TRI-R

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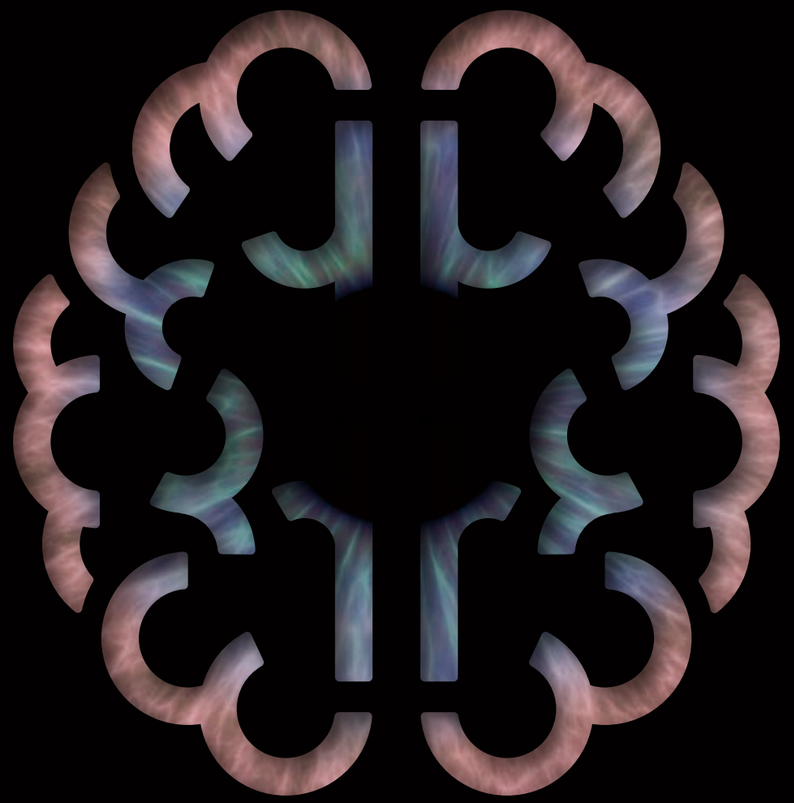
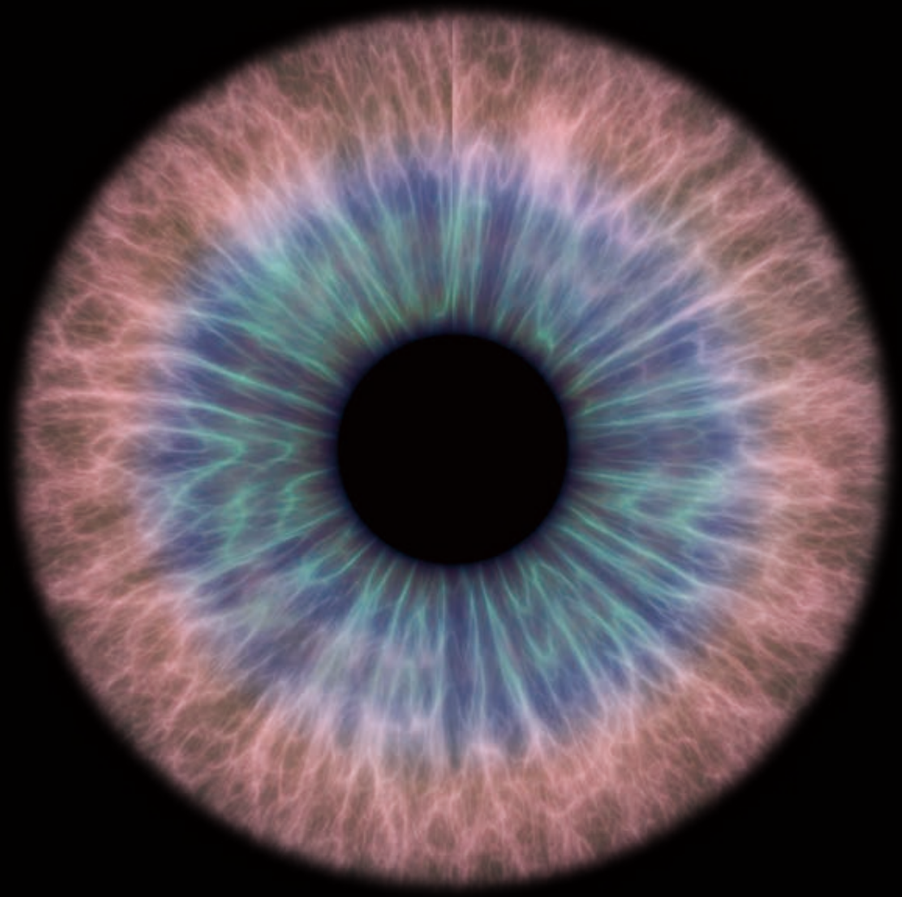
Light Your Brain Desires



