

Touring Exhibition
„Verlust der Nacht“

VERLUST der ✨ NACHT

The Impact of artificial
light on culture,
society, health and
nature.



VERLUST der NACHT

The interdisciplinary research project „Verlust der Nacht“ looks at the reasons for the increasing illumination of the night.

They investigate the consequences of artificial lighting, its ecological, cultural and socioeconomic effects, and the effects on human health. The results of this research will help us to develop improved lighting concepts and sustainable technologies.

Six Leibniz-Institutes, one Helmholtz Centre, and two universities participate in the research project.





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15 Poster of the Touring Exhibition give information about the various aspects of artificial lighting and our research focus:

- Loss of the Night Research Project
- What is Light Pollution?
- A red Sky at Night - Light Dome over Cities
- Measurement of Light Pollution
- History of artificial Lighting
- Light makes our Body Clock stay on Time
- How artificial Light influences Ecology
- Deceptive Light! Impact of artificial Light on Bird Species
- The Spectra of Light
- Benefits and Costs of artificial Lighting
- Navigation Stars guide the Way
- Astronomical Rhythms form Time Concepts
- What are the Sources of Light at Night?
- Public Lighting and Light Pollution
- Light is a healer - but it can also make you

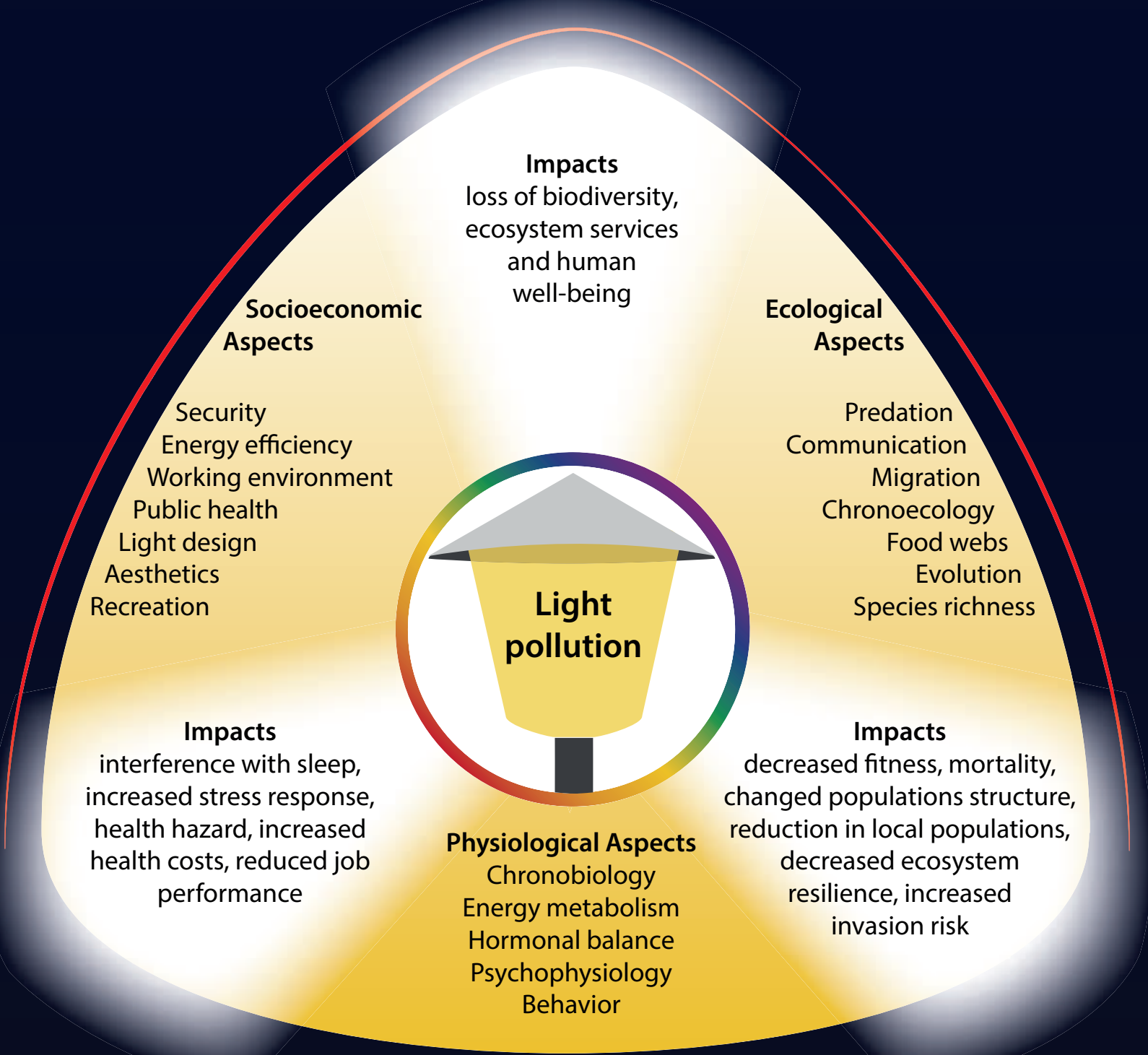
LOSS OF THE NIGHT

RESEARCH PROJECT

LOSS
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A CITY AT NIGHT; MODERN, MAJESTICALLY ILLUMINATED IN VIBRANT COLOUR. Splashes of light highlighting boulevards and buildings, fingers of light stretching to the skies. The streets are the beaming veins of life. An image of modern aesthetics, an attraction for any photographer. A thing of beauty, isn't it?



GRAPHIC: Possible consequences of light pollution on humans and environment. Most of the negative impacts create interfaces between physiological, ecological and socioeconomic aspects.

For more than a century, we have been lighting up the night for reasons of aesthetics, safety and work efficiency. However, the shadow sides of this progress are only gradually becoming more apparent. 19% of the energy consumed worldwide is used for lighting. The night sky is becoming steadily brighter, with an approximately 6 percent increase of artificial lighting each year.

For a growing number of organisms, such as insects, birds and bats, the signs are there that artificial light is causing their living environment to change. Furthermore, there is evidence that sleep disturbances and several diseases may be brought on by nocturnal lighting. Too much artificial light, which is having a negative impact on both mankind and the environment, has since been summed up as “light pollution”.

For the first time an interdisciplinary research association made up of six Leibniz-Institutes, the TU and FU Berlin, as well as one Institute of the Helmholtz Centre, has begun to investigate into the ecological, health, cultural and socioeconomic effects of this nocturnal lighting, as well as the reasons behind its increase. Based on the research results, approaches for modern illumination concepts and sustainable techniques are explored. The project is thus fulfilling an important trans-disciplinary function, i.e. building a bridge between scientific analysis and practical organisation.

Find out more about the importance of light in our society, about the winners and losers of an increasingly brighter night and how we can use light more sustainably. This exhibition invites you to get more involved in the issue. You will find further information at www.verlustdernacht.de.

PARTICIPATING INSTITUTES



WHAT IS LIGHT POLLUTION?

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Europe at night

© Planetary Videos Ltd, Kevin M. Tildesley



Light pollution obscuring the stars

© Jeremy Searles

AT NIGHT, WE ILLUMINATE OUR SURROUNDINGS FOR BETTER ORIENTATION, AS WELL AS FOR AESTHETIC REASONS, for example lighting streets, or highlighting the beauty of a historic building. However, if too much light is used or if it is poorly directed, artificial light can be very disruptive at night. In many urban areas, poorly designed lamps shine into bedroom windows, disturbing people's streets.

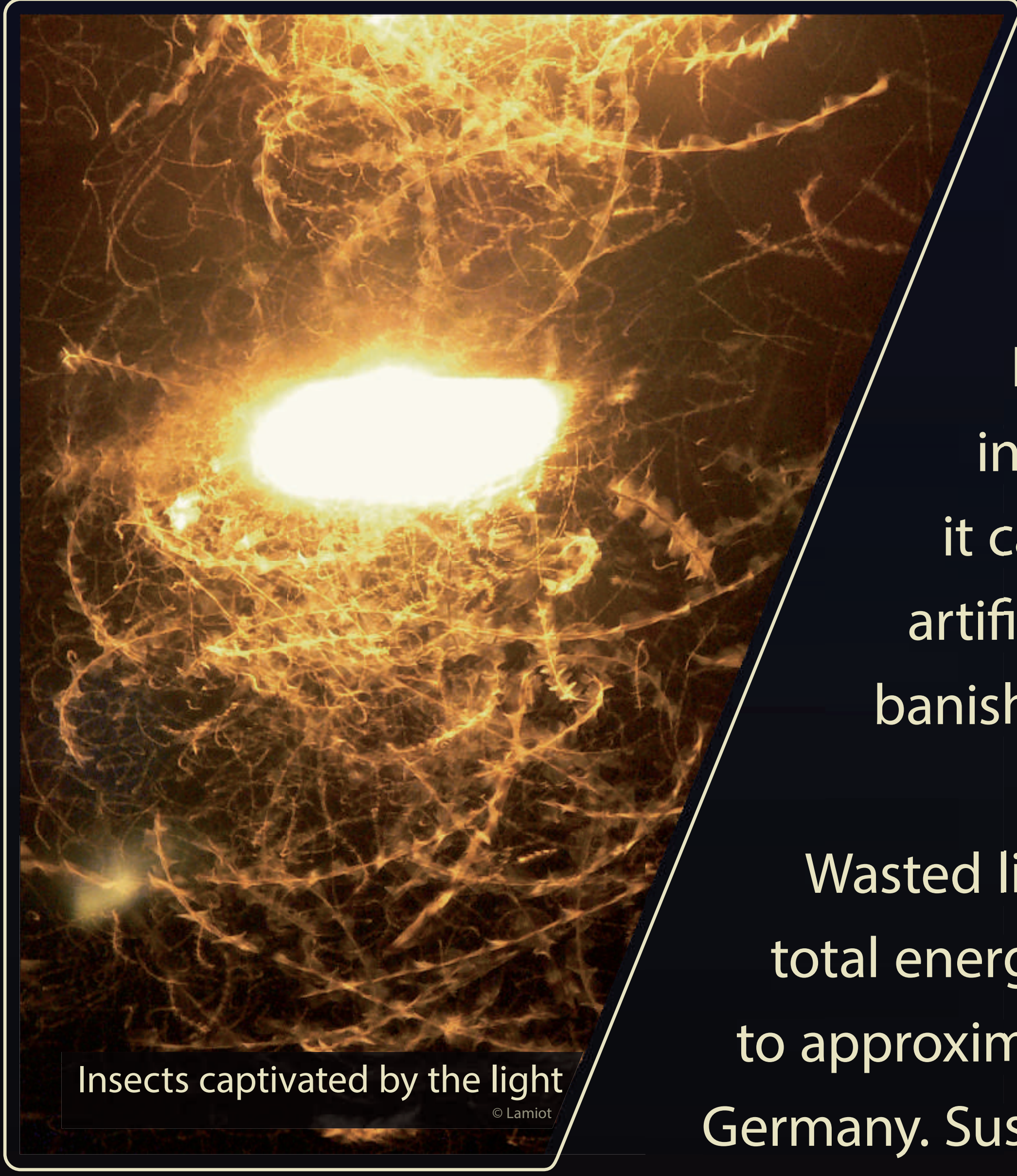


Disruptive lighting: Westhafen Berlin

© Chris Nyba

When light is directed upward, it can scatter in the atmosphere, brightening the sky and obscuring all but the brightest stars and planets. At night in the country, the moon strong shadows, but these shadows are rarely seen in the city. Looking down from an airplane or from space, it is almost as if we have created a new starry sky on the face of the Earth.

Many animals react to light intensities below starlight levels. Because of this, the introduction of artificial light to the night affects ecosystems. The image of insects buzzing around the street lamps is familiar to most people, and demonstrates the pull artificial light at night can exert on some species. These insects have lost their way, and can no longer fulfill their role in the ecosystem.



Insects captivated by the light

© Lumid

Wasted light has a price. 7% of the entire energy consumption in Germany (3.3% of the total energy consumption) is used for lighting indoor and outdoor areas – this corresponds to approximately four times the annual output of the nuclear power plant in Brokdorf, Germany. Sustainable lighting thus makes sense – for people, animals and the environment!



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Project management: Project Management Jülich (PMJ) / Business Area: Environment and sustainability, climate protection

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Design: Markus Hieke

A RED SKY AT NIGHT LIGHT DOME OVER CITIES

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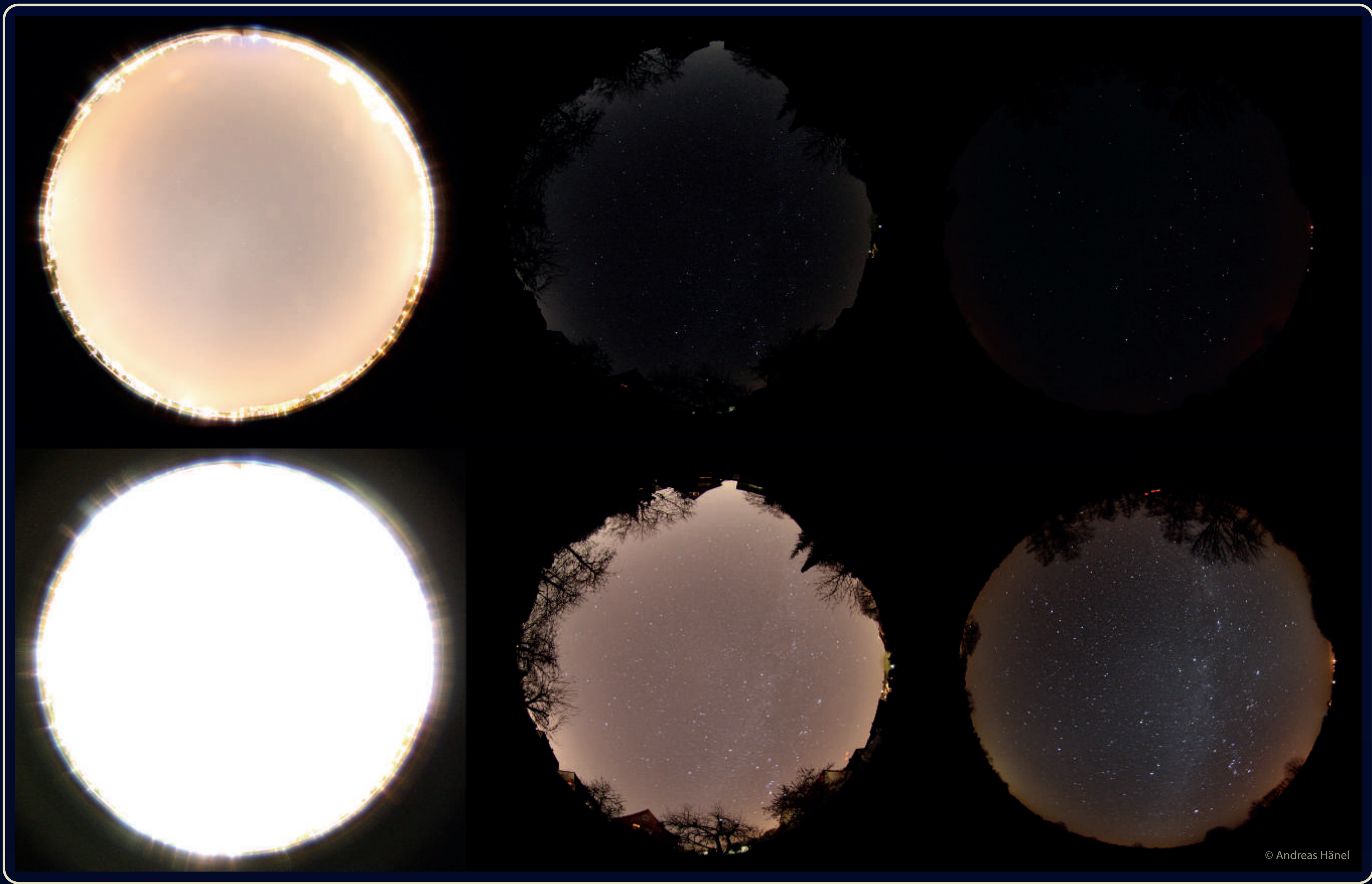


Light dome over Vienna

© Alexander Pehard, Wiener Arbeitsgemeinschaft für Astronomie (Viennese Astronomical Working Group)

WHY IS THE SKY BLUE DURING THE DAY?

Sunlight is made up of a full spectrum of light including all visible colors. When light passes through the atmosphere it is sometimes scattered by air molecules. This process, called "Rayleigh scattering" happens more often to blue photons than red, so during daytime the sky is blue. When the sun is near the horizon, all of the blue light is attenuated by the thicker atmosphere, leaving only the red glow of sunset.



© Andreas Hänel

The same process takes place at night with starlight, moonlight, and artificial light from cities. This is why the sky over cities appear reds when viewed from far away. Like during the sunset, light traveling nearly horizontally is almost certain to be scattered. Most skyglow is caused by light emitted very slightly upwards - a direction which helps no one to see and only wastes energy. This skyglow produces a "light dome" over cities, preventing city dwellers from seeing the stars.



Clouds brighten the city's night sky

© Chris Kyka

VARYING NOCTURNAL
BRIGHTNESS,
FROM LEFT: Berlin,
a suburb of Osnabrück,
and the nature reserve
Westhavelland.

When life evolved, clouds made the sky darker, but in cities, they make the sky much brighter. In many cities, the cloudy night sky is now thousands of times brighter than is natural.

