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DAYLIGHT & ARCHITECTURE MAGAZINE BY VELLUX
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LIGHT FROM A HUMAN PERSPECTIVE





VELUX EDITORIAL

DAYLIGHT IN A HUMAN PERSPECTIVE

For more than a century, architects and lighting consultants have optimised the use of daylight in buildings to support human vision. The positive effects of natural light on human health and well-being have also been acknowledged but rarely incorporated into building codes and everyday design practice.

During the last decade, however, researchers have gained insight into previously undiscovered benefits of daylight that call for a new approach to building design: natural light is essential to human circadian regulation. A lack of daylight can severely disturb our time rhythms, causing health problems such as sleep disturbance, stress and obesity.

In modern society, we spend up to 90% of our time indoors, and much research suggests that our daily light dose is too small to keep us healthy. So sufficient provision of daylight is crucial in every building – not only for reasons of energy efficiency but for the sake of our own well-being. This insight is, however, not yet widely shared with consultants and the building industry. There are no proper guidelines for daylight and health, even though considerable research and documentation seems to exist on how the intensity, time, duration, spectrum and distribution of exposure to light affects human behaviour and physiology.

This issue of D/A explores which conditions, or combination of conditions, will promote human health and well-being indoors. It also raises the question of how the necessary bridges between daylight research and architectural design can be built, thus making a real difference to future buildings.

We present perspectives from four leading researchers and thinkers: circadian neuroscientist Russell Foster, environmental psychologist Judith Heerwagen and the architects Dean Hawkes and Brent Richards

approach daylight from a human perspective. This edition also portrays four architect offices from different parts of the world: SANAA from Japan, Will Bruder from the USA, Jarmund/Vignsnaes from Norway, and Lacaton & Vassal from France. Their buildings are as diverse as the cultures and climates for which they were designed, but at the same time, they cater for universal human needs; to be protected from a harsh climate at the same time as being in close contact with nature. A selected project from each office is documented for the daylight hours of one day.

The winners of the International VELUX Award for Students of Architecture 2010 took up the challenge to portray "The light in my room" over the daylight hours of one day. In their photo project, they considered the different qualities of light as well as many questions about the nature of light: How do we perceive light through our senses? And how does the camera capture light?

The VELUX Group strongly believes in the beneficial effects of daylight. We believe that we need more stringent requirements in building codes – and that operational methods and performance indicators need to be developed alongside useful guidelines and tools for the professionals. The fourth VELUX Daylight Symposium in the Rolex Learning Centre in May 2011 will focus specifically on the effects of daylight on building occupants, how we are affected by daylight and what the requirements are to achieve good daylight environments. We believe that building design should consider all dimensions of people's needs – and that they should be based on insight that is shared between researchers and practising architects and engineers.

Enjoy the read!

D/A

VELUX Editorial	2
Contents	4
Body Clocks, Light, Sleep and Health	6
The experience of daylight	14
Imagining Light: The measurable and the unmeasurable of daylight design	24
In search of an anthropology of daylight	42
4xArchitecture & Daylight	54
Will Bruder: "Light defines the journey of my life"	56
Sanaa: A spatial invitation to presence	70
Jarmund Wignsnaes: "We need to rediscover the economy of daylight"	82
Lacaton/Vassal: "Light is freedom"	94
IVA, International Velux Award	104
The everyday poetics of life	106

BODY CLOCKS, LIGHT, SLEEP AND HEALTH

"We live our lives in dim caves," says the neurophysiologist Russell Foster. Electric light and the emergence of the 'round-the-clock' society have increasingly isolated us from the rhythms of nature. In his article for Daylight & Architecture, Foster describes the consequences this is having for human beings.

THE EXPERIENCE OF DAYLIGHT

Why do people prefer daylight to artificial light, even though both provide enough light to see by? Environmental psychologist Judith Heerwagen investigated this matter closely and, referring to current research, came to the conclusion that this preference is due to human evolution.

IMAGINING LIGHT: THE MEASUREABLE AND THE UNMEASURABLE OF DAYLIGHT DESIGN

"A room is not a room without natural light," says the American architect Louis Kahn. In his article, Dean Hawkes examines how Kahn and other pioneering architects have worked with daylight in their buildings. Great architecture, according to Hawkes, is based on the optimal relationship of quantitative and qualitative aspects in the use of daylight.