TRI-R

LED Spectrum Technology

A spectrum leading us to the future



The brain has immense capabilities, and runs every part of you.
It perceives color, and controls the biological clock that maintains your bodily functions.
The development of TRI-R began by focusing on the spectrum of light,
which fulfills an important role for these mechanisms.

Your eyes are sensors. Three types of photoreceptor cells on the retina detect the intensity of
light on different wavelengths, and transmit this information as signals to the brain.
The brain then perceives this color and, at the same time, issues various instructions.
From this perspective, the idea of what it means
for humanity to have light is now attracting attention all around the world.
TRI-R is a human-centric, LED spectrum technology that will open the way to humanity's future.

Humankind lives alongside, and was created from, natural light.

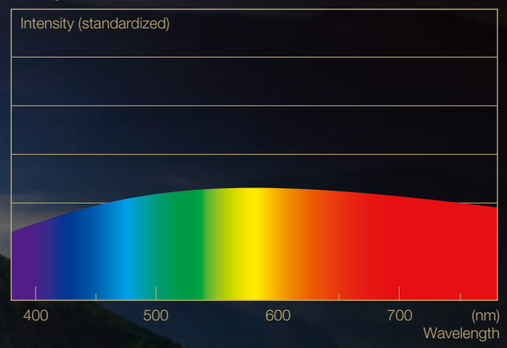
Humankind now lives with artificial light.

Go back four million years, to the time of our ancestors. The light of the sun shines unending, continuously illuminating the Earth. In time, humans encountered fire, and civilizations were born that harnessed the power of natural light from both fire and the sun. Then, about 80 years ago, a new illumination technology appeared: artificial light. The spectrum of this light, however, was quite different from that of natural sunlight and the light from incandescent bulbs that had come before. Compare the spectrum of natural light, which draws a smooth line, to the spectrum of artificial light, which peaks in particular wavelengths and is lacking in others. The effect that these differences have on people is gaining attention.

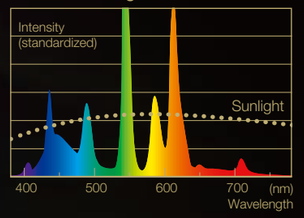
4,000,000 years ago Sunlight
500,000 years ago Fire
3 BC Candles
1879 Incandescent light bulbs
1936 Fluorescent light
1996 LEDs

Natural light → **Artificial light** →

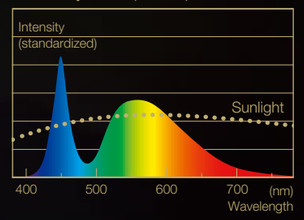
Sunlight



Fluorescent light



Ordinary LED (B+YR)

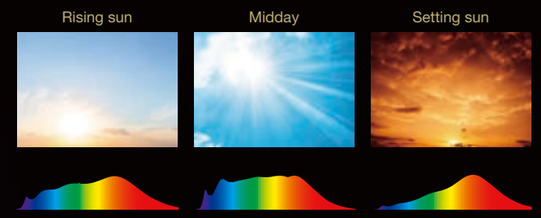


Among all types of light, the light that is visible to the human eye can be separated into the seven colors of the rainbow (violet, indigo, blue, green, yellow, orange, and red) at different wavelengths. The division of these components of light into wavelengths is called a spectrum.