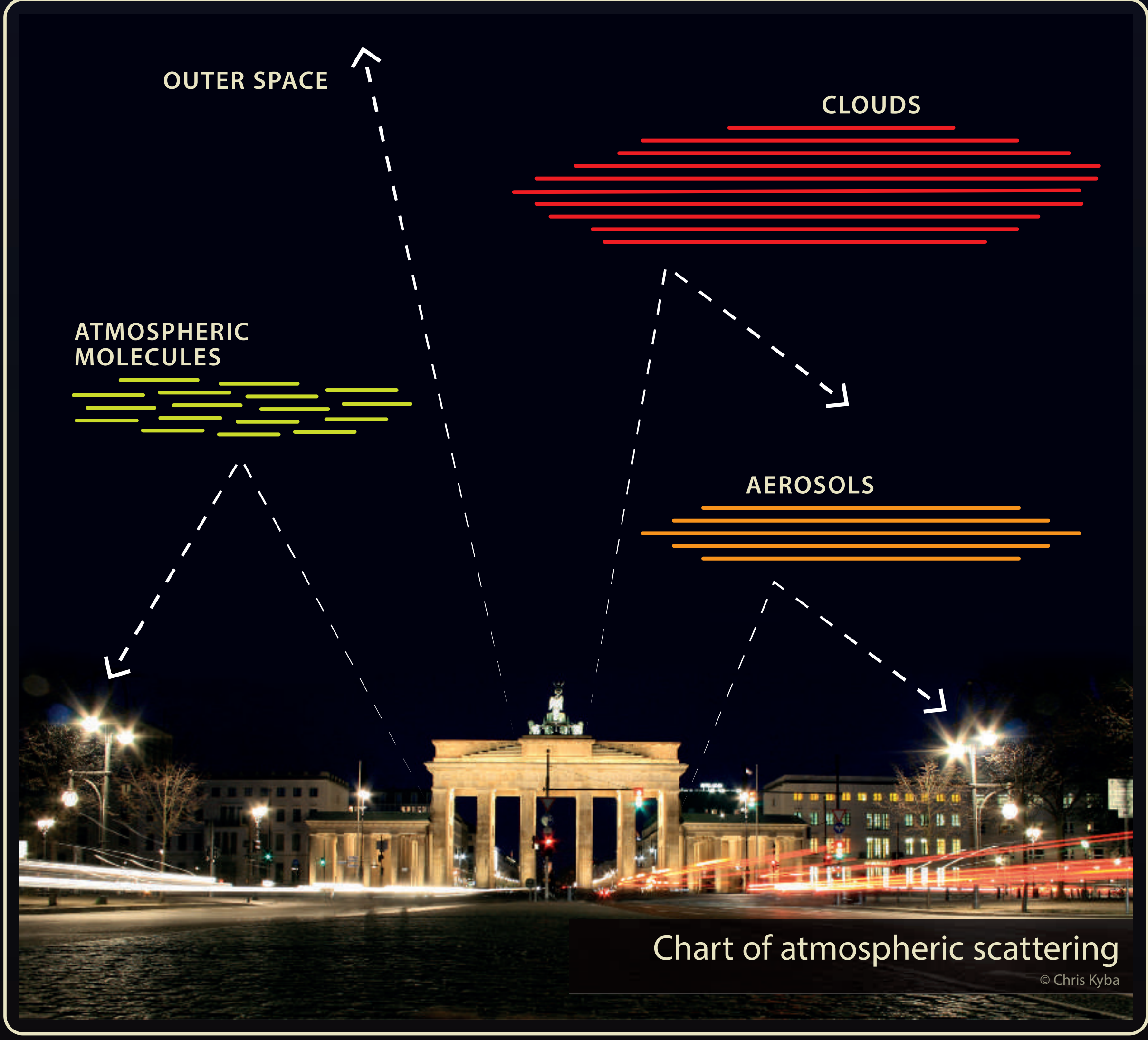


Chart of atmospheric scattering

© Chris Kyka

Just as with other forms of pollution, wasted light can be reduced without sacrificing our quality of living. It's simply a matter of improving lighting design, and being generally more careful when illuminating outdoor spaces. New lighting technologies could help reduce the light dome over cities, by directing the light more carefully and dimming the lamps or turning them off when they are not needed.

With intelligent and sustainable illumination, we can reduce the light dome over cities, preserve the starry sky for generations to come, and save energy – without needing to switch off the city lights.

How bright is the night sky where you live?
Can you still see the stars?



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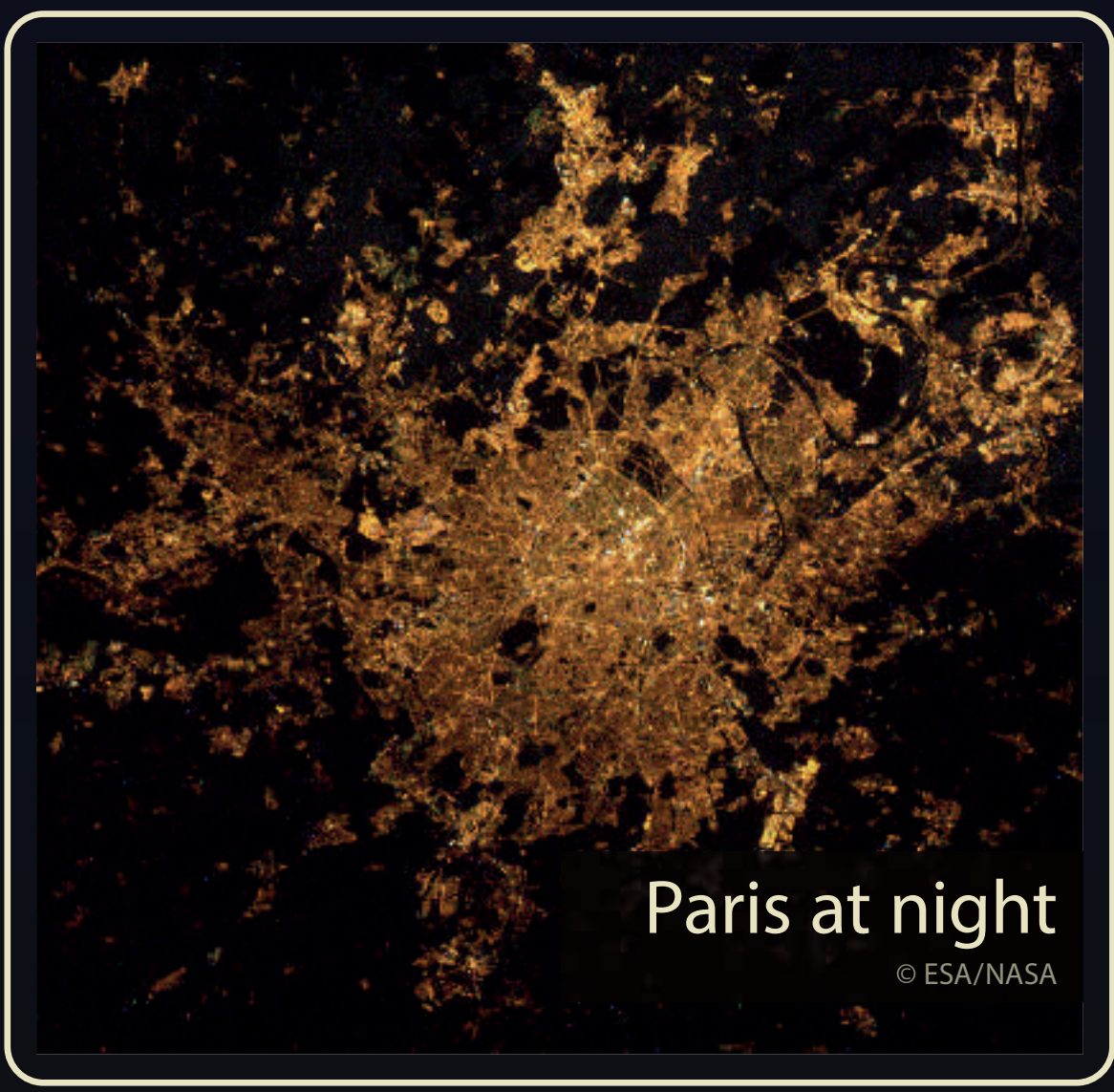
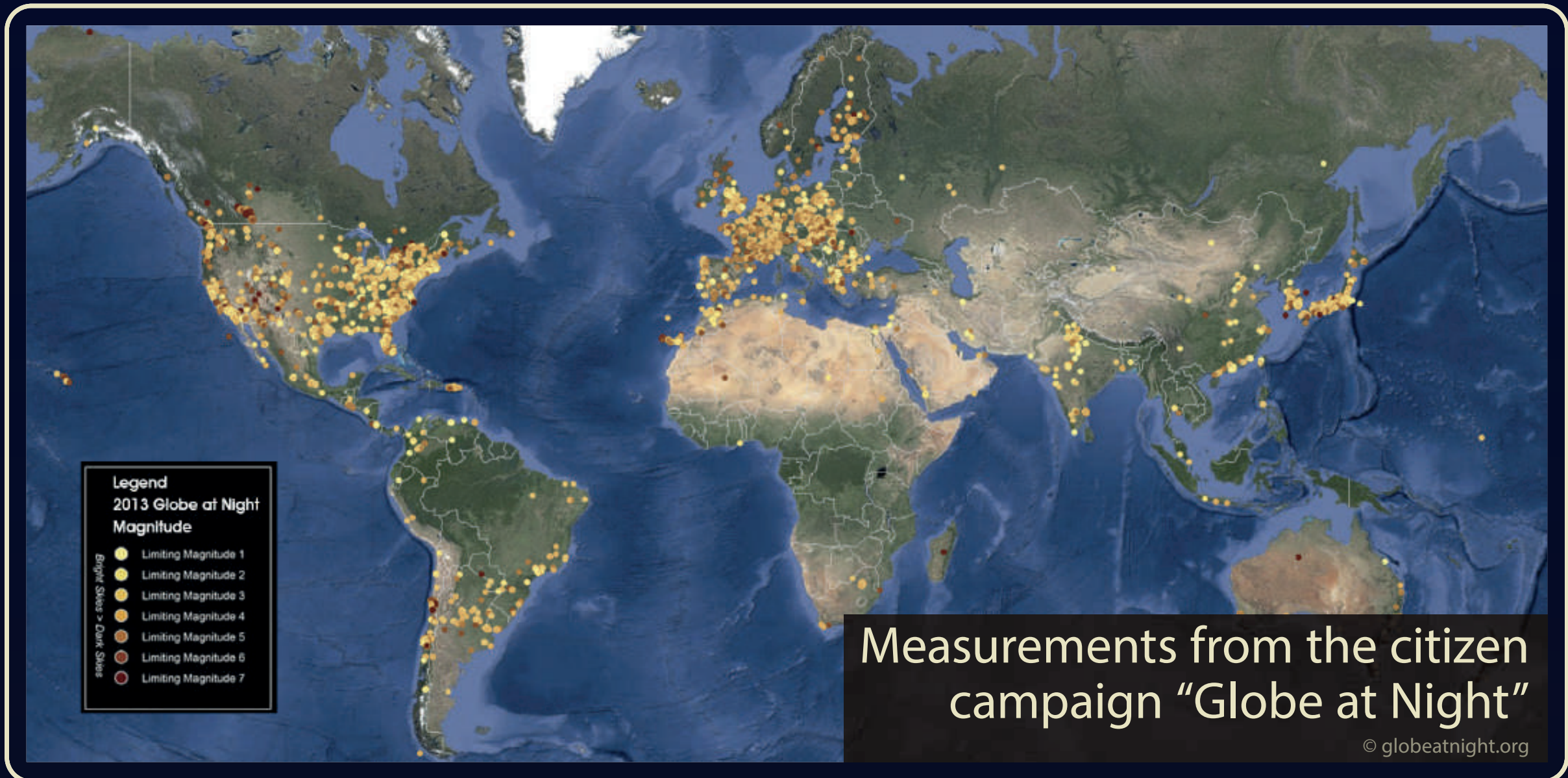
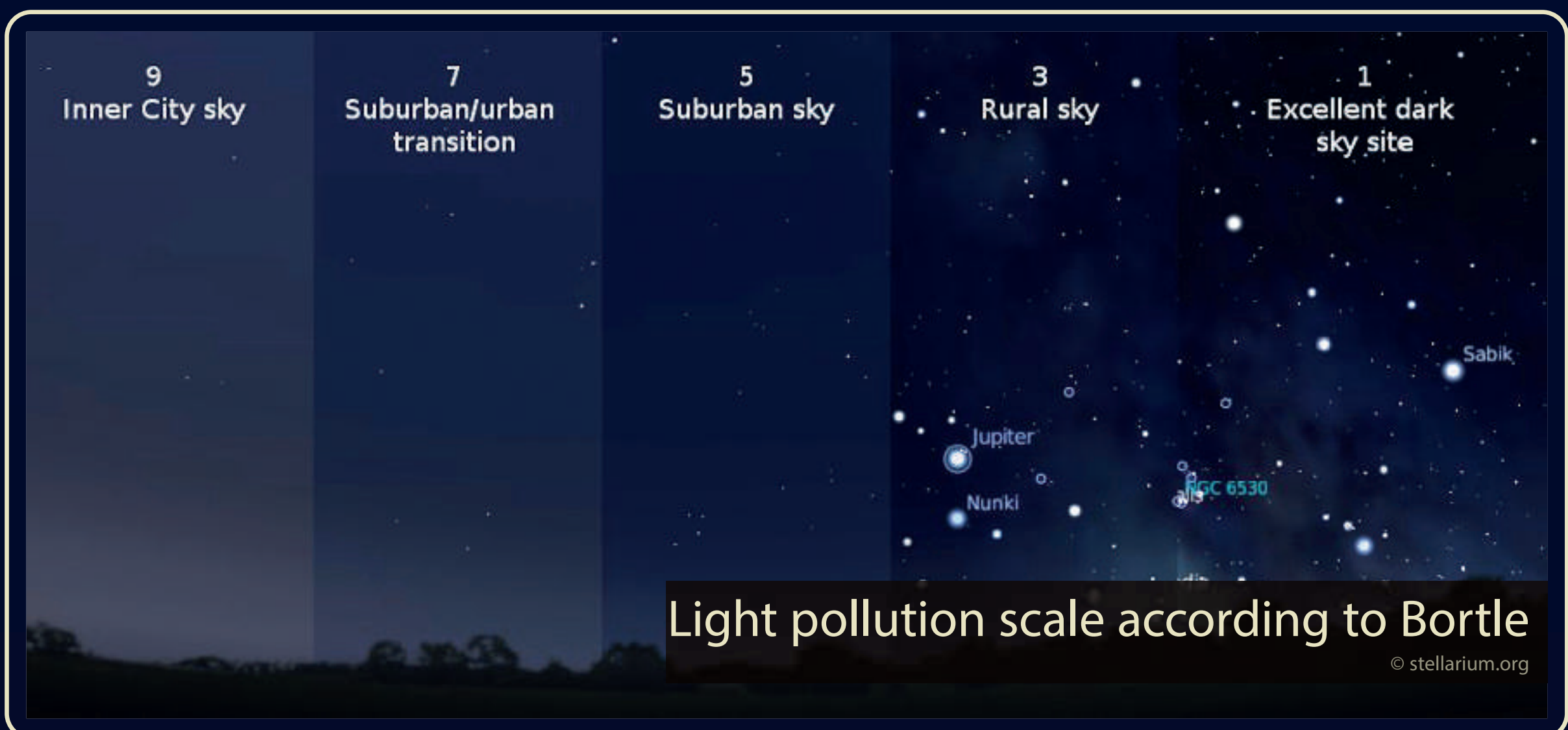
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MEASUREMENT OF LIGHT POLLUTION

LOSS
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ASTRONOMERS WERE THE FIRST TO OBSERVE THE CHANGE IN SKY BRIGHTNESS DURING THE NIGHT, as they were no longer able to observe the stars in urban areas due to urban skyglow.

The brightness of the sky is measured using sensitive meters, for example the Sky Quality Meter (SQM). Worldwide measurements with SQMs show that in urban areas the sky on cloudy nights can be thousands of times brighter than is natural. In earlier times, moonlight was often used to carry on activities after the sun had set. Today, however, street lighting norms often specify illuminance levels many tens of times brighter than full moonlight.

An initial impression of the degree of skyglow at a location can be gained by simply counting the visible stars of a constellation. International campaigns like "GLOBE at Night" provide citizen scientists with the tools to do this. The Loss of the Night project also developed an Android app that works like a star counting game, it is available at <http://tinyurl.com/vdn-app>.

Citizen scientist observations of the night sky brightness are the best tool available for understanding global changes in night sky brightness.

Information about light emissions from cities can be gained from satellites. Such observations have provided important data that has been used in a variety of biological, health, social and economic studies on the theme of artificial light at night.

Astronauts from the International Space Station (ISS) also document the nocturnal situation on earth. Using the Nightpod instrument, astronauts have taken impressive nighttime images of locations around the world.



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HISTORY OF ARTIFICIAL LIGHT

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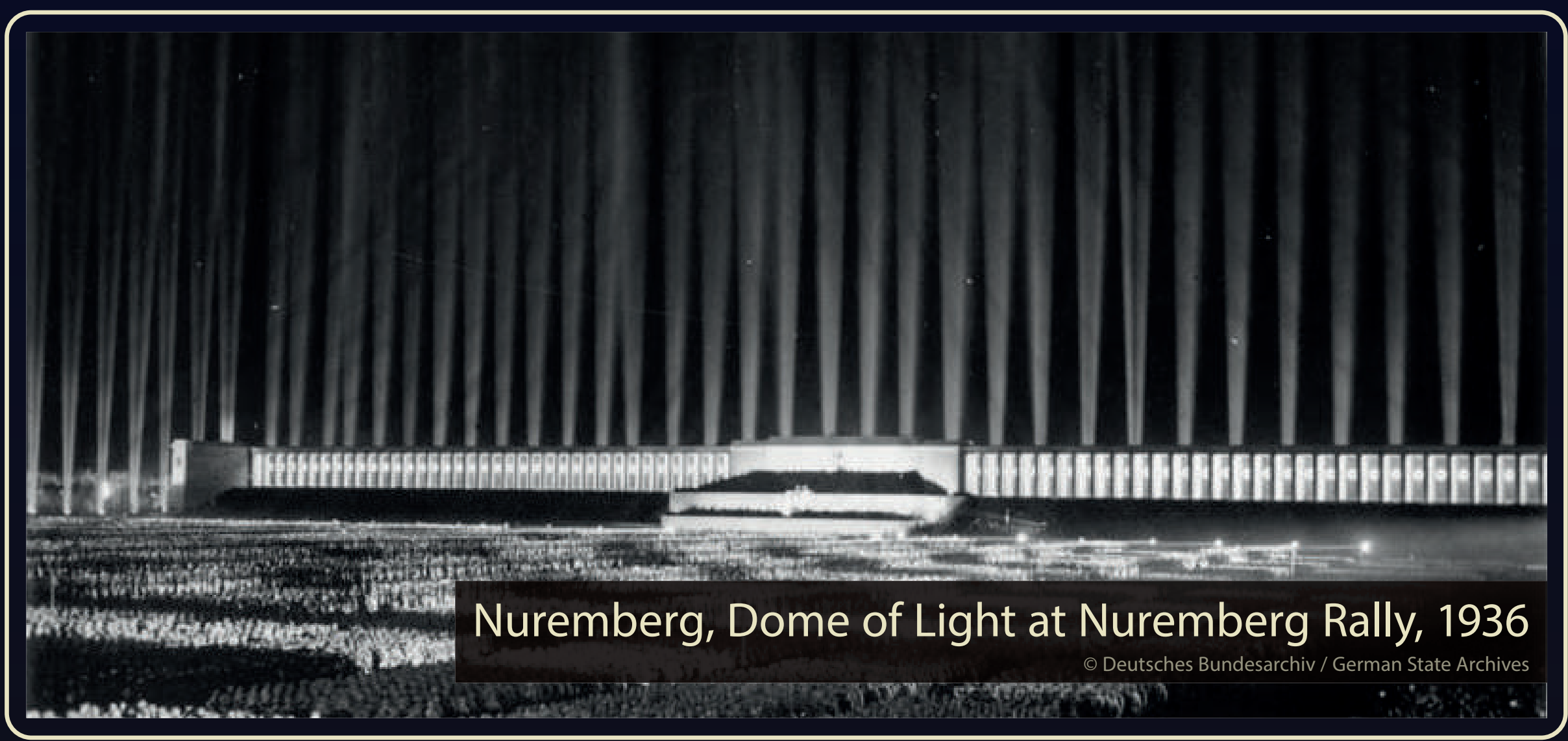
THE “DARK SIDE” OF ARTIFICIAL LIGHT HAS INCREASINGLY COME UNDER PUBLIC SCRUTINY IN RECENT YEARS. Yet how we use lighting is largely based on earlier developments – from the technology of our lighting infrastructure to the perception of nocturnal illuminations.