IN SEARCH OF AN ANTHROPOLOGY OF DAYLIGHT

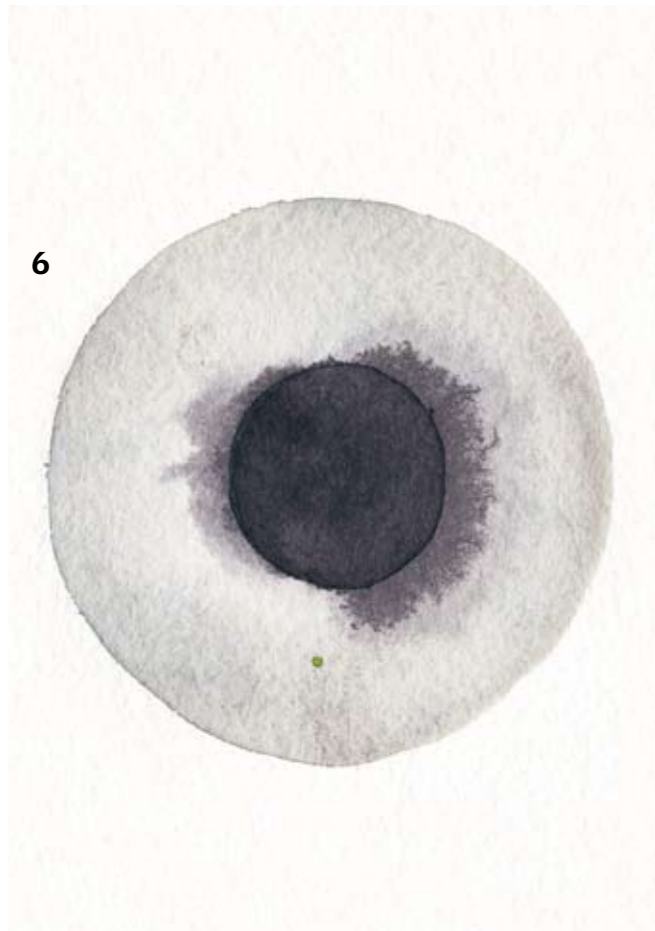
Many architects value the functional and aesthetic advantages of daylight but only know very little about its psychological effect. In his article, Brent Richards looks at how these areas of knowledge can be more closely interlinked. His conclusion: two things are necessary – the holistically thinking architect, and interdisciplinary planning teams in which specialists in different subjects inspire each other.

4x ARCHITECTURE & DAYLIGHT

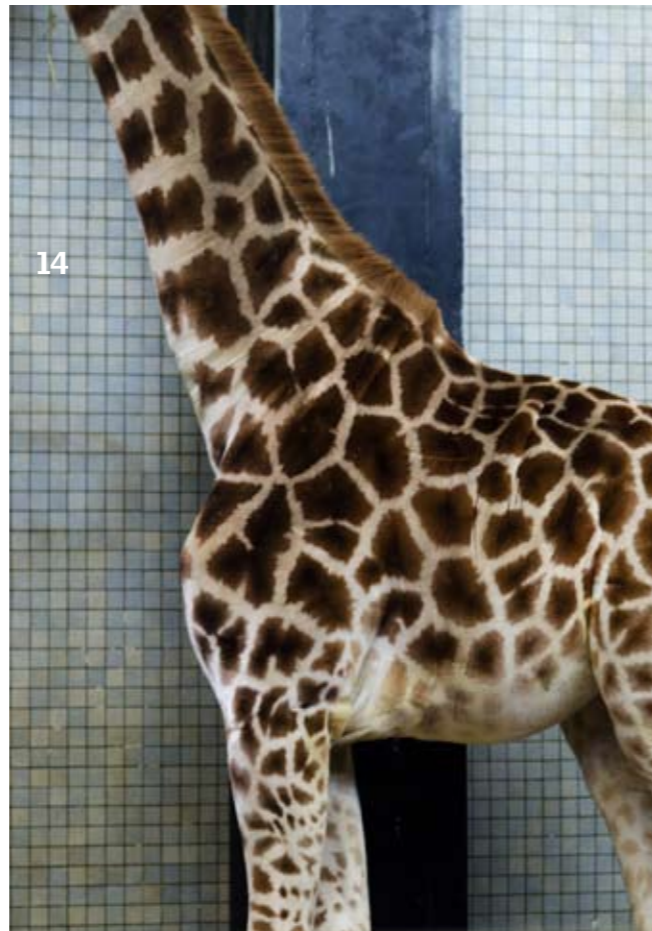
Every building has to mediate anew between a specific site with its climate and daylight, and universal human needs. How this can be done successfully is shown in Daylight & Architecture by four architects' offices from all over the world: Will Bruder from Phoenix, SANAA from Tokyo, Jarmund/Vignsnaes from Oslo and Lacaton & Vassal from Paris.

WILL BRUDER: "LIGHT DEFINES THE JOURNEY OF OUR LIVES"

The American architect Will Bruder has been living in Phoenix, Arizona, for more than 40 years. The city, the surrounding desert landscape and its light have exerted a lasting influence on his work. In an interview with Daylight & Architecture, Bruder describes how he makes use of light to ennoble even the most simple structures and materials in his buildings.