Light, the brain, the body.

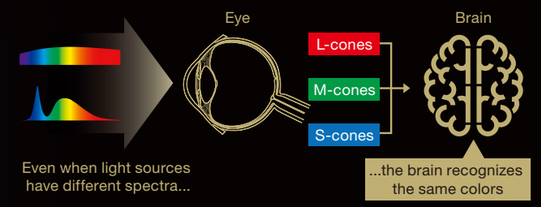
Light and the biological clock

From the time we are born, a biological clock is running not only in our brains, but in each of the countless cells throughout our bodies. This clock naturally operates on a cycle of about 25 hours, but synchronizes with our 24-hour day as the morning light causes a daily correction. This is one way that light is used not only to view objects, but also to maintain our biological functions, and is an important component to sensitivity.



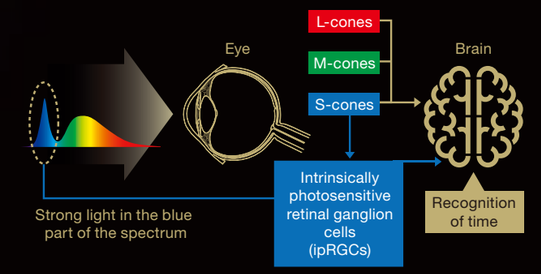
Same perceived color does not mean same spectra

When a spectrum enters the eye, our photoreceptor cells measure the respective intensity of blue, green, and red light. The retina converts and transmits this data to the brain, where it is perceived as colors and luminosity. In other words, the brain interprets the results of calculations, and is not capable of recognizing spectra directly. This allows the brain to recognize the same colors in different spectra, such as natural light, artificial light, or images on a display.



Photoreceptor cells transmit light changes throughout the day to the brain

In 2002, scientists discovered the existence of ipRGCs (intrinsically photosensitive retinal ganglion cells), which transmit the intensity of blue light, a major part of morning light. We now know that these photoreceptor cells control the biological clock. This in turn suggests that spectra might affect the biological clock through ipRGCs. Research is showing us the effects on organisms of intensities in the blue portion of the spectrum that differ from those in natural light, even with light that we perceive as being the same color. This research focuses on disruptions to the biological clock and the resulting degradations in sleep quality, as well as risks involving other illnesses.

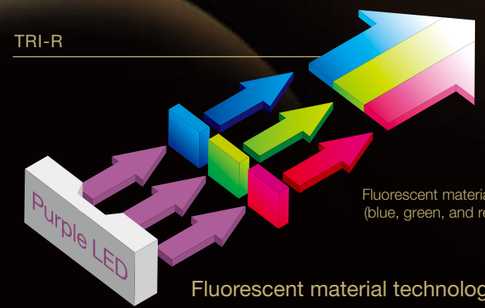


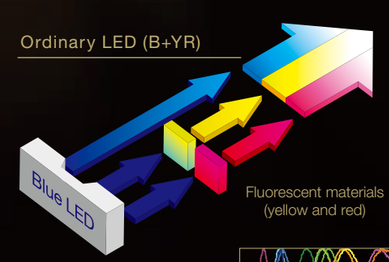
Light closest to that of the sun

TRI-R, a next-generation LED spectrum technology

TRI-R light-emission principles

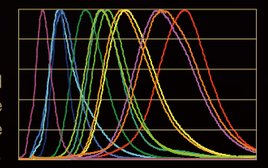
The light from an ordinary white LED is created from the combination of light emitted from a blue LED and light emitted by exciting fluorescent materials. But with TRI-R, virtually all of the excitation light from a violet LED is converted into light emitted from fluorescent materials, which results in a natural and continuous spectrum that is very close to that of sunlight, one that does not have excessive peaks or deficiencies at specific wavelengths.