Light largely triggers positive associations; it represents progress, prosperity and “enlightenment”. Plenty of good lighting was long deemed a luxury in everyday life, so much so that it was reserved for the more prosperous in society and for special occasions. Dazzling displays of illumination demonstrated wealth and power, take for example the Palace of Versailles, the salons of the bourgeoisie or the national socialist lighting displays.

Up until well into the 19th century, torches, candles, and oil lamps gave off a fairly meagre light. Public street lighting was introduced to Berlin in the 1680s and initially remained a modest affair. In the 1780s, around 2,300 rapeseed oil lanterns illuminated the city – however only from September to May, and only as long as there was no full moon. The situation changed with the introduction of gas lighting in the 1820s and the electric light in the 1880s.



The lighting revolution of the 19th and 20th centuries largely contributed to the change of lifestyle and work in industrialised society. It not only allowed for the extension of working hours, but also opened up new opportunities for night-time entertainment. The electric light in particular became a symbol of urban modernity and its glittering big-city culture.



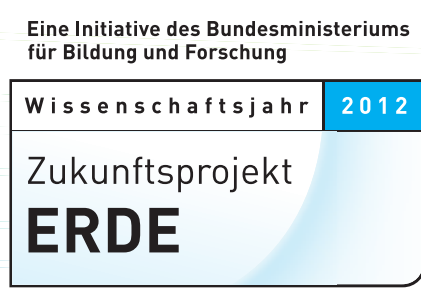
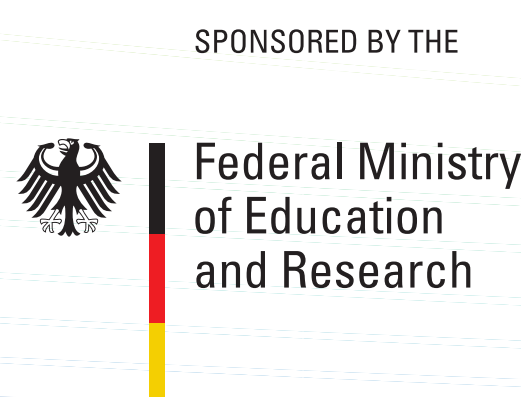
The type of lighting and the extent to which it was used were not welcomed by everyone. Much disputed was the illuminated advertising, lambasted in the early 1900s and 1920s by the heritage protection sector as a “blight” on the cityscape. These protests also led to the introduction of the first regulations on a previously uncoordinated market. Fascination with the illuminated night, as well as the criticism of excessive lighting and the corresponding technology and materials, thus have a long tradition.



Knowledge of these historical path dependencies and turning points is a useful basis for achieving acceptance of minimised light pollution.



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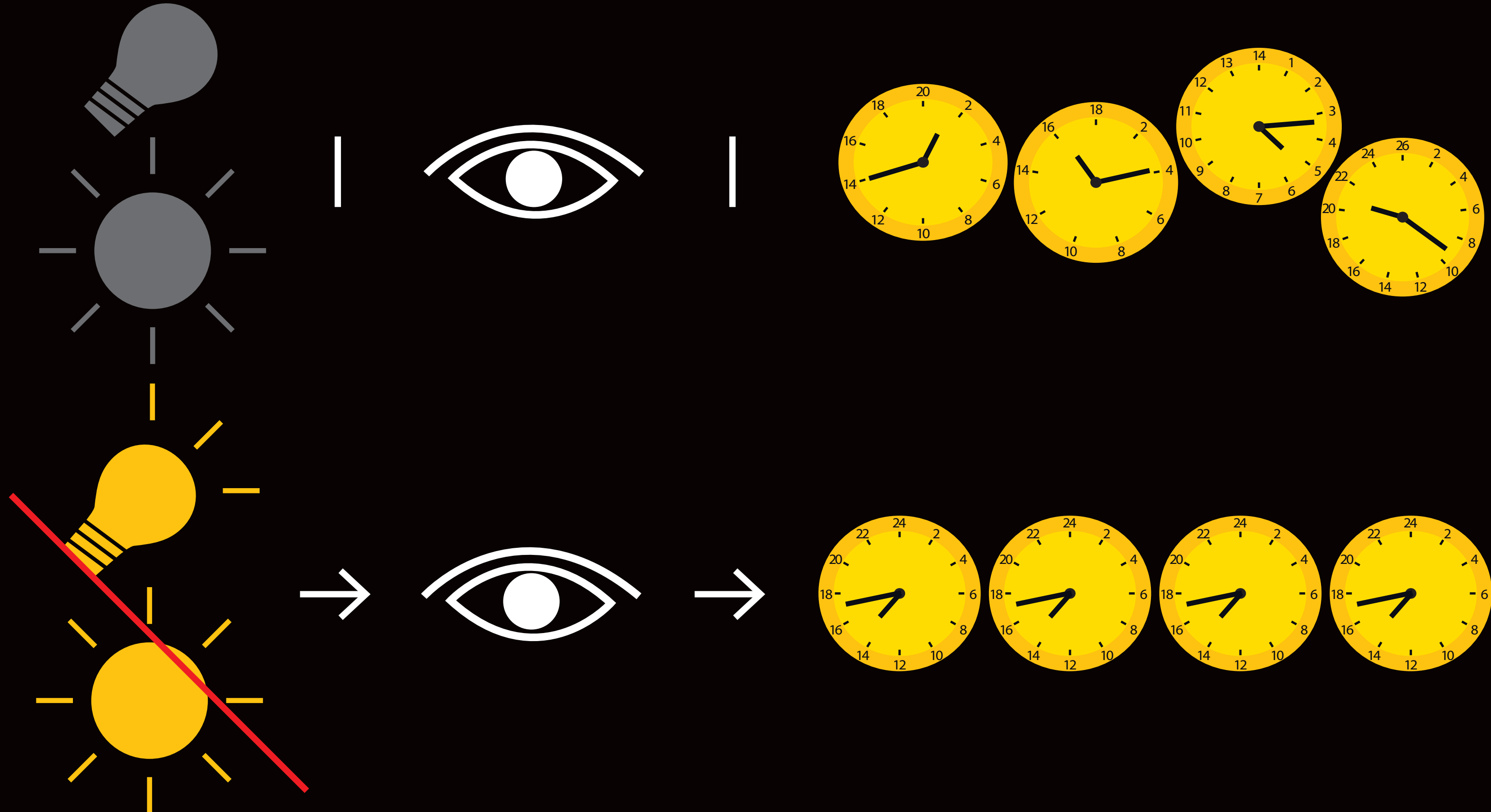
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LIGHT MAKES OUR BODY CLOCK STAY ON TIME

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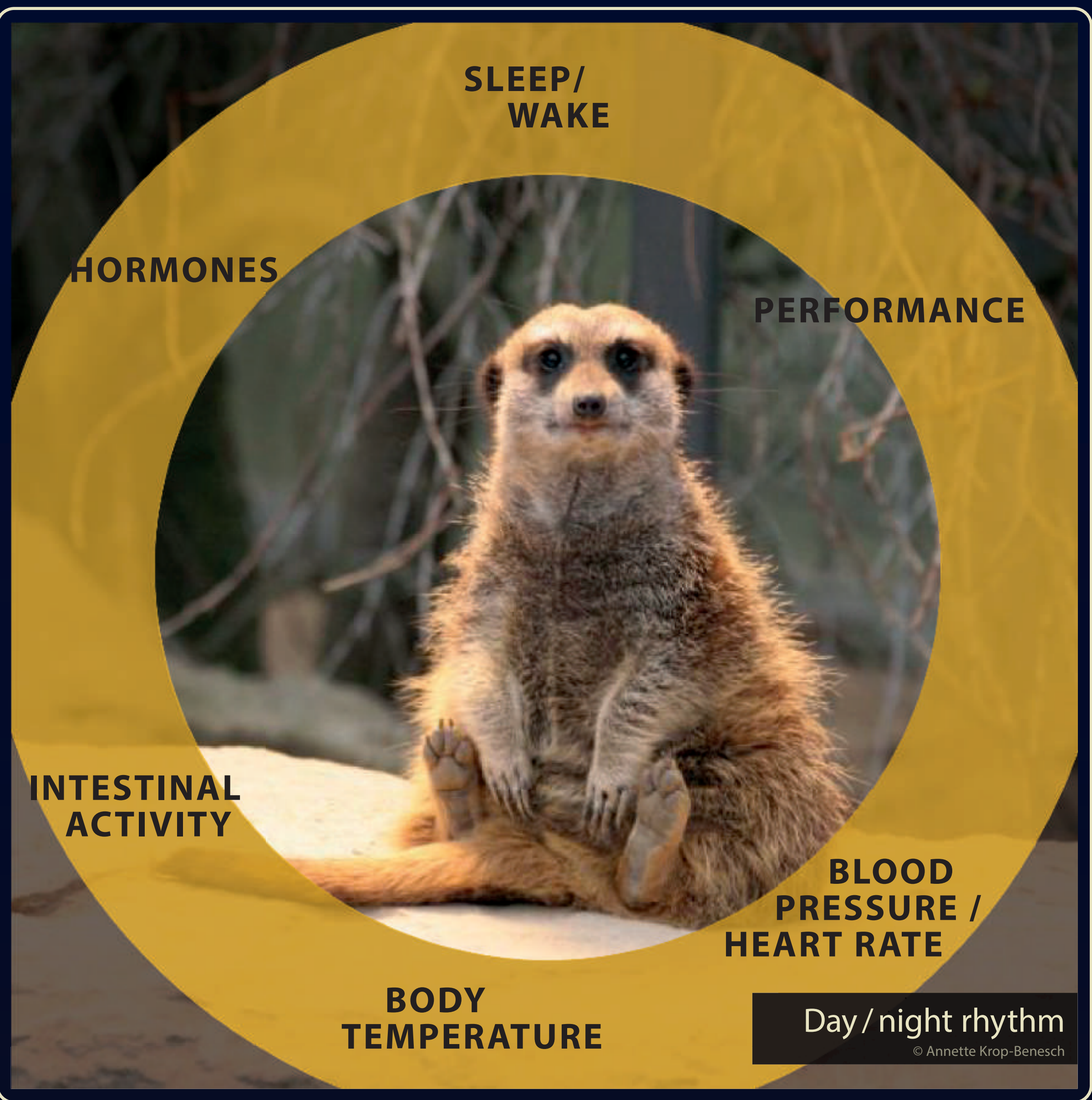
EVERY BODILY FUNCTION HAS ITS OWN RHYTHM. Without synchronisation, the body clock runs on different times; something we are familiar with from jetlag. When our bodies are exposed to sunlight, or even artificial light, the individual rhythms synchronise.

LIFE IS RHYTHM. THE MAJORITY OF ALL ORGANISMS, INCLUDING US HUMANS, HAVE ADAPTED TO THE NIGHT AND DAY RHYTHM IN THE COURSE OF EVOLUTION. Many bodily processes follow the rhythmical changes of light and dark. This includes the sleep-wake rhythm, the daily rhythm of body temperature and heart-beat, the production of various hormones, as well as the reading of genes.

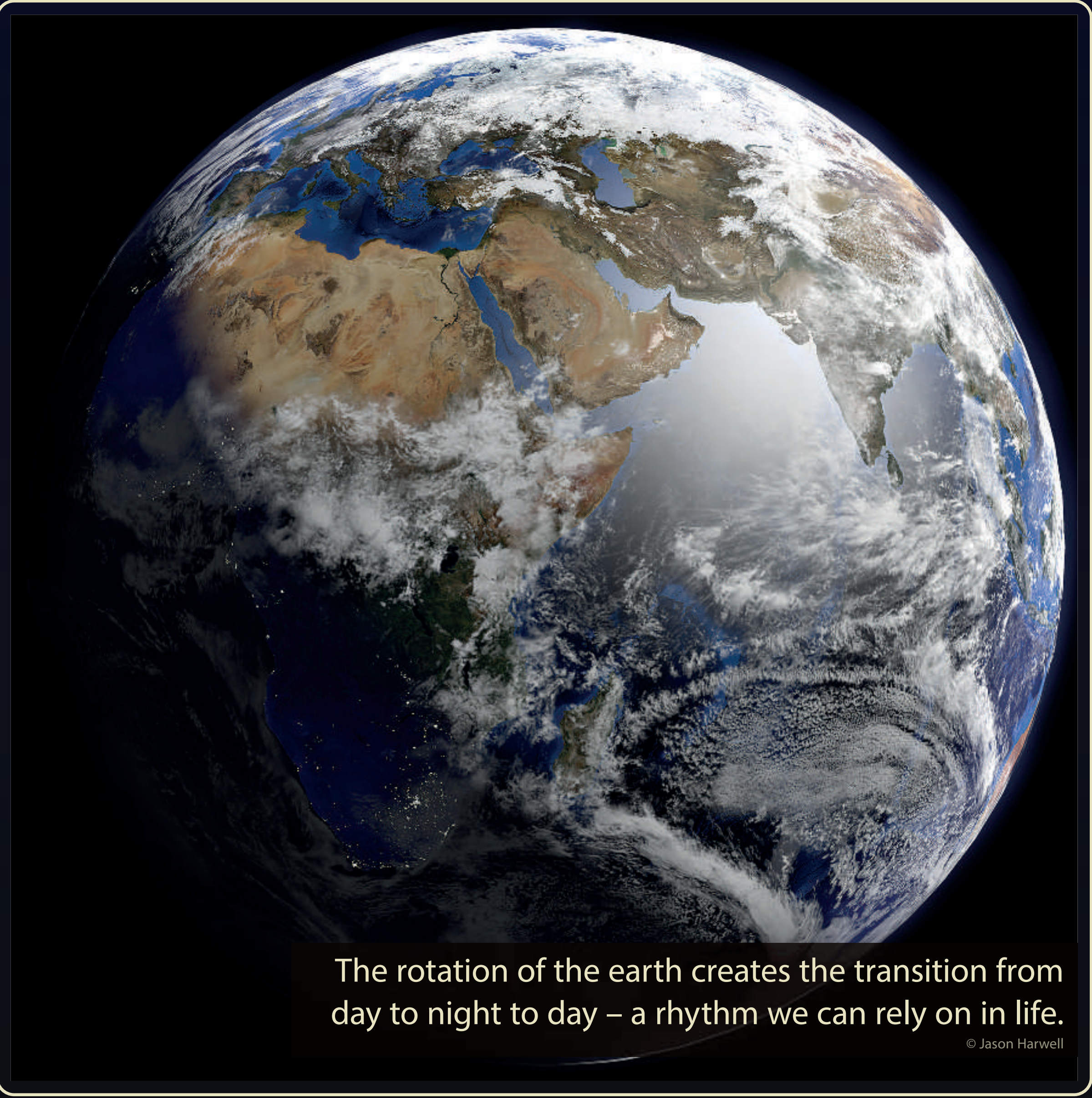
This body rhythm is controlled by an internal clock and can be compared to a symphony orchestra. Because every cell has its own clock, all of which run in time with

a genetically determined rhythm, the individual rhythms need to be synchronised by a master clock that sets the pace. For mammals, like humans, this clock is located in the hypothalamus, part of the diencephalon or “interbrain”.

The master clock creates a circadian rhythm (lat. Dian “day”) of only approximately 24 hours, depending on the animal species generally between 22 and 26 hours. Without any further control, our internal clock would run away from the day-night rhythm. In order to prevent this, the internal clock is set daily – through light. Light is thus regarded as a time clue or zeitgeber.



DAY-NIGHT-RHYTHM:
Most bodily functions, for flora or fauna, follow a day/night rhythm which is controlled by an internal clock. This illustration shows just a few examples of these bodily functions.

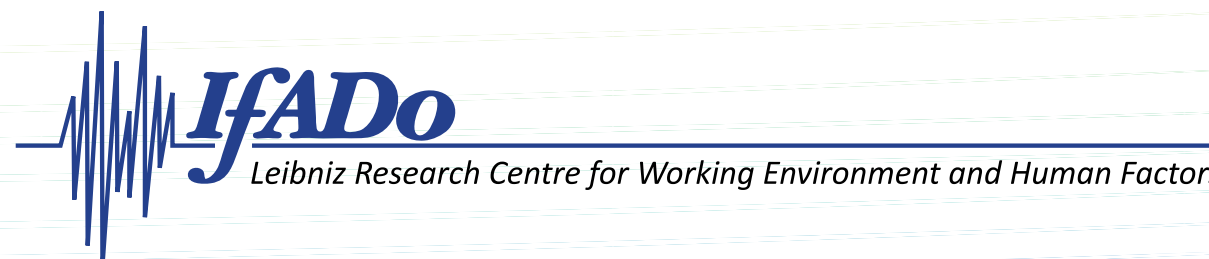


Light is perceived via special receptors in the eye, which for most mammals react to blue light. Bright, pale blue light suppresses the production of the hormone melatonin. Day-active animals, like us humans, become tired at night, i.e. when the level of melatonin increases. Bright light, on the other hand, makes us more alert. If there is no light, or it comes at the wrong time, the individual rhythms in the body diverge. Coordination of the various bodily functions is no longer correct and the body is less productive. Jetlag is an example for such a desynchronisation.

Particularly important for synchronisation is the change between light and dark. Twilight is a far better zeitgeber than a simple on and off. Which makes it unsurprising that so many people wake up better when exposed to natural light than when the room is kept dark by roller shutters.



