms. The controls are easy to adjust and do not require the operator to know what color temperature corresponds to what setting.

Airbus did an experiment with different color temperatures on a demonstration plane and people were tested on 3 realistic long distance flights. They used warm light (3000k) at the beginning of the flight and cool light (6000k) when they reached the destination. The results led to better performance at first business meetings after a flight and tourists had a more rested start to their vacations[7].



Just think about the possible productivity improvements with Sigma Luminous Color Tune Technology. Lighting comprises of only about 20% of a company's electricity bill, which is a small portion of the company's operational expenses. While the Sigma Luminous color tune panel and troffer do use less than half the electricity of a fluorescent lighting system, it still results in a small savings overall. If employees are more awake and alert at work, while being relaxed when they need to be, they will be happier and more productive at work. If productivity improves just one percent with a company of 100 employees, they would save the costs of hiring an additional employee, which far exceeds any energy savings received by switching to LED. Imagine if productivity and employee well-being improves even more. The possibilities are endless with Sigma Luminous Color Tune Technology.

Contact us at sales@sigmaluminous.com with any questions or to schedule a demonstration today!

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