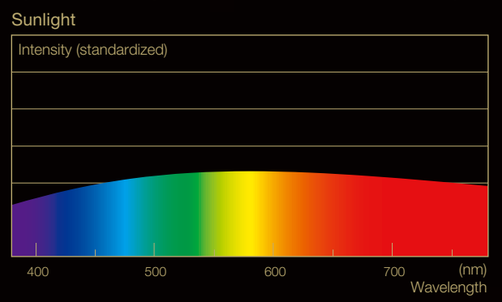


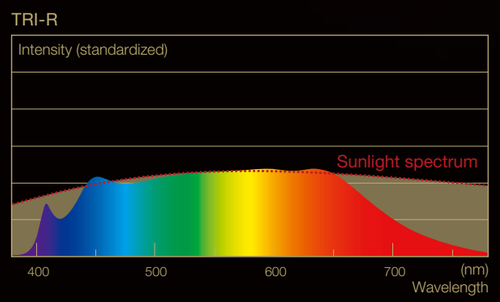
Fluorescent material technology in TRI-R

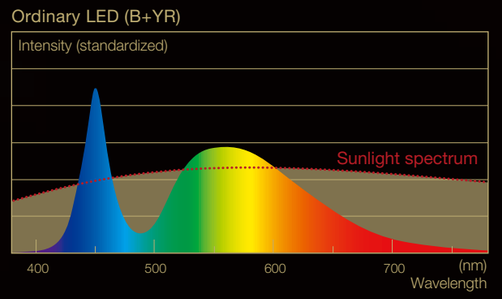
Based on our research into fluorescent materials that give rise to excited luminescence at various wavelengths and our accumulated expertise, we developed fluorescent materials that are optimized for generating white light from violet LEDs, as well as the technology needed for this blending.

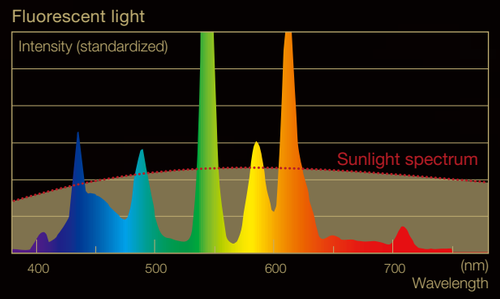


Spectral comparison of 5000 K color temperature







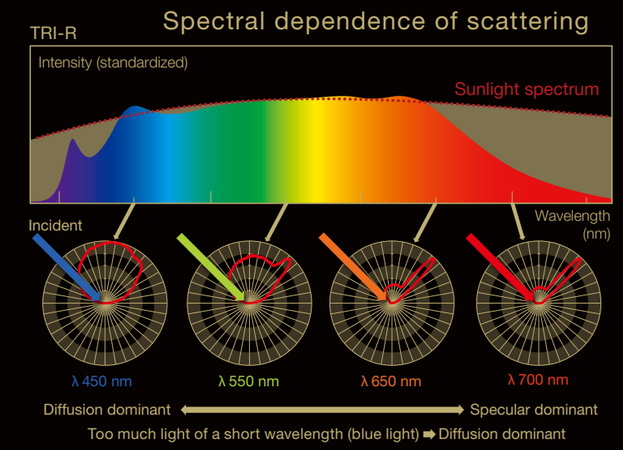


Recreating the sunlight spectrum

Faithful reproduction of natural colors, contrasts, and three-dimensionality

Artists select colors and brush strokes to create depth and perspective when viewed under natural light, and viewing paintings under the same lighting with which the artist created them is one way to properly appreciate them. TRI-R faithfully illuminates paintings as they would appear under sunlight in terms of color and contrast. We must also not forget texture, or three-dimensionality, when illuminating works of art, fashion, or interior design. TRI-R delivers a natural spectrum without excessive blue light, which is easily scattered, and therefore produces specular reflection from the surface of objects, imparting a greater sense of three-dimensionality and texture.