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HOW ARTIFICIAL LIGHT INFLUENCES ECOLOGY

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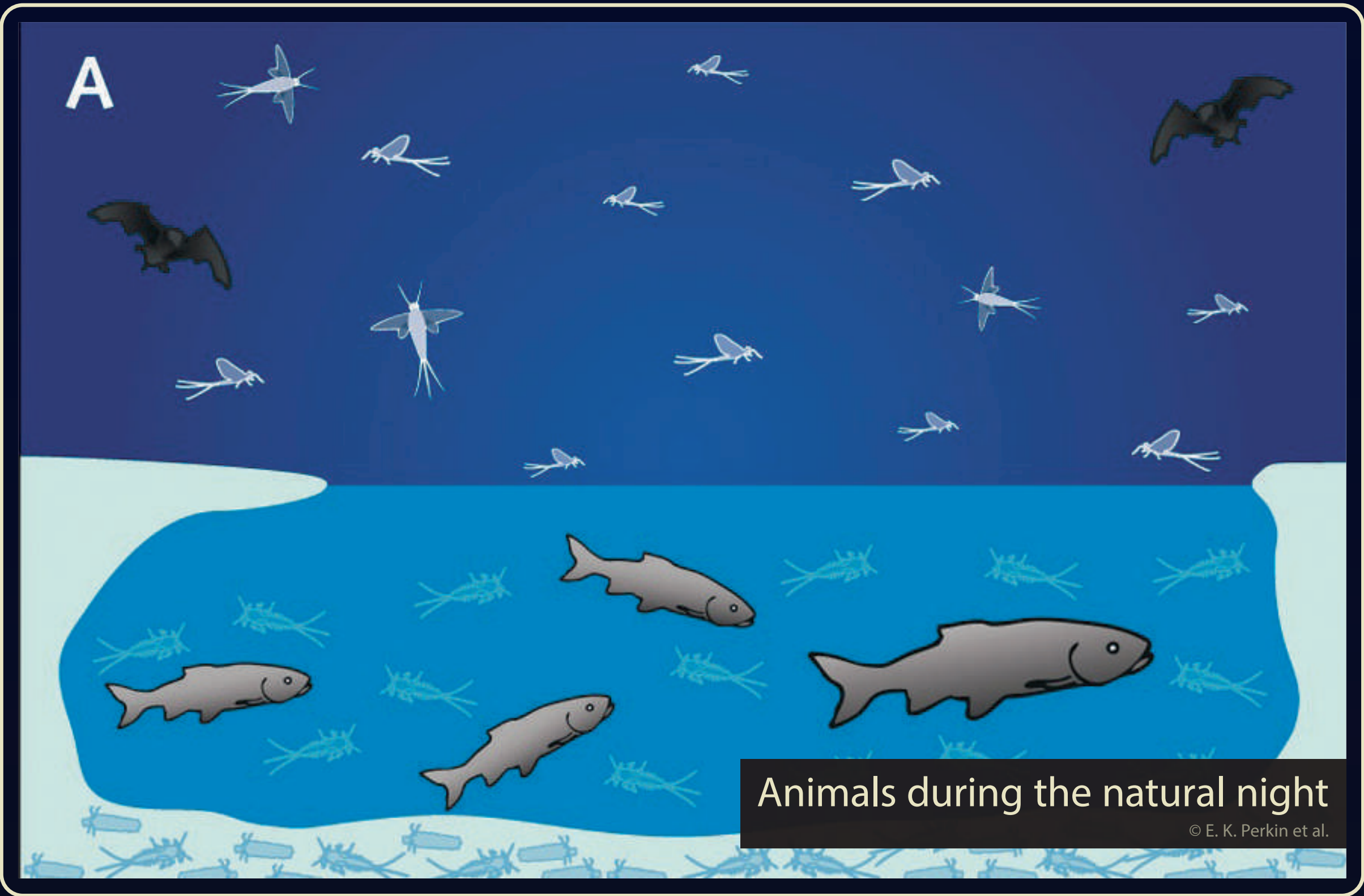
Gecko hunting on a night lamp

ONE CONSEQUENCE OF RAPIDLY INCREASING ARTIFICIAL LIGHT AROUND THE WORLD HAS BEEN THE FUNDAMENTAL CHANGE TO OUR NIGHT LANDSCAPES OVER THE PAST SIX DECADES. This concerns both quality (e.g. colour spectra) and quantity of light. This illumination of our night landscapes may have an important, but mostly ignored impact on our ecosystems and biodiversity.

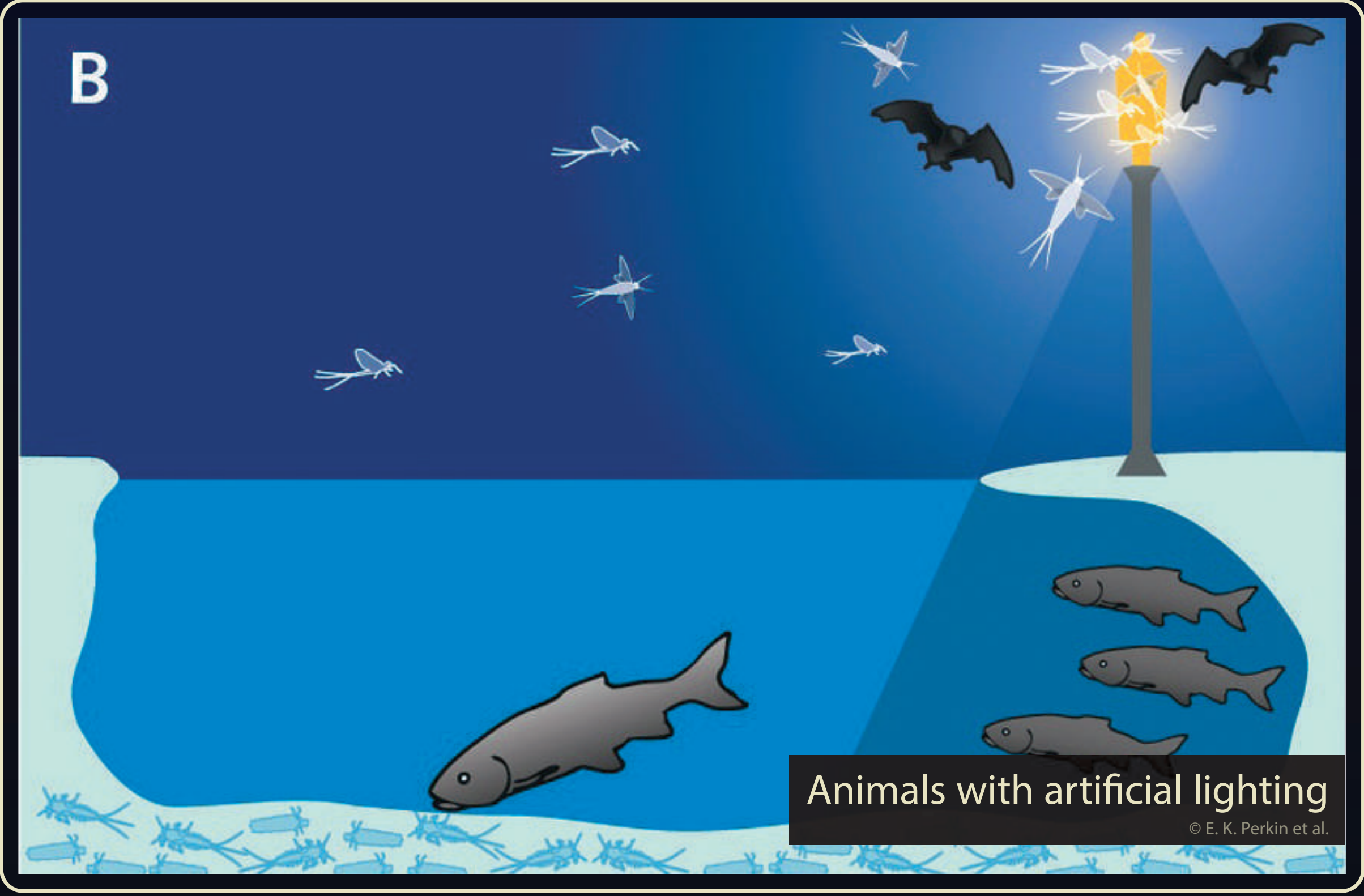
30% of vertebrates and 60% of invertebrates are active at night.

Depending on intensity, colour

spectrum, time, and duration of the illumination, artificial light can cause changes in behaviour that include disorientation, attraction, numbness or deterrence. This influences nocturnal behaviour such as migration, feeding, communication and reproduction, and can lead to a changed structure of communities and food webs.



Animals during the natural night



Animals with artificial lighting

A: Food web of a natural European inland body of water: During the night, insect larvae and zooplankton rise up and are eaten by fish. Flying insects are eaten above the water by bats.

B: The same biotope with artificial light: The water-based insects stay on the ground and thus do not enter the food chain. Small fishes avoid the light and find less food. Flying insects swarm around the lamps, where they become easy prey for the bats. Light-sensitive bat species come away empty-handed.

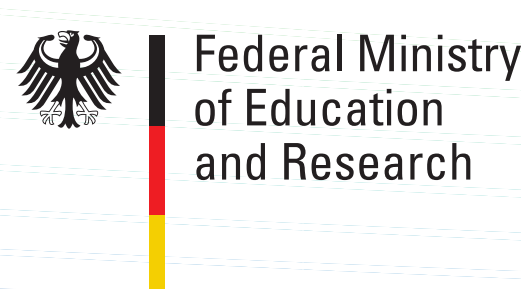
The consequences for ecological systems are plain to see: light-sensitive species (e.g. numerous insects) will disappear, and so in turn the nutritional basis for birds and other organisms, as well as important pollinators for plants. Several animals have learned to use the generous supply of food found close to the light to their advantage: spiders build their webs directly in front of the light, several bat species swarm around the lamps, while geckos sit on them. As a consequence of this impact, the so-called ecosystem services are being compromised.. This concerns, for example, pollination of wild flowers by moths or the productivity of an ecosystem. Also the cultural value of a dark night is being lost to more and more people through light pollution.

Many organisms have adapted to the natural day and night, moon and seasonal rhythms over the course of evolution. If light changes these cycles, the seasonal habitat will change too. Several species, particularly those with short generation time, may be capable of adapting evolutionarily to their new conditions.



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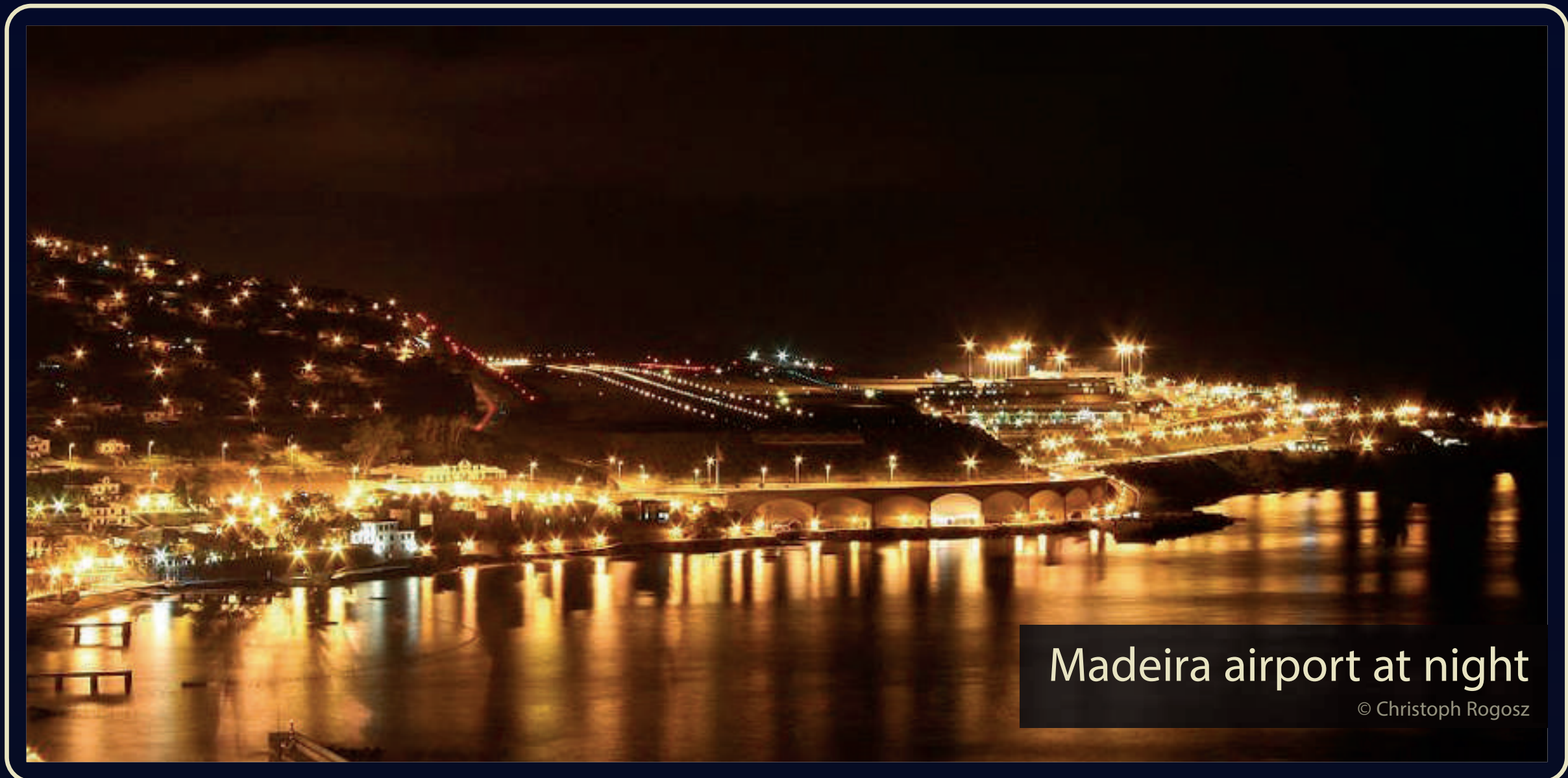
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DECEPTIVE LIGHT! IMPACT OF ARTIFICIAL LIGHT ON BIRD SPECIES

LOSS
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Post tower in Bonn



Madeira airport at night



Bird strike on lighthouse

BIRDS RELY ON THEIR VISUAL SENSE LIKE ALMOST NO OTHER ANIMAL GROUP, depending on it for orientation, communication, partner selection, foraging and avoiding predators. Artificially changed lighting conditions can thus have a variety of repercussions.

Hundreds of bird species fly at night. In certain weather conditions, they are attracted en masse by light houses, illuminated drilling platforms, railway tracks and multi-storey buildings. As soon as they reach the light, their eyes adjust to the brightness and the dark surroundings appear impenetrable. Which leaves the birds effectively stranded – trapped by the light. At the same time, the bright light is blinding. In a worst case scenario, the birds collide with the buildings, leading to injury or death.

It is estimated, in the US alone, that between 4 and 50 million birds are killed through the collision with technical infrastructure each year. Even when the birds manage to survive, time and energy reserves are wasted which are otherwise needed for migration.

Several seabirds are threatened with extinction as their chicks do not fly out over the sea when first leaving the nest, i.e. where the moon and stars are the brightest orientation points under natural conditions. Instead, they are flying to the far brighter, artificially illuminated coastal areas, where they starve or become easy prey for cats, dogs and other predators.

Light pollution also influences the behaviour of many bird species:

Activity – Most of Europe’s songbirds are active during the day and sleep at night. It has become apparent that due to artificial lighting, robins, blackbirds and others are breaking into song at night or searching for food under the light of the street lamps.

Choice of partner – For the female blue tit, the time at which the male tit breaks into morning song indicated a trustworthy partner – only older, more experienced and well-fed male tits sing early. Artificial lighting means the young and less experienced male tits are waking up earlier. This misleads the female tits, who are thus increasingly choosing the wrong partner.

Choice of hatchery – Nocturnal lighting is alienating other bird species. Black-tailed godwits will only breed in areas that are sufficiently dark. This can have far-reaching consequences if, for examples, conservation areas that have been specially set up do not meet these nightfall requirements.