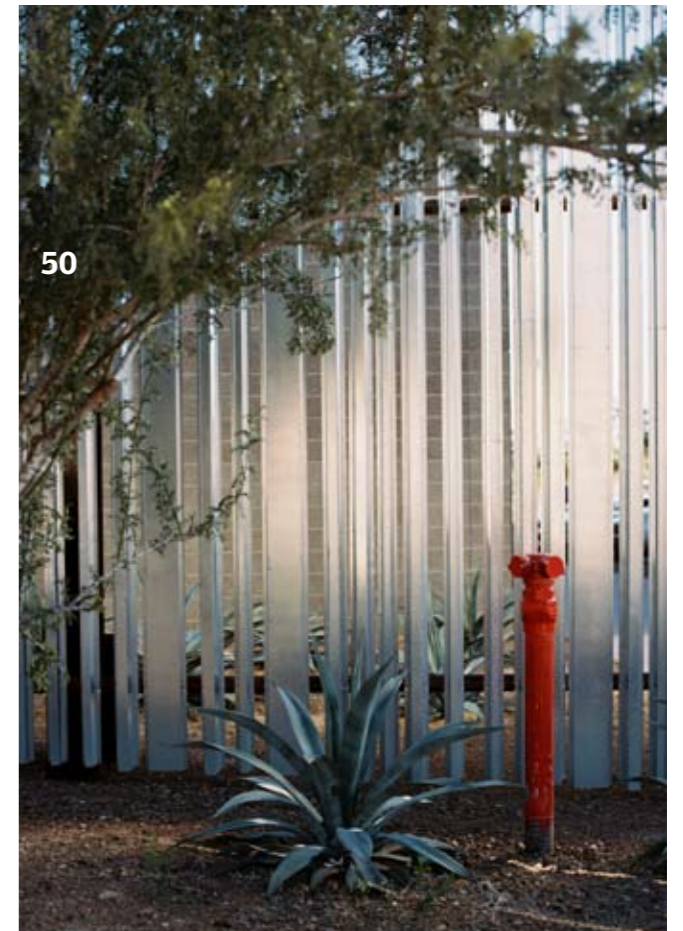
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**SANAA:
A SPATIAL
INVITATION TO
PRESENCE**

The buildings of SANAA are a product of Japanese culture and its own very special relationship to daylight, nature and technology. Per Olaf Fjeld has examined the architecture of the Pritzker prize winners for Daylight & Architecture. SANAA, he writes, not only uses daylight to create visual effects but also uses it as a means of shaping spaces.

**JARMUND/VIGSNÆS:
"WE NEED TO
REDISCOVER THE
ECONOMY OF
DAYLIGHT"**

The work of the Norwegian architects Jarmund/Vigsnæs is firmly rooted in the Norwegian culture and landscape. In an environment that is determined by stark contrasts, their buildings seek to establish a balance between sheltering and opening up, between opaqueness and transparency, and between different qualities of daylight and views.

**LACATON&VASSAL:
"LIGHT IS FREEDOM"**

Freedom, openness and economy of means are key concepts in the work of Lacaton & Vassal. In an interview, the Parisian architects, who won the Daylight & Building Component Award of the VELUX Foundation in 2011, explain why they hardly ever erect walls in their buildings – and what contemporary architects can learn from Africa.

**THE EVERYDAY
POETICS OF LIGHT**

We decide for ourselves how we live –but daylight also plays an important role in the decision. In order to get to the bottom of this phenomenon, the winners and runners-up of the International VELUX Award 2010 made a photographic record of the daylight in their homes over a period of a day.



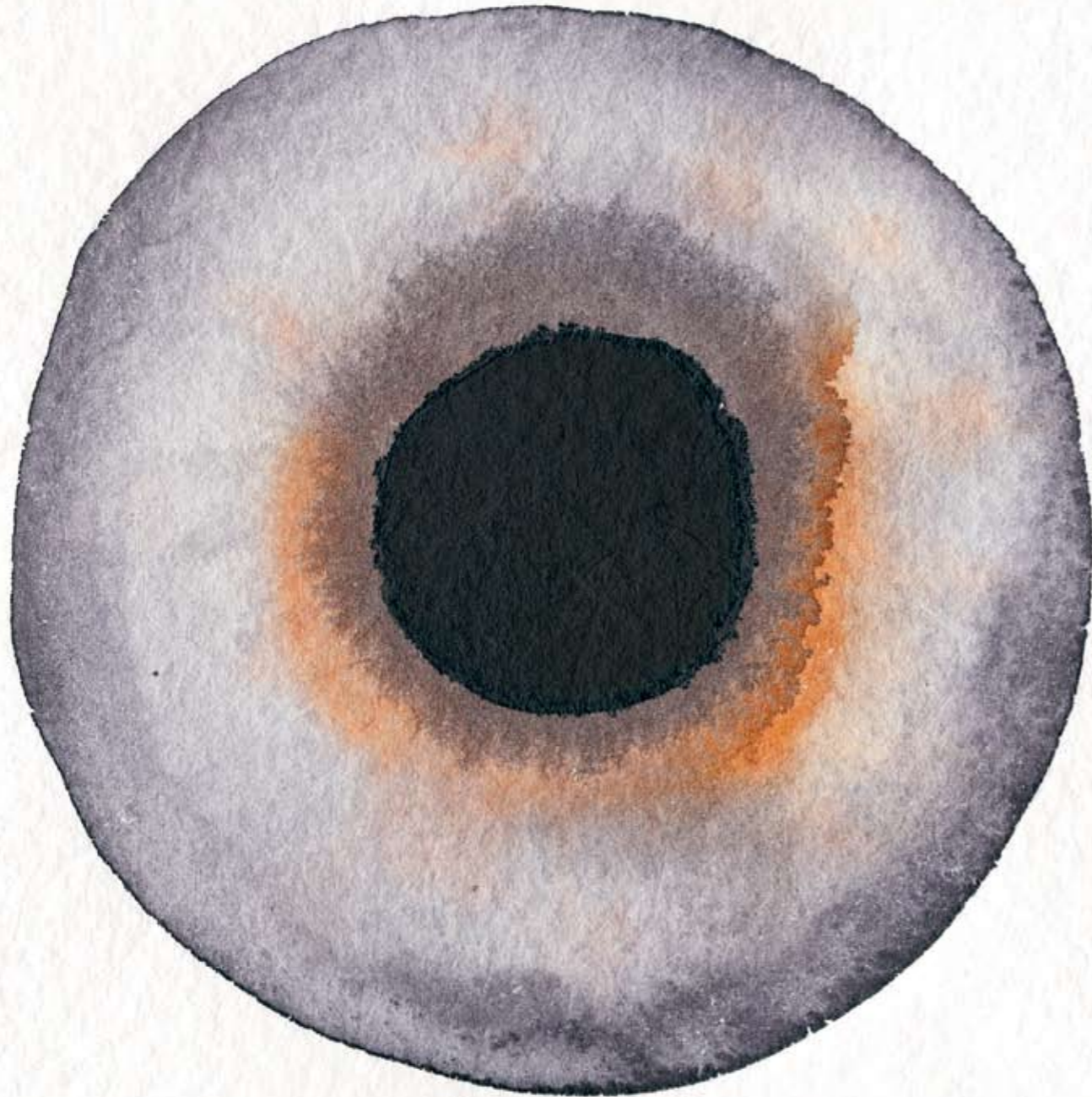
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BODY CLOCKS, LIGHT, SLEEP AND HEALTH