Peter Paul Rubens's *Self-portrait* (1623) from the Royal Collection

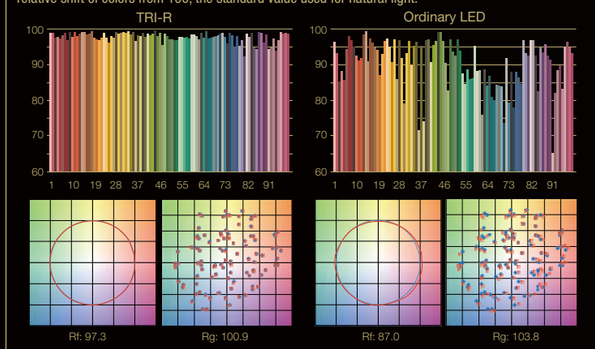


Superb color rendering and expression of texture

Sometimes the color of clothing looks different outside than it did in the store. This happens because the spectrum of light in the store differs from that of natural light. Color rendering indicates the effect that a light source has on how the colors of objects are perceived, with 100 representing colors under natural light. TRI-R exhibits superior color rendering properties, with a value close to 100 when using not only the traditional CRI (Color Rendering Index) standard, but also the new TM-30-15 standard (the IES Method for Evaluating Light Source Color Rendition). The technology expresses natural colors at events such as exhibitions of European art and fashion shows.

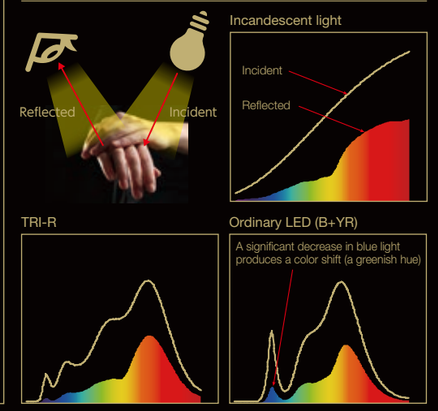
TM-30-15

TM-30-15 is a method that evaluates light by using two properties: Rf, the fidelity of color reproduction; and Rg, the color gamut (vividness). Furthermore, a chromaticity diagram can be used to illustrate the relative shift of colors from 100, the standard value used for natural light.



TRI-R has color rendering properties closer to 100, and is capable of reproducing colors in a manner comparable to that of the sun.

Spectrum difference between incidence and reflection



True-to-life expression

Rendering high-quality scenes with depth

TRI-R allows for superb color rendering and expression of texture. Art galleries, showrooms, shops, hotels, and restaurants are just some examples of places that are capable of maximizing this potential. The light from TRI-R produces natural scenes with depth in various spaces.

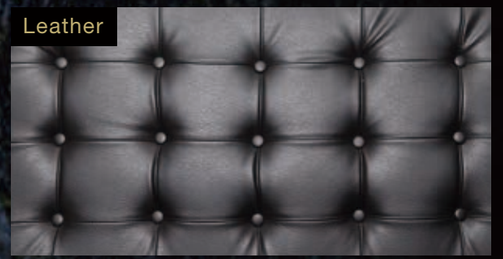
Skin

With light that is exceedingly close to that of the sun, TRI-R can illuminate human vitality. The technology allows for the accurate expression of the natural colors and textures inherent to the skin.

Japanese clothing

TRI-R lighting clearly brings out colors ranging from faint to vivid. The beauty of the meticulous weaving of clothing items is depicted in every detail.