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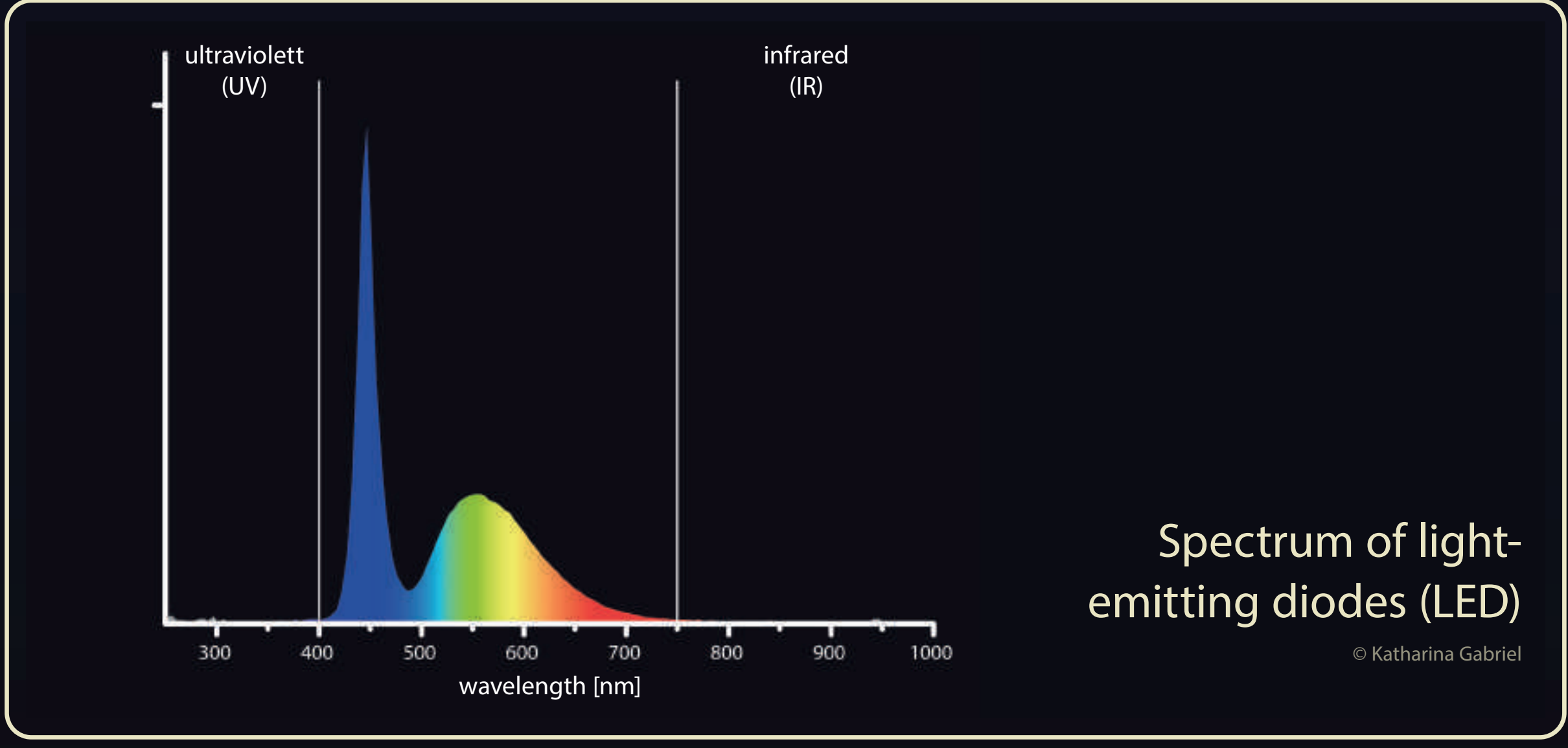
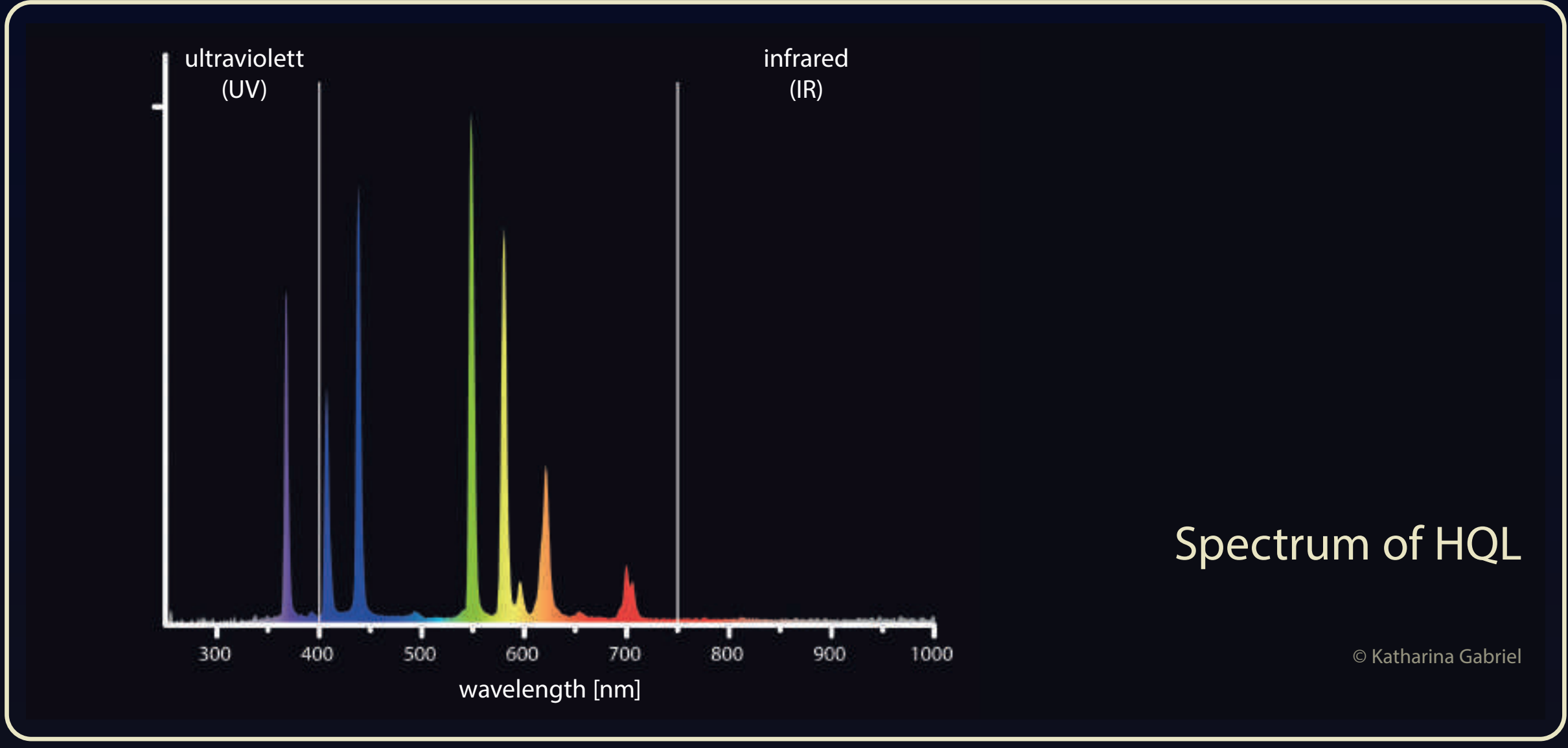
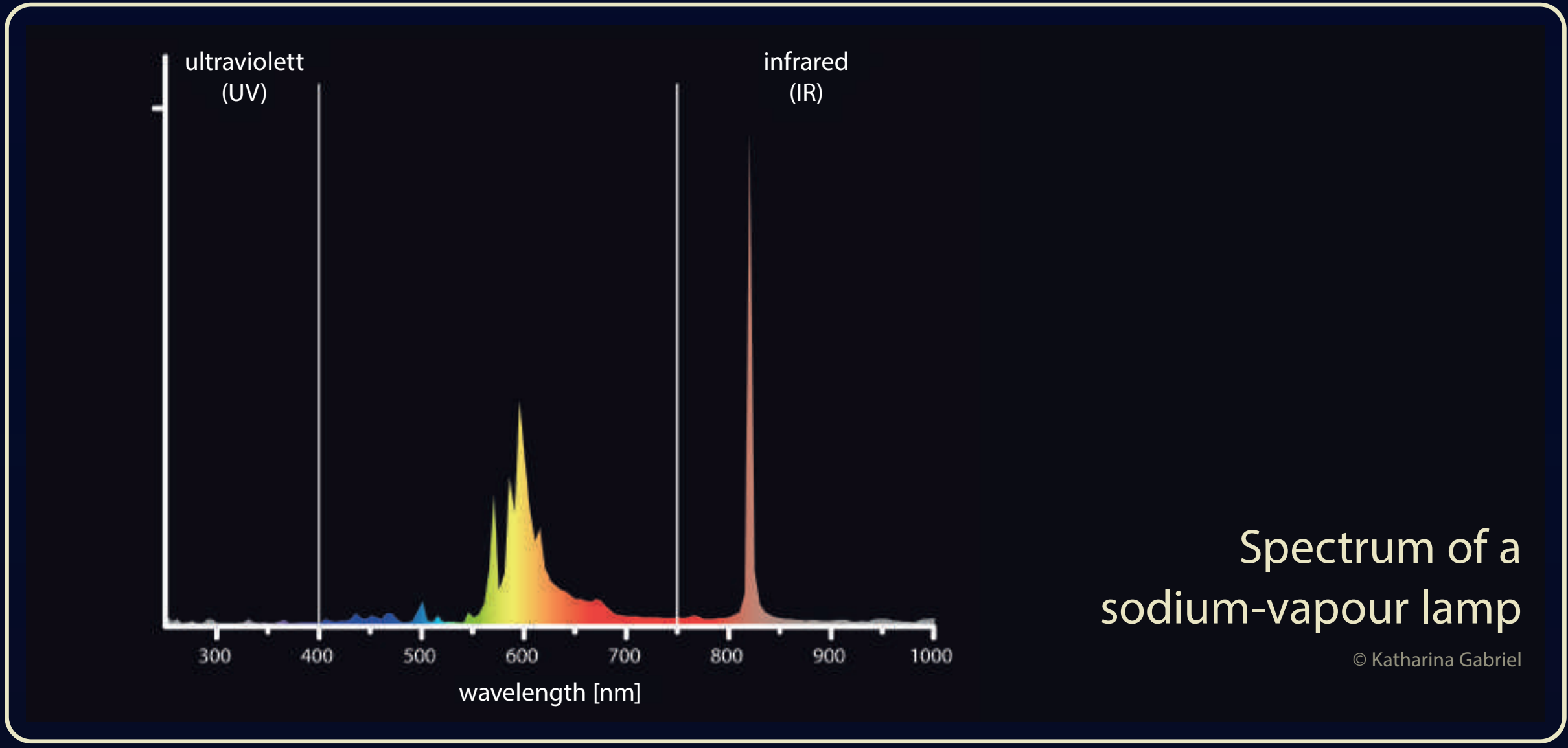
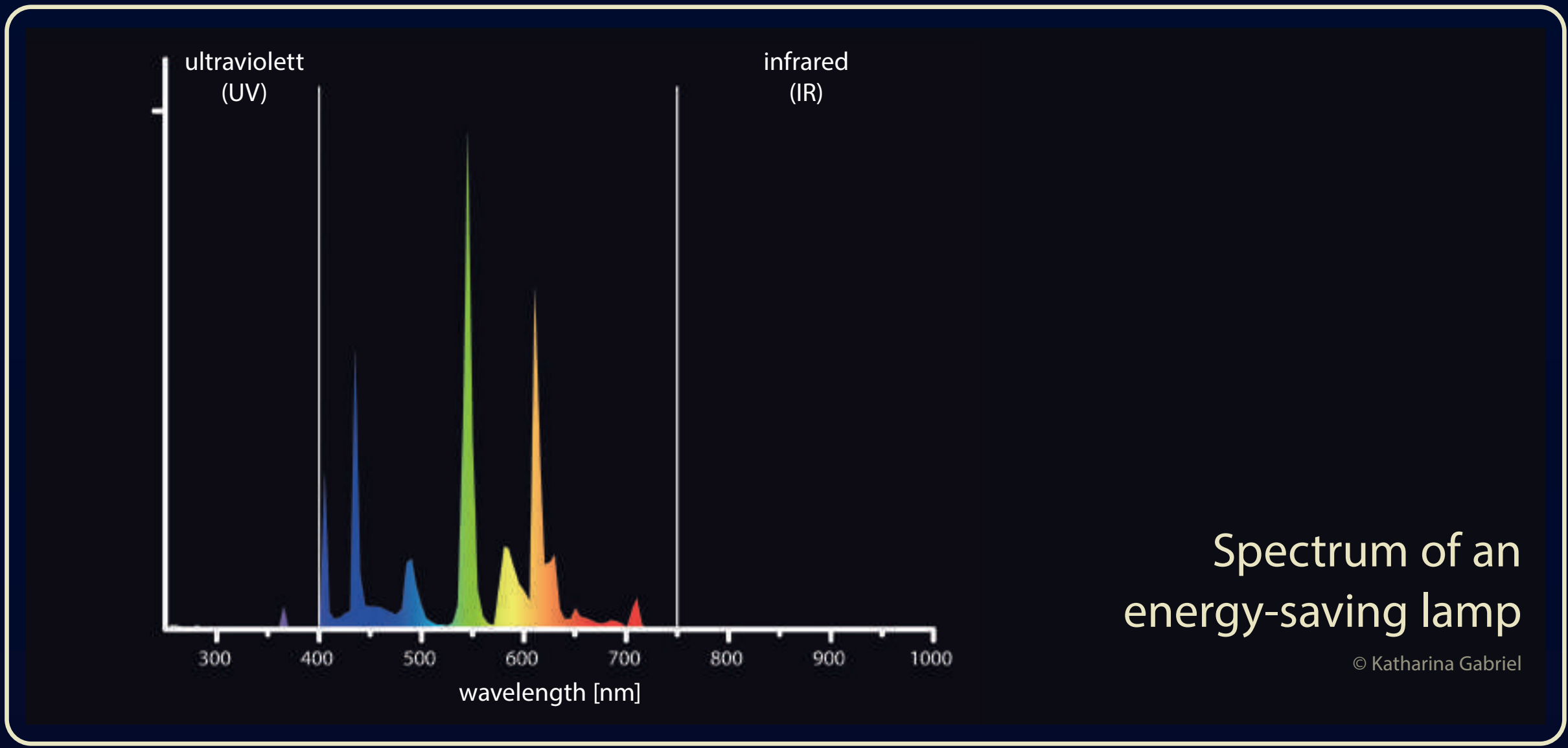
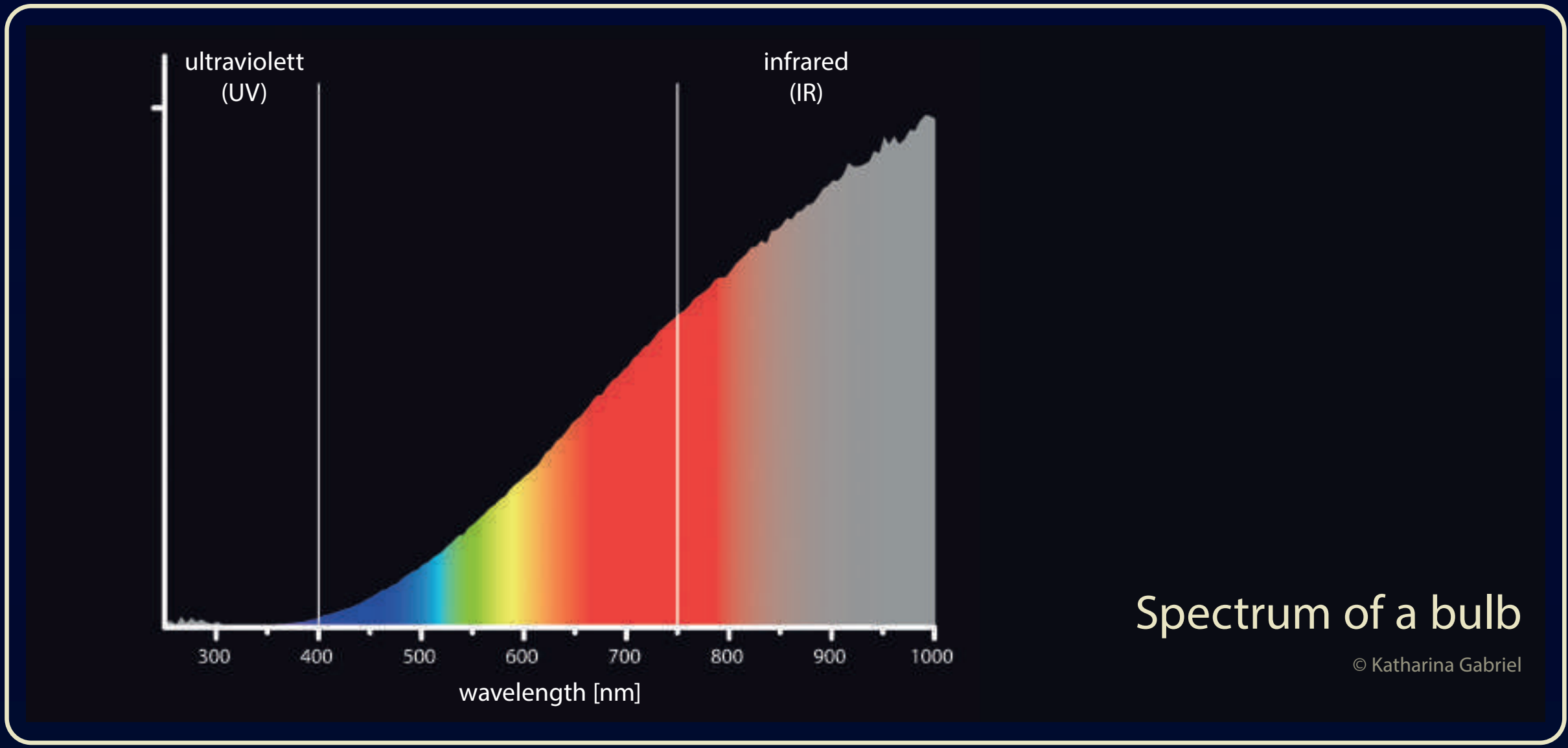
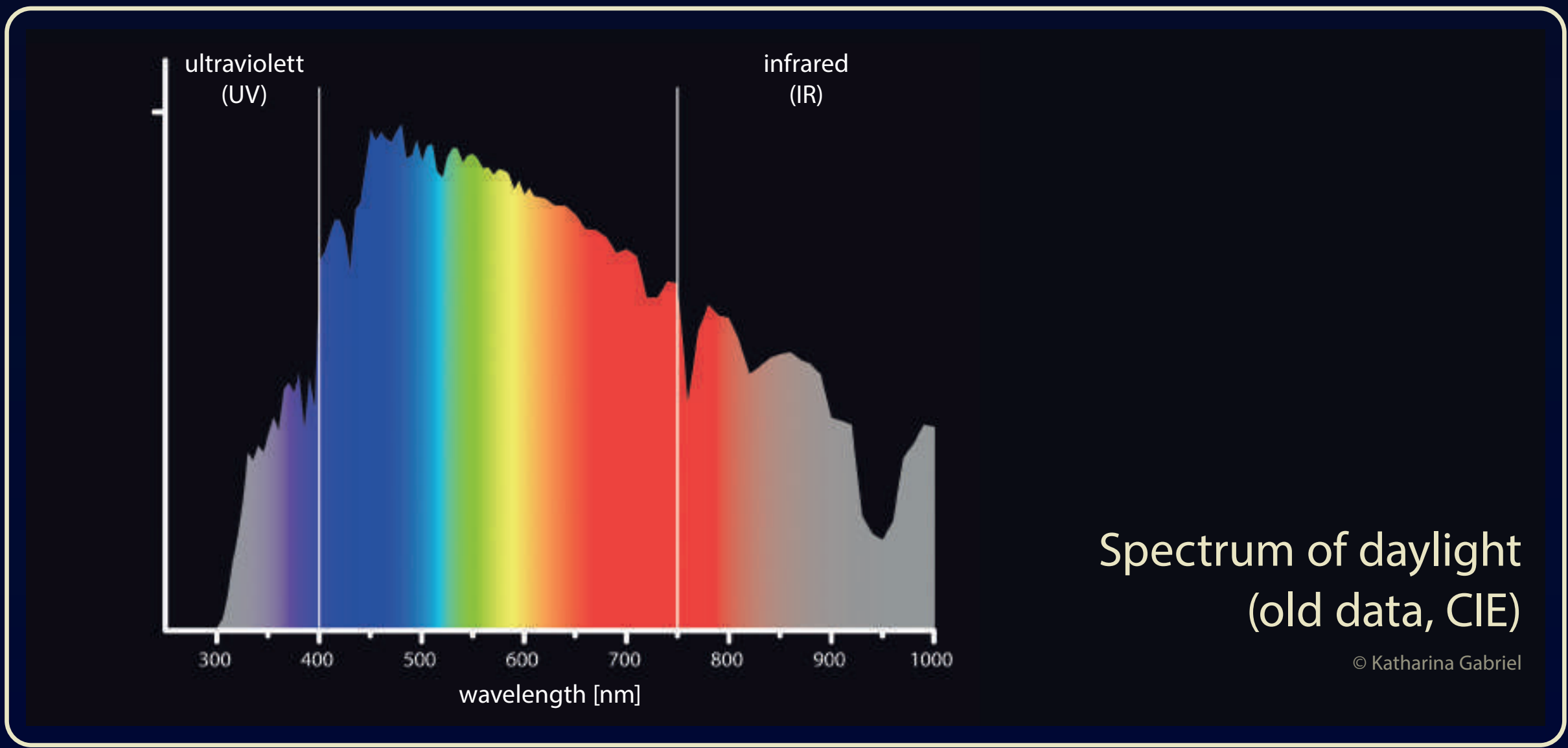
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THE SPECTRA OF LIGHT

LOSS of the NIGHT



HUMANS ARE DESIGNED TO BE ACTIVE DURING THE DAY, WITH VISION BEING THEIR STRONGEST SENSE OF ORIENTATION. With our eyes, we are able to perceive wavelengths between 380 nm and 780 nm. This is the only spectral range of physical electromagnetic radiation that we can see and is thus defined as light. We perceive radiation with greater wavelengths (IR, infrared) as heat, shorter wavelengths (UV, ultraviolet) are absorbed via the skin. Rays from these wavelengths have only a biological impact on humans and are not perceived as brightness.

The spectrum of daylight is relatively continuous, going from short-wave UV range to visible range to long-wave thermal range.

The first artificial light sources, e.g. open fire, oil lamps or candles, also have a continuous spectrum. Thanks to their high proportion of long-wave radiation, they are also heat radiators. Gas lamps on the street and light bulbs in the home also contain a large proportion of infrared.

Modern lamps such as LEDs or energy-saving lights, however, do not radiate heat. When generating light, e.g. through gas discharge, their energy is used almost exclusively for the generation of light and, while they may be more energy-efficient than light bulbs, they also have no continuous spectrum. The colours emitted from individual peaks are mixed and perceived, for example, as white light.

LEDs that appear white generate their radiation through a semiconductor with a high percentage of blue. Even if we don't consciously realise it, this blue light can influence our internal clock.