The eye establishes a connection to the outer world not only for our sense of sight but also for our sense of time and for many temporal processes in our body.

Over the last one and a half centuries, artificial light and the restructuring of working times have seemingly 'liberated' us from the diurnal cycles of light and dark that nature imparts on us. Yet recent research has shown that this separation from nature comes at a considerable cost, causing health and social problems. A reconnection to the rhythms of nature is therefore needed – and this will also have a profound influence on architecture.

By Russell G. Foster
Illustrations by Ulrika Nilsson Carlsson

Our lives are ruled by time and we use time to tell us what to do. But the digital alarm clock that wakes us in the morning or the wrist-watch that tells us we are late for supper are unnatural clocks. Our biology answers to a profoundly more ancient beat that probably started to tick early in the evolution of all life. Embedded within our genes, and almost all life on earth, are the instructions for a biological clock that marks the passage of approximately 24 hours. Biological clocks or 'circadian clocks' (circa about, diem a day) help time our sleep patterns, alertness, mood, physical strength, blood pressure and much more. Under normal conditions we experience a 24-hour pattern of light and dark, and our circadian clock uses this signal to align biological time to the day and night. The clock is then used to anticipate the differing demands of the 24-hour day and fine-tune physiology and behaviour in advance of the changing conditions. Body temperature drops, blood pressure decreases, cognitive performance drops and tiredness increases in anticipation of going to bed. Whilst before dawn, metabolism is geared-up in anticipation of increased activity when we wake.

Few of us appreciate this internal world, seduced by an apparent freedom to sleep, work, eat, drink, or travel when we want. But this freedom is an illusion; in reality we are not free to act independently of the biological order that the circadian clock imparts. We are unable to perform with the same efficiency throughout the 24h

day. Life has evolved on a planet that experiences profound changes in light over the 24h day and our biology anticipates these changes and needs to be exposed to the natural pattern of light and dark to function properly. Yet we detach ourselves from the environment by forcing our nights into days using electric light, and isolate ourselves in buildings that shield us from natural light. This short review considers some of the important consequences of our increasing detachment from the sun.

THE DAY WITHIN

At the base of the brain, in a structure known as the anterior hypothalamus, is a cluster of about 50,000 neurones known as the suprachiasmatic nuclei or SCN. If this region is destroyed as a result of a stroke or tumour, then 24h rhythmicity is lost and physiology becomes randomly distributed across the day. The finding that individual SCN neurones, isolated from all other cells, show near 24-hour rhythms in electrical activity demonstrated that the basic mechanisms that generate this internal day must be part of a sub-cellular molecular mechanism. To date, approximately 14–20 genes and their protein products have been linked to the generation of circadian rhythms.

At the heart of the molecular clock is a negative feedback loop that consists of the following sequence of events: the clock genes are transcribed and the messenger RNAs (mRNAs) move to the cytoplasm of

the cell and are translated into proteins; The proteins interact to form complexes and then move from the cytoplasm into the nucleus and inhibit the transcription of their own genes; the inhibitory clock protein complexes are then degraded and the core clock genes are once more free to make their mRNA and hence fresh protein. This negative feedback loop generates a near 24-hour rhythm of protein production and degradation that encodes the biological day.