Leather



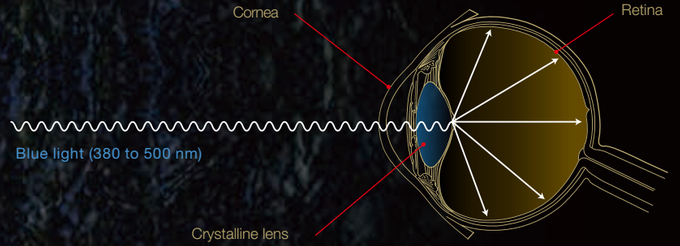
TRI-R faithfully reproduces the appearance of even monotone leather products and other items that do not have an easily perceived texture. Viewers are able to recognize the craftsmanship that has gone into such items.

Gold

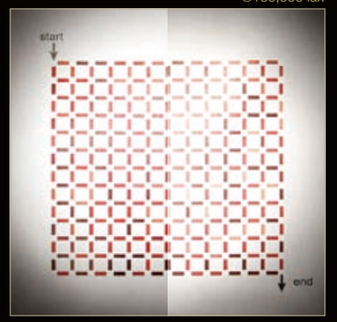
Because of TRI-R's natural and smooth, continuous spectrum, the technology is capable of accurately revealing the deep luster of objects made of gold, and the accompanying feeling of luxury.

Excellent visibility, with little glare

An ordinary LED light source transmits a strong beam of light from a blue LED, which scatters greatly due to its short wavelength and high energy. This scattering occurs not only on an illuminated object but within the eye itself, where it is easier to perceive shimmering and glare. Because TRI-R does not contain a high-intensity blue light component, the technology provides light that offers excellent visibility with little glare.



@160,000 lux



TRI-R Ordinary LED (B+YR)

Words from the Experts

Ingo Maurer

Designer

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The incandescent light bulb is special, because, with its filament, it reminds us of fire. Fire is a natural light source but humans have used and controlled it since ancient times. Its warmth makes us feel safe. Until recently, LED lighting and the light emitted by fluorescent bulbs have never been able to create the same atmosphere.

Since the quality of LEDs has become so much better, in many cases it is now possible and recommendable to replace incandescent or halogen bulbs with high-quality LEDs. But the emphasis here is on “high-quality”. As a designer, LED technology provides a lot of new possibilities. We now can create lighting fixtures that are very thin or flat. It is an exciting change and since the early 2000s, my team and I have presented many new designs that would not have been possible without LED technology. But I still love the shape of the lightbulb, and its warm light. We believe that we should be permitted to use a variety of light sources, each with their unique quality, just as we can consume a variety of bread or use a variety of cars, which consume more or less energy.

The TRI-R bulb is an amazing combination of the new technology and the bulb. I am still amazed at its light. It dims smoothly, providing brightness when turned up, and when you dim it, the bright spot in the middle of the bulb turns to a beautiful reddish tone. I was always very skeptical before the meetings with the engineers who presented the prototypes. I think it is a great achievement. Bravo!

Marco Piva

Architect

“Lighting design is a fight against darkness.”

When I design lighting, my reference models are paintings, particularly Renaissance paintings. I’ve always been fascinated by the light in paintings. Light is never insignificant and it’s always used theatrically. Its value goes beyond the technical, optical, or sensory aspects as it helps emphasize situations and moods, becoming a strong psychic, emotional, and narrative ingredient.

Fascinated by the world’s magic and continuous transformations, I address projects—from architecture to design—as a process of continuous research into volumes, surfaces, materials, and light, to help build future scenarios stretching between function and emotion. It is precisely this theme of light that I have addressed in several projects relating to lighting systems, where the light loses its connotation as a static feature, and becomes freed in space like a dynamic vibration.

Francesco Murano

Architect / Lighting Designer

Assistant Professor of the Department of Design at the Polytechnic University of Milan

Up until a little while ago, LED technology had been considered as a field suffering from technical problems and, hence, its quality had not reached the required level. However, there have recently been considerable improvements being made, just as can be seen in the color values perceived by people (CRI).