Unlike people, some insects and several birds can also see in the UV range, which means lamps with a high percentage of UV, such as the mercury vapour lamp, can by all means influence their behaviour.



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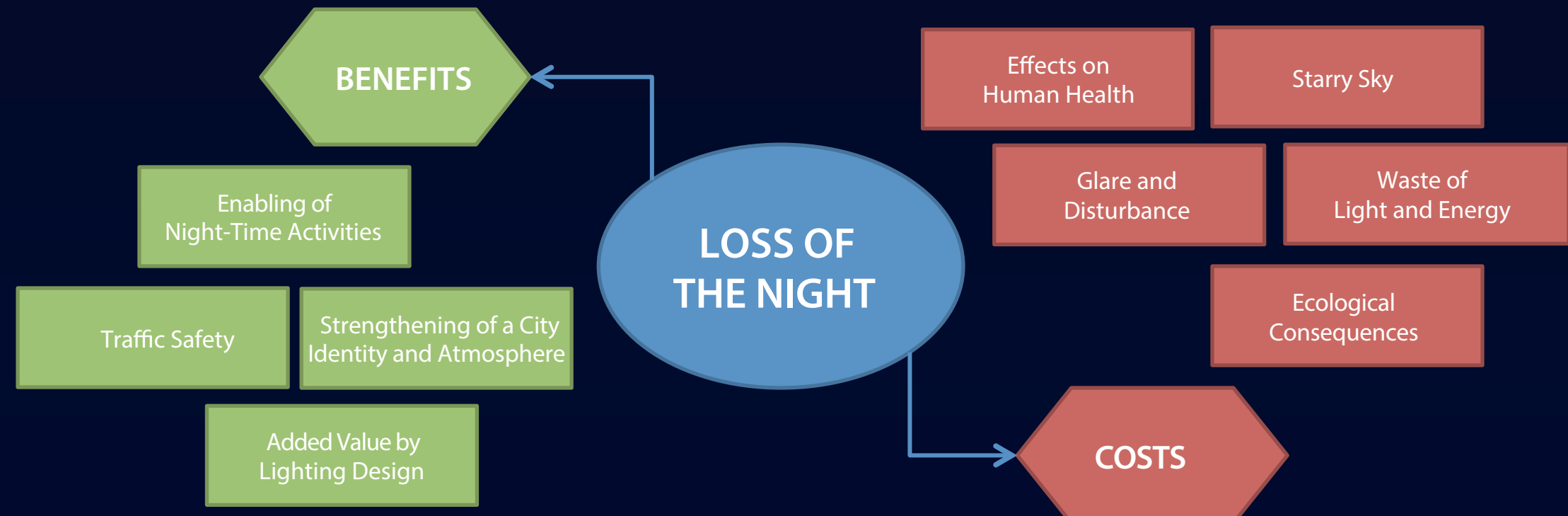
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BENEFITS AND COSTS OF ARTIFICIAL LIGHTING

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Possible costs and benefits to artificial lighting
© Portmann / IGB



ARTIFICIAL LIGHTING HAS ALWAYS BEEN OF HIGH SYMBOLIC VALUE FOR PEOPLE. The appearance of artificial lighting in cities around one hundred years ago represented a move towards modernity. Artificial lighting is now taken for granted and has largely allowed for a day-and-night continuum.

More often than not, it is used positively and represents progress and prosperity. These days, however, criticism is mounting against the increasing number of new, primarily outdoor, light sources around the world that are having a serious negative impact.

By breaking up the rhythm of day and night, artificial light has facilitated the extension of economic and social activities well into the early hours. Light is thus also enabling a round-the-clock society (24/7), with a whole host of production, repair and entertainment services now available. Light also increases safety on the streets and open spaces. With artificial light, business districts and shopping miles, entertainment venues, construction sites and entire cities are all put under the spotlight, enticing customers, creating an atmosphere and developing identity.

The many positive aspects have their price. The “shady side” to artificial light is becoming increasingly clear. In addition to the high (and despite greater lighting efficiency) energy consumption required for daily artificial illumination, there are further, largely indirect yet no less relevant, costs. Light pollution, in other words the pollution of the natural nocturnal light by artificial light, creates a variety of negative effects on nature and people. Light can massively disrupt a person in his/her natural periods of rest. The effects on animals are even more obvious. For example, nocturnal animals use the stars in the sky and the light of the moon as orientation aids. This orientation is sometimes hampered by artificial light to such an extent that they die from the exhaustion. This is changing the ecological balance in ways that are still largely unknown. The starry sky is a cultural asset of the first order, yet hardly recognisable in many cities due to artificial brightness.

This price we pay has also created new challenges when it comes to the regulation of artificial lighting: namely that, in addition to energy efficiency, the ecological, health-related and cultural impact must also be considered when drawing up guidelines and lighting plans.



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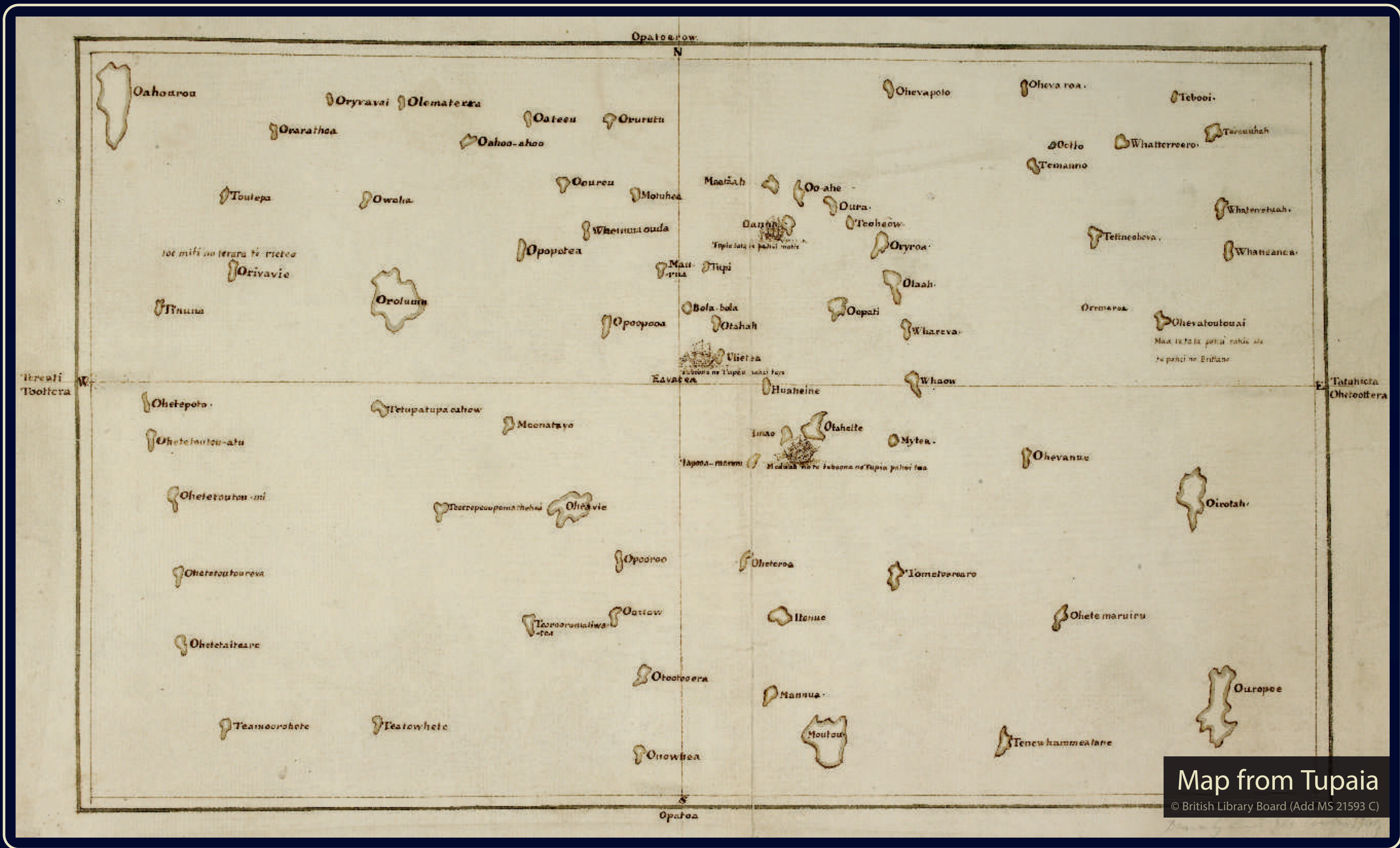


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NAVIGATION

STARS GUIDE THE WAY

LOSS
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NIGHT



SINCE THE EARLY HISTORY OF MANKIND, SUN, MOON AND THE STARS GUIDED THE WAY – for example, when settling in new regions, on trade routes and expeditions, and especially on the high seas where there were no landmarks.

The great achievement of the Polynesian navigators, who colonised the islands of the Pacific Ocean more than 1500 years ago, saw them take to the open seas with neither compass nor sextant. An accurate observation of the skies, as well as the landmarks or the behaviour of the birds and fish, were combined to gain information on their whereabouts and course of travel.

MAP FROM TUPAIA:
Supposedly drawn by the Polynesian explorer Tupaia in the year 1769 for Captain James Cook, when Captain Cook was on his first trip around the world with the ship “Endeavour”. It covers a distance of 4000 km.



Astrolabes for navigation, determination of time and astrology

Nomads like the Tuareg use the cold nights when migrating. They look to the starry sky as a guide, just as the first caravans did on the Silk Road. Based on their observations of the stars, the Arabian Nomads developed astronomical knowledge that was used to navigate their route. The calculations and methods required for this led to further mathematical developments.



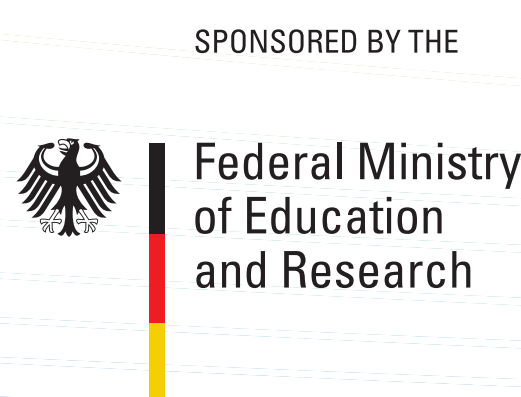
The sextant is still used by today's seafarers

Since the late 15th century, European seafarers have been using latitude determined from the highest position of the sun (noon latitude) or the position of the stars. Calculation of the longitude proves a challenge in comparison. Initially, there was a relatively vague estimation using the direction of motion, speed and onboard time. From the 18th century until well into the 20th century, the position of the moon as predicted by astronomers and specific individual stars (moon/star distances), as well as chronometers which give the time at the zero meridian, were used for the accurate calculation of the longitude.

Despite satellite-supported navigation (e.g. GPS), astronavigation, i.e. the determination of location and course according to the stars, is still used by private seafarers and even the military today. It is a method that requires no technical support and (apart from the clouds) is not influenced by any interfering signals. Unlike a magnetic compass, the electromagnetic field of the ships also has no effect on astronavigation.



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ASTRONOMICAL RHYTHMS

FORM TIME CONCEPTS

LOSS
of the
NIGHT

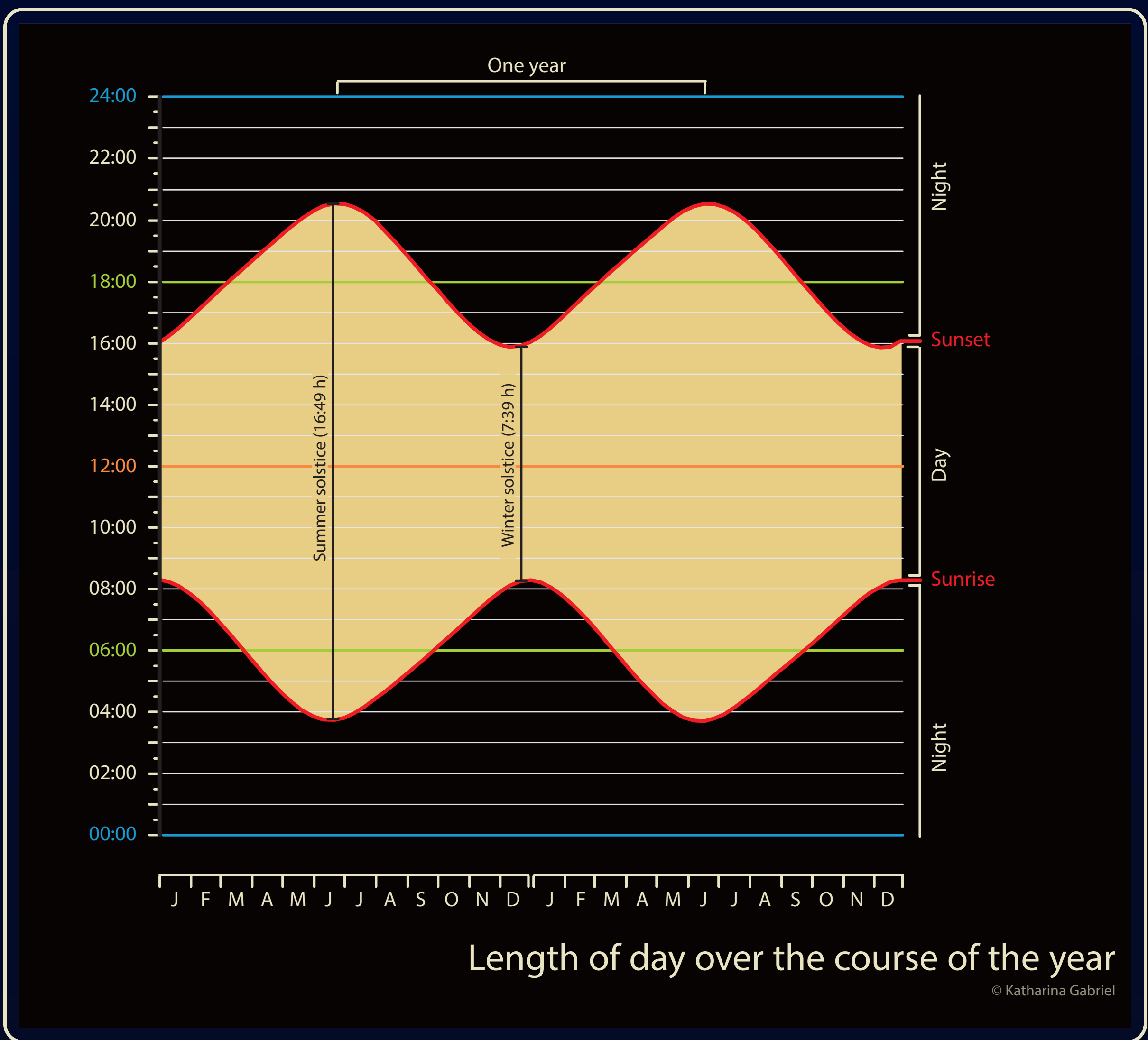


Phases of the moon

THE MOST EXPLICIT RHYTHM IN THIS WORLD IS THAT OF DARKNESS AND LIGHT – what we humans have called night and day. This change is caused by the rotation of the earth around its own axis.

As Earth tilts slightly, the duration of brightness and darkness changes as the planet rotates around the sun: in summer days are longer than the nights and the other way round in winter. As early as the Stone Age, people celebrated both the longest and shortest days of the year

(Summer and Winter Solstice). We recognise this repeated cycle of the different lengths of day as a year.



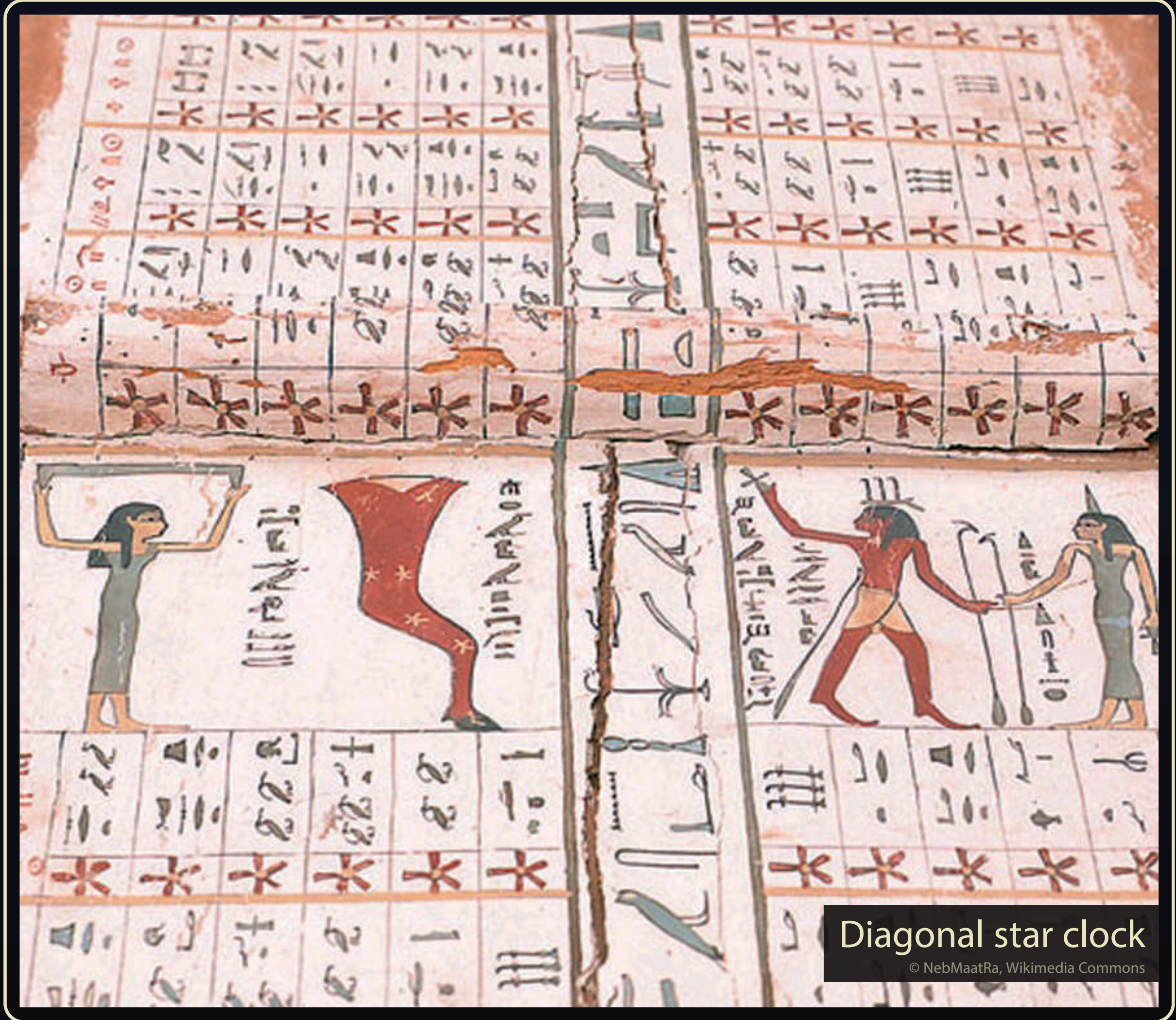
Length of day over the course of the year

Another natural rhythm is created by the lunar phases, or phases of the moon. The duration of the cycle incorporating the slow increase and decrease of the moon corresponds to what we call a month. The lunar calendars are less important today, however religious festivals such as Christianity’s Easter or Islam’s Ramadan are still determined according to the lunar rhythm.