The original assumption was that SCN neurones collectively drive or impose a 24h rhythm on physiology and behaviour. However, the discovery that isolated cells from almost any organ of the body produce clock genes/proteins in a circadian pattern led to a major shift in our understanding. We now appreciate that the SCN acts as a master pacemaker, coordinating the activity of all cellular clocks in a manner that has been likened to the conductor of an orchestra, regulating the timing of the multiple and varied components of the ensemble. In the absence of the SCN, the individual cellular clocks of the organ systems drift apart and coordinated circadian rhythms collapse – a state known as internal desynchronisation. Internal desynchronisation is the main reason why we feel so awful as a result of jet lag. All the different organ systems, the brain, liver, gut, muscles etc., are working at a slightly different time. Only when internal time has been re-aligned can we function normally once more.

Inner timepiece: special photoreceptors in the ganglion cells of the optic nerve synchronise our inner clock with the cycles of light and dark in our environment – and thus with local time.

OUR BODY CLOCKS ARE DIFFERENT – GENES AND HORMONES?

Our body clocks are not all the same. If you are alert in the mornings and go to bed early you are a 'lark', but if you hate mornings and want to keep going through the night, then you are an 'owl'.

These terms have been used to describe the real phenomenon of diurnal preference – the times when you prefer to sleep and when you do your best work. Diurnal preference is determined partly by our clock genes. Exciting research in recent years has shown that small changes in these genes have been linked to the fast clocks (shorter than 24h) of larks or slower clocks (longer than 24h) of owls. But it is not just our genes that regulate our diurnal preference. Sleep timing changes markedly as we age. By the time of puberty, bed times and wake times drift to later and later hours. This tendency to get up later continues until about the age of 19.5 years in women and 21 years in men. At this point there is a reversal and a drift towards earlier sleep and wake times. By the age of 55–60 we are getting up as early as we did when we were 10. These and allied results demonstrate that young adults really do have a problem getting up in the morning. Teenagers show both delayed sleep and high levels of sleep deprivation, because they are going to bed late but still having to get up early in the morning to go to school. These real biological effects have been largely ignored in terms of the time structure imposed upon teenagers at school. Of the few studies undertaken, later starting times for schools have been shown to improve alertness and the mental abilities of students during their morning lessons. Ironically, whilst young adults tend to improve their performance across the day, their older teachers show a decline in performance over the same period! The mechanisms for this change in diurnal preference remain poorly understood, but are thought to relate to the marked changes in our steroid hormones (e.g. testosterone, oestrogen, progesterone) and their rapid rise during puberty and subsequent slower decline.

LIGHT CLOCKS AND ALERTNESS

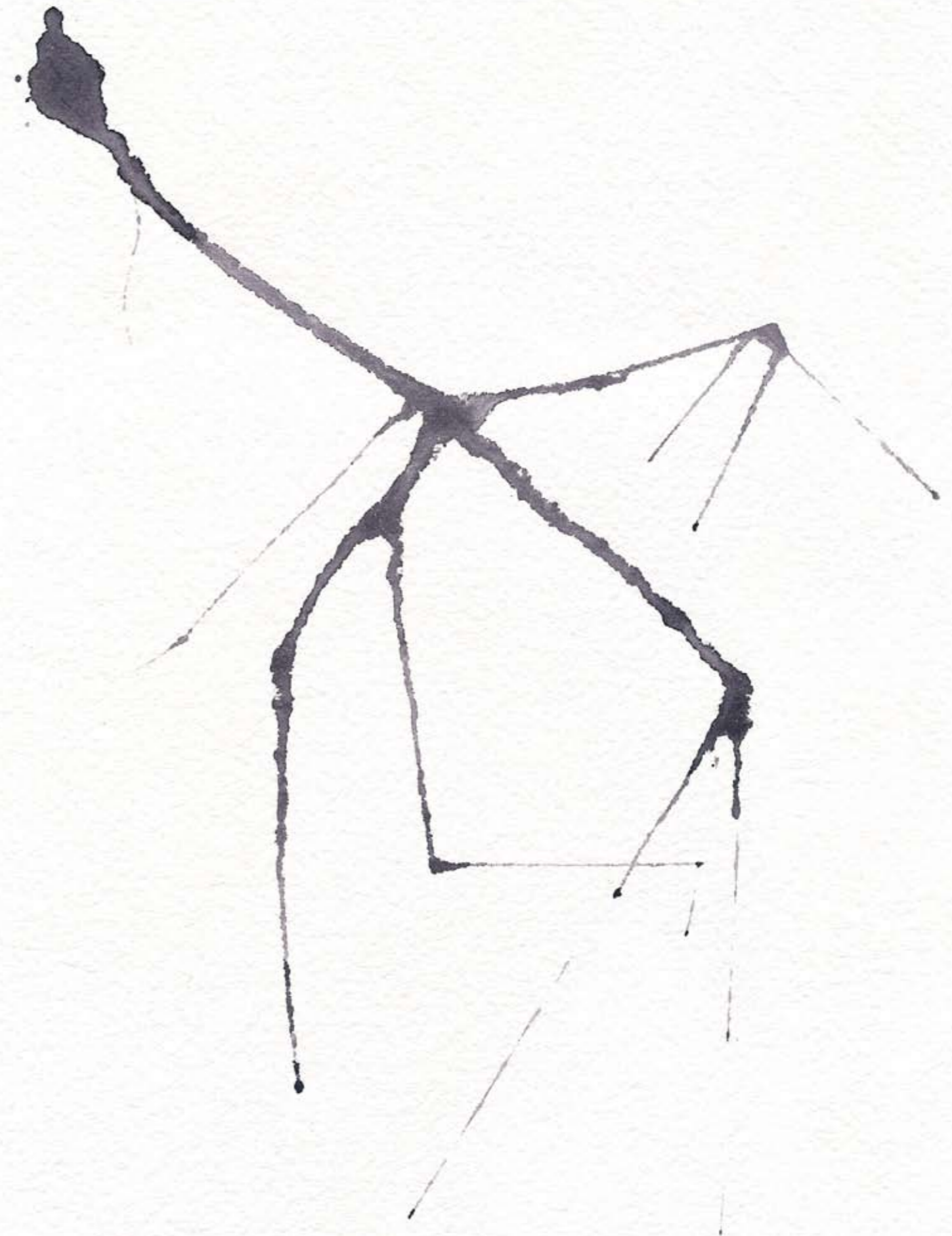
A clock is not a clock unless it can be set to local time – and the molecular clocks within the SCN are normally adjusted (entrained) by daily exposure to light around dawn and dusk detected by the eyes. Failure to expose the clock to a stable light/dark cycle results in drifting or 'free-running' circadian rhythms or disrupted cycles. Detachment from solar day is common in industrialised societies and the special case of shift workers will be discussed below; however isolation from robust dawn and dusk signals occurs in many different instances. For example, paediatric and adult intensive care units frequently utilise low and constant light. In such an environment circadian rhythms would be expected to drift and become desynchronised. The result, as discussed below in the sub-section 'Disrupting the clock', will be a weakened health status of the patient. Light does more than regulate the timing of circadian rhythms – it also has a direct effect on alertness and performance. Brain imaging following light exposure shows increased activity in many of the brain areas involved in alertness, cognition and memory (thalamus, hippocampus, brainstem) and mood (amygdala). Furthermore, increased light has been shown to improve concentration, the ability to perform cognitive tasks and to reduce sleepiness. As a result, inappropriate light exposure in a building will not only disrupt sleep and circadian timing but also levels of alertness and performance. We will return to this topic below.