A remarkable feature being witnessed within the exhibition field is the extension of the life span of LEDs, the most considerable change to date, constituting a great improvement in the problem of maintenance. When changing halogen bulbs, people have the tendency to choose the wrong type of bulb, often causing the problem of different types of bulbs existing within the same space. When I used TRI-R, what I noticed the most was the difference in color. This is partly because its CRI values are high, but I also felt that by using warm light and cold light—that is to say, by mixing two color light sources with different color temperatures—we were able to achieve a completely different result from the point of view of the senses and how the colors are perceived. The colors were shown with a much clearer radiance. I believe the reason for this can be attributed to the fact that the light was generated as a continuous spectrum similar to sunlight.

Dr. Christian Cajochen

Head Centre for Chronobiology at the University of Basel

Around 20 years ago, I started to be fascinated by light. Many people think that light is the most ordinary thing in the world, which does not influence us in any particular way. However, when I started to realize how important light is for sleep, especially for those people who are not able to see the light, I was fascinated by the fact that light can, first of all, affect sleep and, second, that light is the most powerful “drug” influencing our circadian rhythms. We do not have any medication as powerful as light to regulate our daily circadian rhythm. Thus, for me light is also a medication.

A lot of people wish incandescent lamps would come back as they got used to them and they like their colors but I think that LEDs will be the future. I hope that LEDs can create any kind of light we want so we can sort of tailor the light. For me, it’s a bit boring just to have only incandescent light. LEDs have a lot of potential to be put in different areas, for instance, in domestic areas at home, in schools, in hospitals, in museums, etc. You can specify which color temperature, which spectral characteristics and intensity you want. For that reason, the future of LEDs will be very bright. I am very much interested in dynamic light solutions, which mimic light in the course of the day. My personal motivation is to find out how important the shape of light and its temporal dynamics are in terms of their impact on human circadian rhythms and sleep.

Dr. Hitoshi Okamura

Professor of the Department of Systems Biology at Kyoto University

Circadian rhythms are a gift from our planet, and an endogenous clock that synchronizes us with the rotation of Earth has resided at the core of the cell since the dawn of life. This oscillatory machinery, composed of clock genes discovered at the end of the last century, orchestrates physiology and metabolism.

Sleep-wake cycles are the most important circadian rhythms. The circadian clock whispers to you: “now is the time for you to get up” and “now you should sleep”. Every day, our body clock is reset by morning light that regulates our clock genes. Light until late at night disrupts clock gene oscillations, and disorganization of cell regeneration and metabolism ensues. As a result, health is impaired, and the risk of developing hypertension, obesity, and other lifestyle related diseases increases.

The circadian clock is confronted by the new artificial environment of our modern 24/7 society. LED apparatuses, including televisions, smartphones, and personal computers, excessively excite blue light-sensitive melanopsin-expressing cells and confound the master clock in the brain. We need to avoid these abnormal stimuli that disrupt autonomic nervous functions and that promote diseases. If you instead obey your natural rhythms, you will be reborn healthy every morning when you get up!

University of Bologna

The Alma Mater Studiorum-University of Bologna, the oldest University in the Western world, covers all disciplines and many of them, including agriculture, architecture, engineering, medicine, cultural heritage, biotechnology, and veterinary medicine, are interested in utilizing light for different purposes.

TRI-R LEDs, as a component of indoor lighting systems, could contribute not only to human well-being, but also to a well-balanced and more natural growth of plants used for indoor green landscaping (e.g., in green walls and interior green isles). Their low thermal output allows the lamp to be positioned inside the foliage with scenographic effects and a significant energy savings.

Moreover, the lower energy requirements and their remarkable spectrum could be exploited to maximize the efficiency of artificial lighting systems in commercial greenhouses. Above all, the “natural” wavelength ratio could contribute to increasing the organoleptic quality of vegetables and the shelf life and aesthetic value of ornamental pot plants and cut flowers.

Dr. Maria Eva Giorgioni

Professor of the Department of Agricultural Sciences at the University of Bologna