By observing the changing position of the sun, the day can be divided up further. This becomes particularly clear when following the wandering shadows on a sundial. And at night? It started with many of the ancient advanced civilisations who not only used the stars as a means of orientation but also to tell the time: the Aborigines in Australia, a nomadic people, used the stars to determine the rhythm of their food sources. The disappearance of the Lyra constellation, for example, marked the egg deposition of the Malleefowl.



Sundial

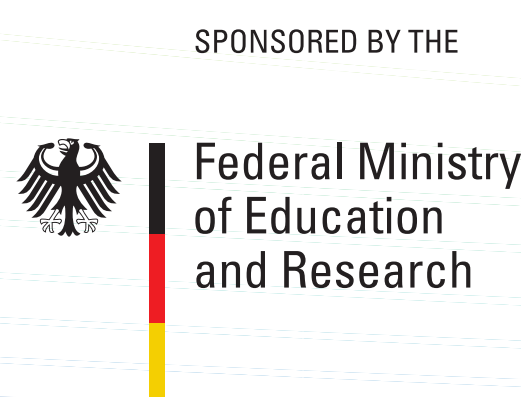


Diagonal star clock

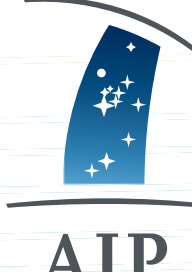
The Pleiades or Seven Sisters announced autumn’s rainy season in the ancient Mediterranean region and thus the time to sow. Its disappearance in spring heralded the harvest period. The ancient Egyptians were able to divide the night into precise time periods using the course of individual stars and had thus founded the first “night clocks”. Today, however, light pollution means that very few would be punctual using this system ...



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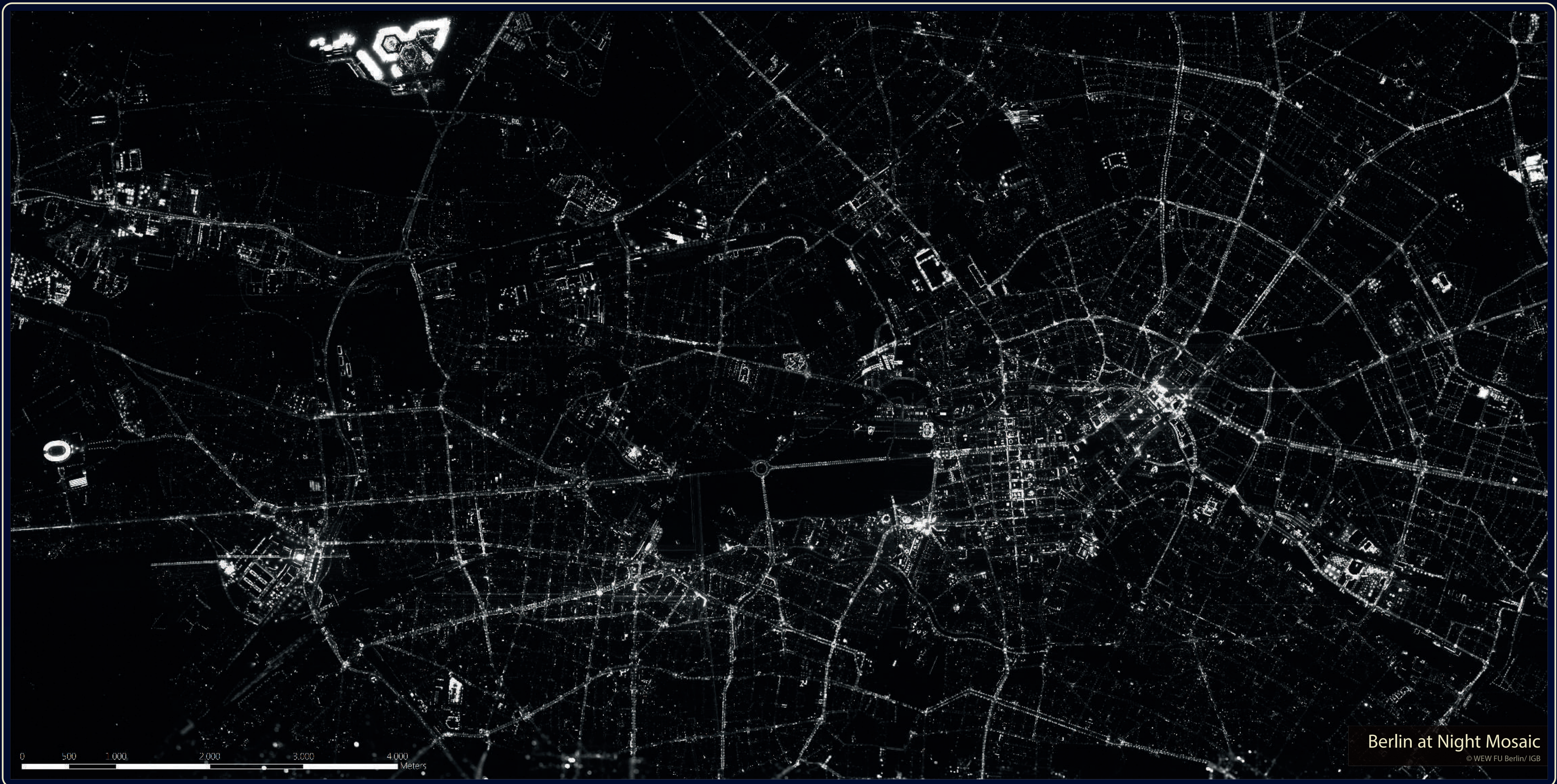


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WHAT ARE THE SOURCES OF LIGHT AT NIGHT?



UNDERSTANDING THE SPATIAL DISTRIBUTION OF LIGHTING

Light sources and light intensities, the distribution and the temporal change of light emissions can be identified, represented and analysed by examining images of cities at night. The interdisciplinary research association, Loss of the Night, produced a high-resolution map of the city of Berlin to understand the sources of artificial night brightness. The images were taken in September 2010, and include light reflected or directly emitted upwards in the spectral range of 400-1000 nm, with a spatial resolution of one meter.

In the area surveyed, which covers 42% of the city, the various urban structures such as streets and buildings have been analysed, and particularly bright light sources were identified. Such information is useful for planning the reduction of light pollution in a region. Public spaces are responsible for a large fraction of light emissions, and are the direct responsibility of local authorities.

PLACES	BRIGHTNESS FACTOR
airports	9.60
core inner city area, railway facilities	5.50
construction sites	5.40
town squares and promenades	5.00
historical buildings	3.50
motorways	3.00
streets	2.30
commercial & industrial areas	1.70
community areas	1.60
average map brightness	≡1

HIGH INTENSITY LIGHT SOURCES: The brightness factor was derived by dividing the mean emission of each class by the mean of the mosaic. This allows an area independent comparison of the radiance of different land use types (e.g. a land use class with 2.0 is twice as bright as the average pixel in the mosaic).

PLACES	EMISSION FRACTION (% OF TOTAL AREA)	AREA (% OF BERLIN)
streets	31.60	13.60
commercial & industrial areas	15.60	9.10
community areas	9.60	6.00
core city areas	6.30	1.10
airports	3.70	0.39
parks, green spaces	2.00	6.10
forest	0.61	12.30
flowing waters	0.38	1.50
tree rows and groves	0.36	1.90
standing waters	0.16	3.50

MAIN SOURCES OF ARTIFICIAL LIGHT IN BERLIN'S CITY CENTRE: The fraction of all light emitted per land use class was obtained by dividing the total light observed for each class by the total amount for the whole study area.



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PUBLIC LIGHTING AND LIGHT POLLUTION

LOSS
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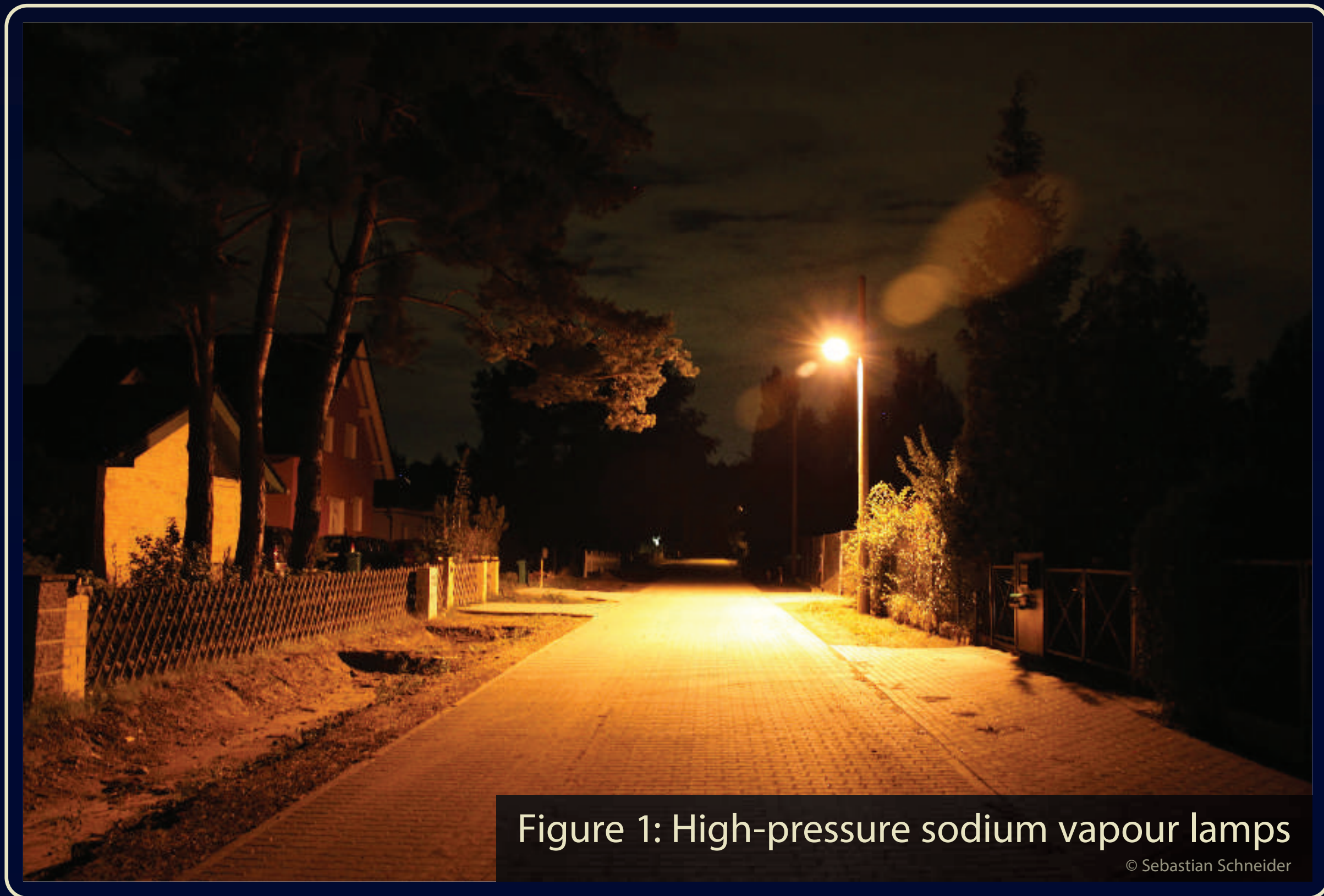


Figure 1: High-pressure sodium vapour lamps



Figure 2: High-pressure mercury vapour lamps

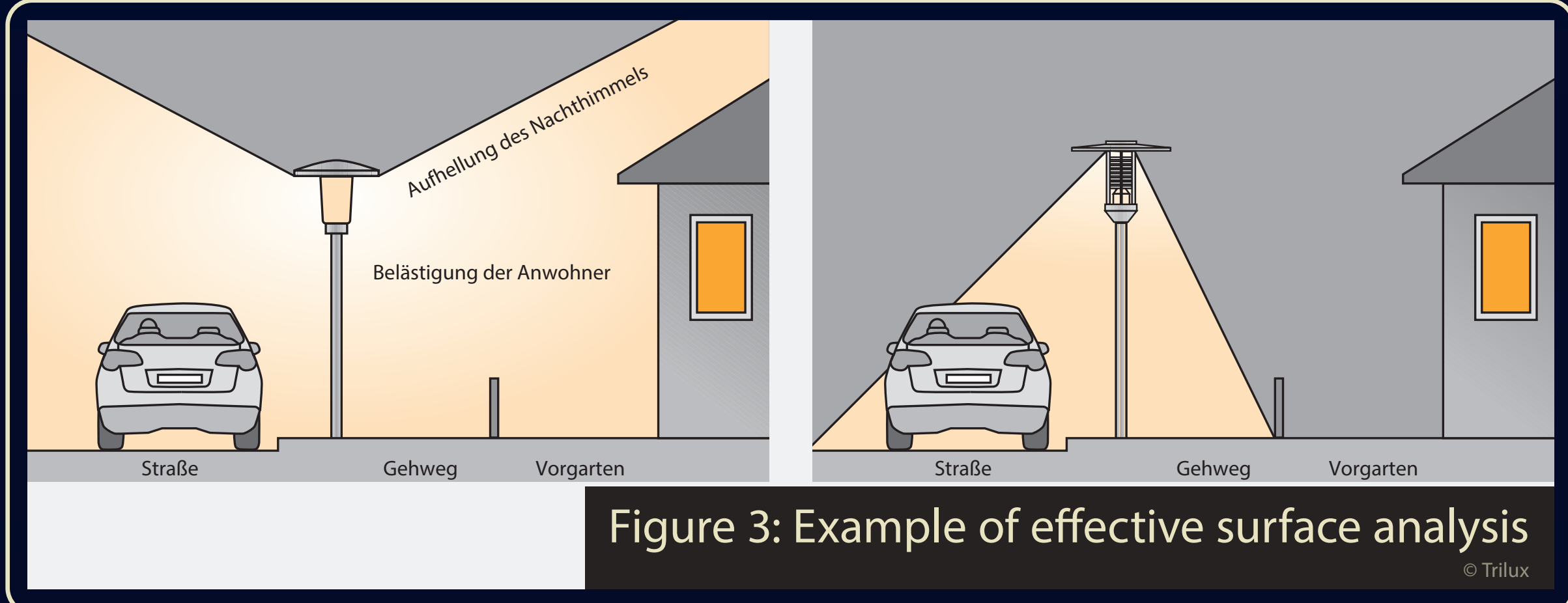


Figure 3: Example of effective surface analysis

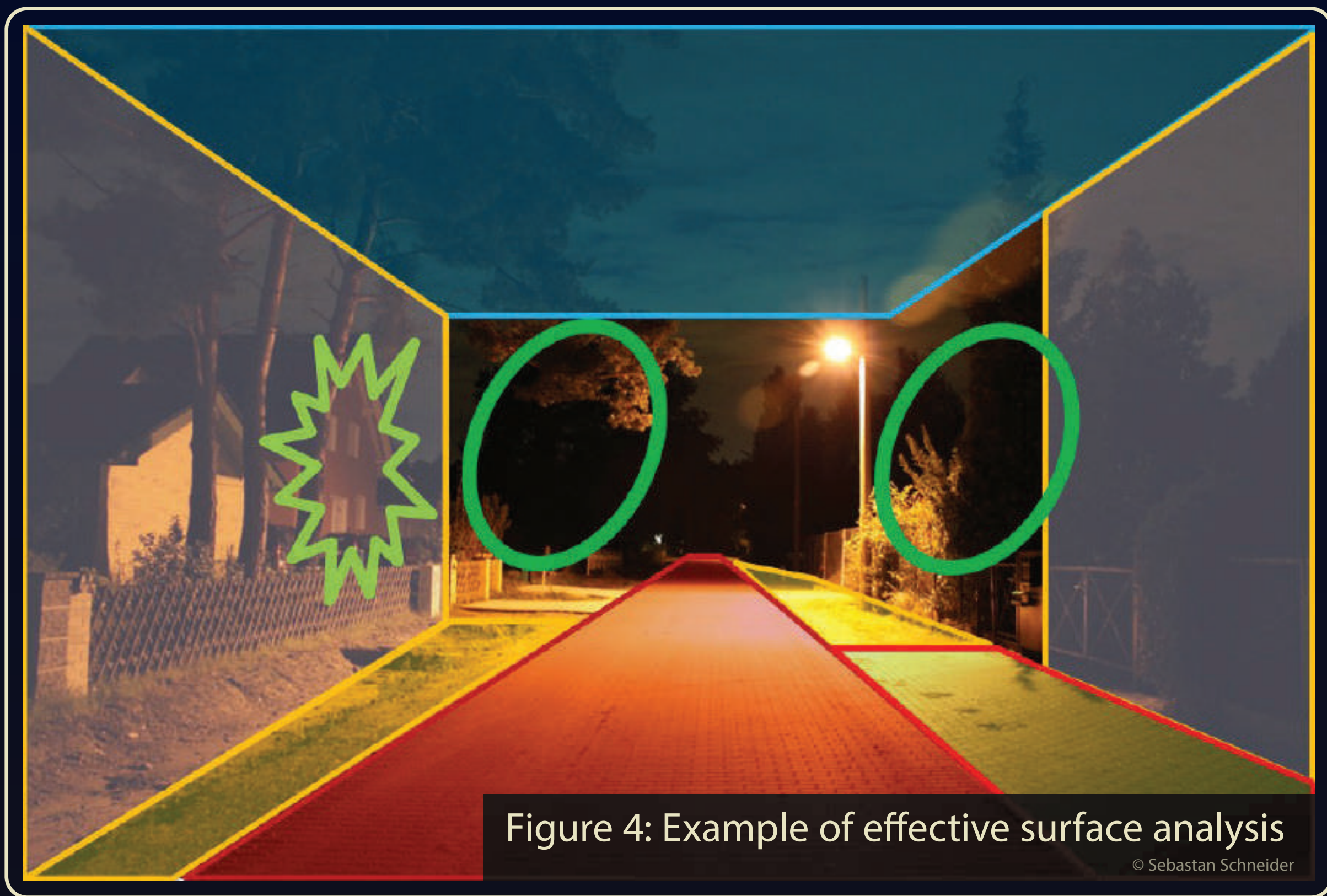


Figure 4: Example of effective surface analysis



Figure 5: LED street lamps that meet modern requirements

An important issue when addressing the complex theme of light pollution is the public lighting of streets and buildings in cities and towns, which causes up to 50% of the light pollution in urban areas¹. However, the main function of this lighting is often to guarantee road safety or, in the case of decorative lighting, to enhance the cityscape. A reduction of the energy requirements and unnecessary light immissions must therefore take both sides into consideration, with three options essentially available here:

- Replacement of the lamps with energy-efficient models:

A considerable share (approx. 45%¹) of the street lamps used in Germany are high-pressure mercury vapour lamps. These lamps have a considerably lower light output in comparison to high-pressure sodium vapour, halogen metal-vapour or LED lamps (50 lm/W compared to 100-140 lm/W).