Our understanding of how light regulates circadian rhythms and alertness has been advanced dramatically over the past few years with the discovery of an entirely new photoreceptor system in the eye. This novel photoreceptor is not located in the part of the eye containing the rods (night vision) and cones (day vision) that are used to generate an image of the world, but in the ganglion cells that form the optic nerve. Most ganglion cells form a functional connection between the eye and the brain, but a small number of specialised ganglion cells (1–3%) are directly light-sensitive and project to those

"Of the few studies undertaken, later starting times for schools have been shown to improve alertness and the mental abilities of students during their morning lessons. Ironically, whilst young adults tend to improve their performance across the day, their older teachers show a decline in performance over the same period!"

parts of the brain involved in the regulation of circadian rhythms, sleep, alertness, memory and mood. These photosensitive retinal ganglion cells (pRGCs) contain a light-sensitive pigment called Opn4, which is most sensitive in the blue part of the spectrum with a peak sensitivity at 480 nm – very similar to the 'blue' of a clear blue sky. This light-detection system has evolved to be anatomically and functionally independent of the visual system, and probably evolved before vision as the main way to detect light for entraining daily rhythms. Remarkably, the pRGCs can still detect light to shift the circadian clock or affect alertness even in animals or people where the rods and cones used for vision are completely destroyed and who are otherwise totally visually blind. This raises important implications for ophthalmologists who are largely unaware of this new photoreceptor system and its impact on human physiology.

In view of the colour sensitivity of Opn4, we would predict that blue light should be the most effective wavelength (colour) for shifting circadian rhythms and alerting the arousal systems. In all studies undertaken to-date, this has been shown to be the case. Blue light exposure at night is most effective at shifting the timing of the circadian clock, reducing sleepiness, improving reaction times and activating areas of the brain mediating alertness and sleep. In addition to its spectrum, light timing, duration, pattern and history all interact to influence circadian rhythms and alertness. Light timing is particularly important. Light can either





Even the colour of the sky has left its traces in our genes: the photoreceptors of our 'biological clock' react more sensitively to blue light than to any other colour.

advance (go to bed earlier) or delay (go to bed later) the circadian system depending on the timing of exposure. Under conditions of solar light exposure, light around dusk causes a delay of the clock, whereas light exposure around dawn will advance the clock. This delaying and advancing effect of light keeps the SCN locked onto to the solar day. Such differential effects of light become vitally important when trying to understand the impact of jet lag, shift work (see below), or building design on sleep/wake timing.

The pRGCs are not as sensitive to light as the rods and cones, so that short light exposure that is easily detected by the visual system is not recognised by the pRGCs. However, dim light can have an effect if it is delivered over long periods of time. Thus relatively dim indoor room light from bedside lamps and computer screens (less than 100 lux) can have measurable effects on the clock and arousal systems over several hours, and may exacerbate sleep disorders. Collectively, these effects of light – spectral composition, time of exposure and brightness – have widespread clinical and occupational applications in not only treating sleep disorders and fatigue but in the architecture of hospitals, schools, offices, retail space and domestic buildings.

DISRUPTING THE CLOCK – SHIFT WORK AND 24/7

The introduction of electricity and artificial light in the 19th century and the restructuring of work times have progressively detached us from the solar 24-hour cycles of light and dark. The consequence has been disruption of the circadian and sleep systems. Much has been written about the effects of this disruption, and in general terms the effects are clear (Table 1). Sleep and circadian rhythm disruption results in performance deficits that include increased errors, poor vigilance, poor memory, reduced mental and physical reaction times and reduced motivation. Sleep deprivation and disruption are also associated with a range of metabolic abnormalities, including the glucose/insulin axis. For example, sleep disrupted individuals take longer

to regulate blood-glucose levels and insulin can fall to levels seen in the early stages of diabetes – abnormalities that can be reversed by normal sleep. Such results have suggested that long-term sleep and circadian rhythm disruption might contribute to chronic conditions such as diabetes, obesity and hypertension. Furthermore, obesity is strongly correlated with sleep apnoea and hence additional sleep disturbance. Under these circumstances a dangerous positive feedback loop of obesity and sleep disturbance can often result.

Sleep loss and circadian rhythm disruption are most obvious in night-shift workers. More than 20% of the population of employment age work at least some of the time outside the 07:00–19:00 day.

Josephine Arendt at the University of Surrey makes the point: “Because of their rapidly changing and conflicting light-dark exposure and activity-rest behaviour, shift workers can have symptoms similar to those of jet lag. Although travellers normally adapt to the new time zone, shift-workers usually live out of phase with local time cues”. Even after 20 years of night-shift work, individuals will not normally shift their circadian rhythms in response to the demands of working at night. Despite the great variety and complexity of ‘shift systems’, none have been able to alleviate fully the circadian problems associated with shift work. Metabolism, along with alertness and performance, are still high during the day when the night-shift worker is trying to sleep and low at night when the individual is trying to work. A misaligned physiology, along with poor sleep, in night-shift workers has been associated with increased cardiovascular mortality, an eight-fold higher incidence of peptic ulcers, and a higher risk of some forms of cancer. Other problems include a greater risk of accidents, chronic fatigue, excessive sleepiness, difficulty sleeping and higher rates of substance abuse and depression. Night-shift workers are also much more likely to view their jobs as extremely stressful.

So why don't shift-workers shift their clocks? After all, if we travel across mul-

tiple time zones we do recover from jet lag and entrain to local time. The answer seems to be that the pRGCs that entrain the circadian system are fairly insensitive to light. The clock always responds to bright natural sunlight in preference to the dim artificial light commonly found in the workplace. It is not obvious but shortly after dawn, natural light is some 50 times brighter than normal office lighting (300–500 lux), and at noon natural light can be 500 to 1,000 times brighter – even in Northern Europe. Thus exposure to strong natural light on the journey to and from work, combined with low levels of light in the workplace, entrains the night-shift worker onto local time. In this way biological and social time are persistently misaligned in night-shift workers. In the absence of any natural light, however, the clock will eventually respond to man-made light. Theoretically this information could be used to develop practical countermeasures to the problems of working at night. However, most night-shift workers prefer not to be adapted to a reversed sleep-wake cycle as they like to spend their work-free time with family and friends at maximum alertness. One suggestion has been to select individuals

Table 1
Consequences of Circadian Rhythm Disruption and Shortened Sleep

Drowsiness/microsleeps/unintended sleep
Abrupt mood shifts
Increased irritability
Anxiety and depression
Weight gain
Decreased socialisation skills and sense of humour
Decreased motor performance
Decreased cognitive performance
Reduced ability to concentrate and remember
Reduced communication and decision skills
Increased risk-taking
Reduced quality, creativity and productivity
Reduced immunity to disease and viral infection
Feelings of being chilled
Reduced ability to handle complex tasks or multi-task
Increased risk of substance abuse

Long phases of human evolution took place in bright sunlight. However, this has been changing since the beginning of the industrial age – with consequences for our health and psyche that are only gradually becoming known today.

for shift work on the basis of their diurnal preference – ‘owls’ have naturally better alertness at later hours and make better night-shift workers, while ‘larks’ are usually better at adapting to early morning shifts.

There is increasing evidence of a complex and important interaction between circadian rhythm/sleep disruption and the immune system. Rats deprived of sleep readily die of septicaemia, and in humans the activity of natural killer cells can be lowered by as much as 28% after only one night without sleep. Sleep disruption also alters many other aspects of the immune system including circulating immune complexes, secondary antibody responses, and antigen uptake. Cortisol provides an important link between the immune system, sleep and psychological stress. Sleep disruption and sustained psychological stress increase cortisol levels in the blood. Indeed, one lost night of sleep can raise cortisol by nearly 50% on the following evening. High levels of cortisol act to suppress the immune system, so excessively tired people are more likely to acquire an infection. In this context, night-shift workers are at a higher risk of certain types of cancer and there has been considerable speculation as to the cause. In view of the considerable physiological stress and sleep loss associated with night-shift work, immune impairment could provide a mechanistic link with the increased risk of cancers in night-shift workers.