- Better guidance of light:

As Figures 1 and 2 clearly show, there is great potential for restricting light pollution through the reduction of diffused light. Strong light immissions on house walls or in the night sky (see Figure 3) are often the result of poor light guidance. An analysis of the effective surface, as shown in Figure 4, allows for a concrete planning of the light control. This is possible through appropriately positioned reflectors in the lights or targeted LEDs. Figure 5 shows a new lighting system design with greater uniformity and less diffused light.

- Spatially and temporally adapted control of light:

Fitting the street lamps with LEDs will allow for a continuous dimming of the lights, and thus an easily organised dimming of the light at times when the roads are used less. Furthermore, thanks to the use of modern motion sensors, the light can also be spatially controlled, only illuminating the necessary area in front of cars or bicycles, slowly dimming again afterwards. This technology is currently being tested in several pilot projects (among them Göttingen²) and has been positively received by the residents.

The task of the light technology department at the Technische Universität Berlin is to analyse the lighting installations and develop specifications for appropriate street lighting that meet the requirements on all sides. For example, luminance measurements of the street lamps will be carried out here for the purpose of qualitative and quantitative assessment (see Figure 6).

¹ Outdoor lighting, TRILUX GmbH, 2009

² http://www.lighting.philips.de/projects/goettingen_nonnenstieg.wpd



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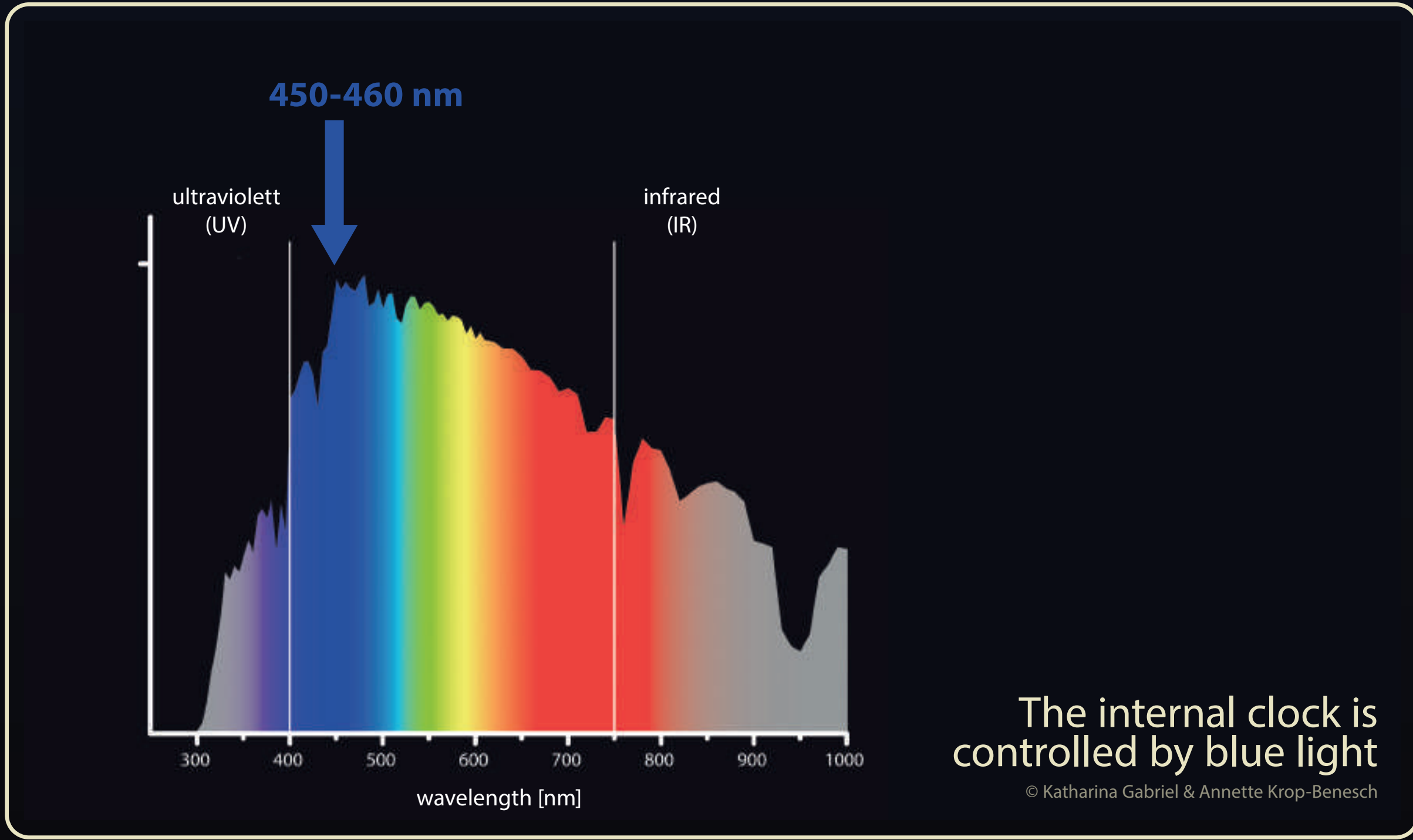
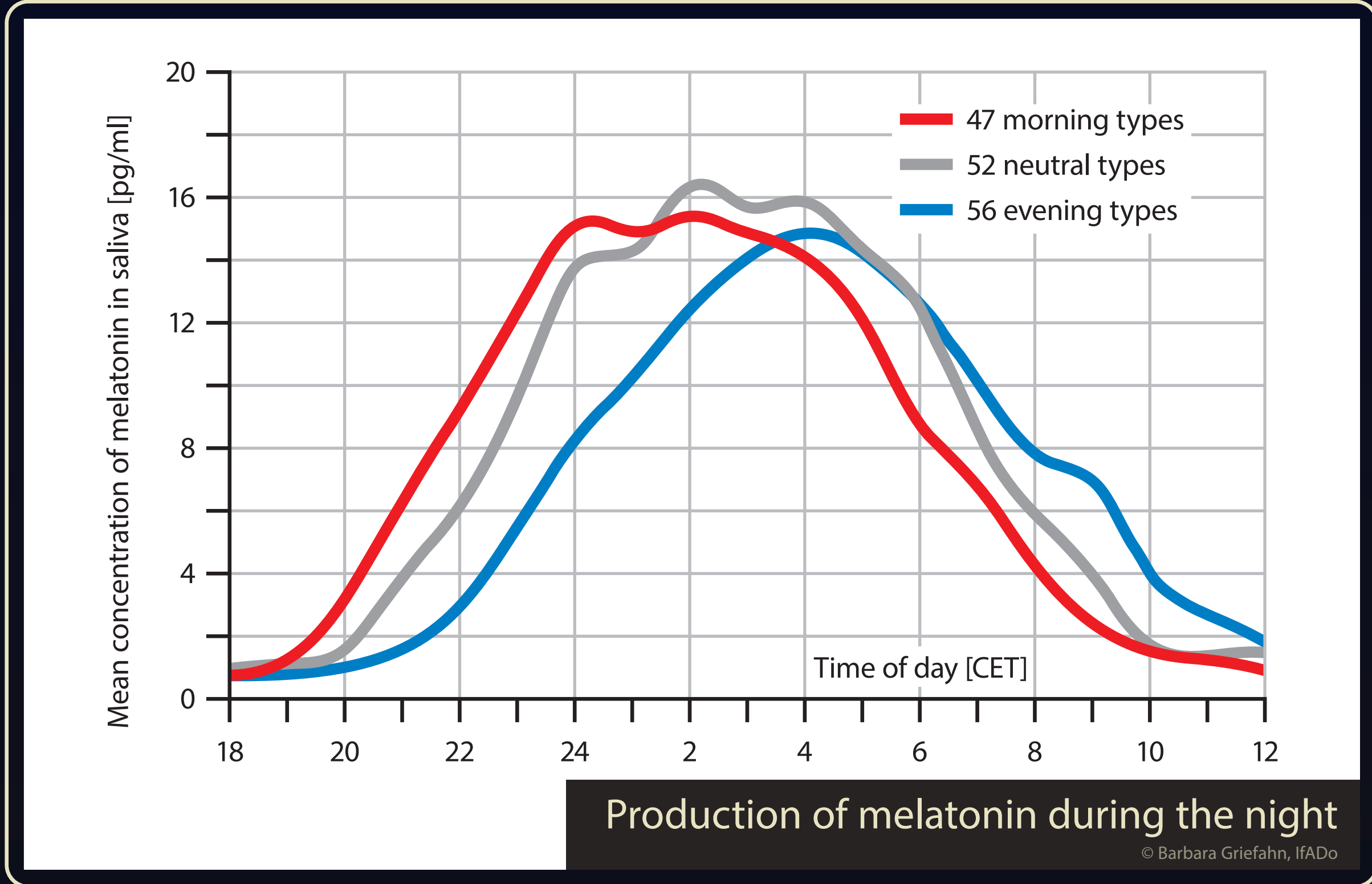
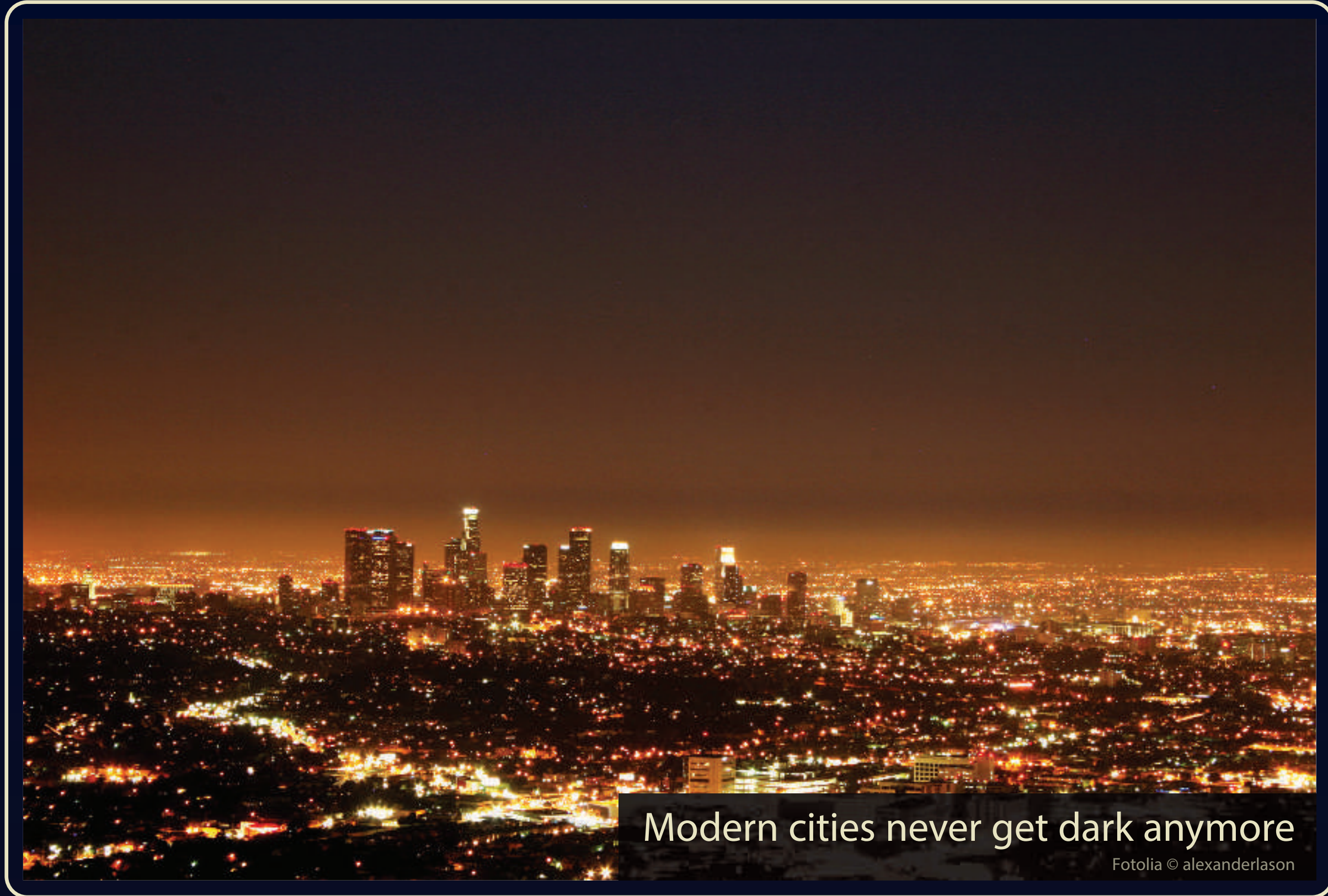
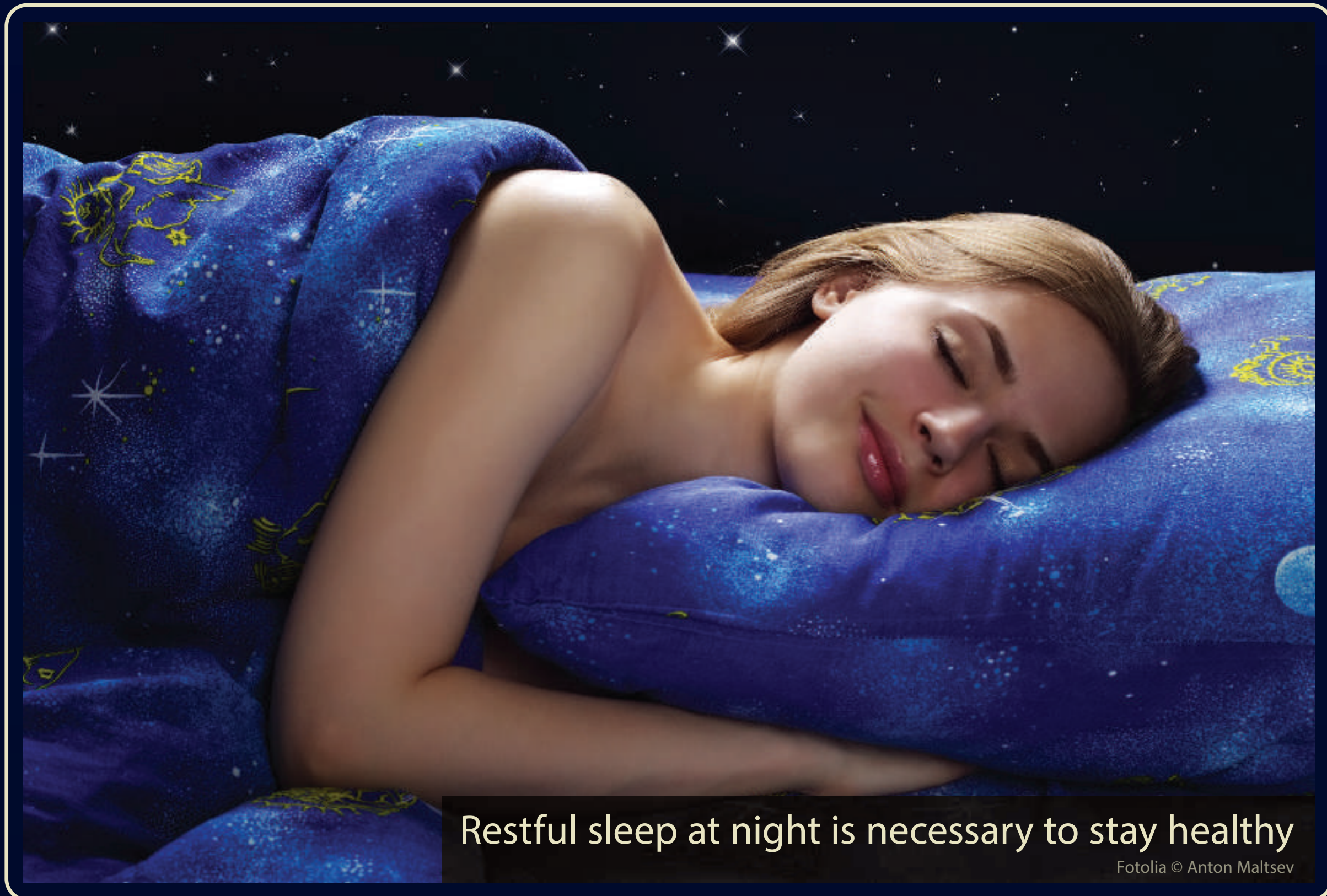
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LIGHT IS A HEALER

– BUT IT CAN ALSO MAKE YOU SICK

LOSS
of the
NIGHT



Light has an important influence on our bodies. It controls our internal clock, promotes the development of vitamin D and serotonin, and also makes us happy. Yet the signs are increasing that light, at the wrong time, can also make us sick.

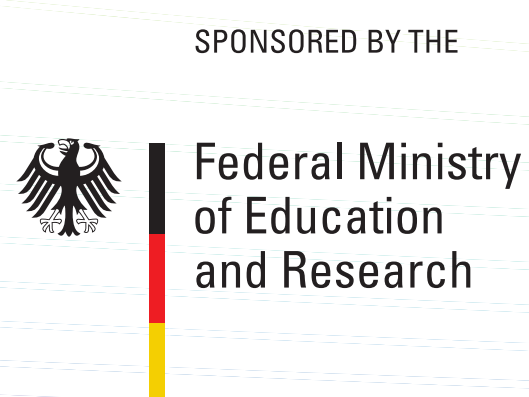
Light suppresses the production of melatonin, the hormone that controls our internal clock. Thanks to this hormone, we are active while there is light, but relax and regenerate during darkness. Many important processes take place at night. Our blood pressure is reduced to relieve the strain on our cardiovascular system while our immune system, on the other hand, works hard to fight off infections at night. Growth and regeneration processes also take place at night. And we sleep considerably better in the dark too, while our brain processes all the information of the day.

Light at the wrong time can disturb the finely adjusted system of the day-night rhythms. Studies have shown that people who are exposed to light at night, for example shift workers, are at a far greater risk of diabetes and obesity. The WHO has since identified shift work as a factor in the development of breast and prostate cancer. Far more common are sleep disturbances and depression.

Blue light in particular, such as that found in the cold light of LEDs and modern screens, influences our internal clock. If you sit in front of a computer or television until late at night, you should not be surprised to suffer from sleepless nights, as the body still thinks it is daytime due to the blue light they emit.

It is currently unknown whether light has a direct influence on these diseases or if the disturbance of the natural day-night rhythm is the cause. We know that the hormone melatonin, formed when it is dark, directly activates the immune system and works like an antioxidant against cancer cells. We are still looking for clear threshold values that will tell us from what point light is damaging to our health.

Until we achieve a better understanding of this, we should at least be aware of how we use light at night time.



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