CONCLUSIONS AND PERSPECTIVES

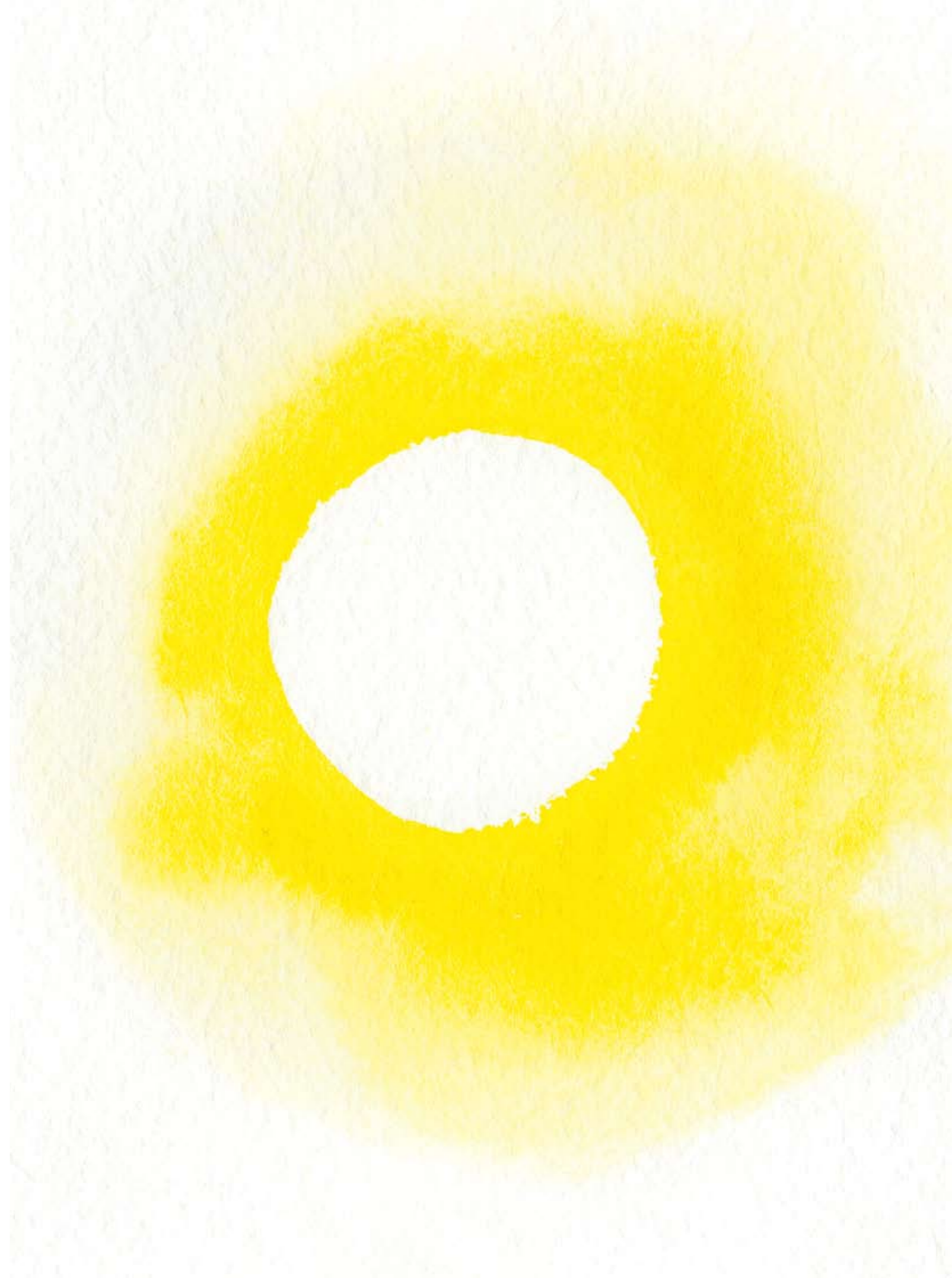
The discussion in this article has considered both the biology of internal time and some of the general problems we face if we ignore the role of sleep and circadian timing in our lives. It is now clear that poor sleep, mood changes, decreased cognitive performance, reduced communication skills and a higher risk of disease can arise from the demands of a 24/7 society. One of the consequences of this impairment of brain function is the reliance by large sections of society on day-time stimulants and night-time sedatives to replace the order normally imposed by the circadian system. Shift-work is perhaps the most

extreme example, but we should not ignore the fact that many of our children in schools, healthcare professionals in hospitals, and manufacturing and business workforces are isolated from natural light. This will not only increase their likelihood of circadian rhythm and sleep disturbance but also have a significant impact upon their cognition, mood and sense of well-being. We are a species that has evolved under bright light conditions – even on an overcast day in Europe, natural light is around 10,000 lux, and may be as high as 100,000 lux on bright sunny days. Yet we live in homes and work in offices, factories, schools and hospitals that are often isolated from natural light and where artificial light is often around 200 lux and seldom exceeds 400–500 lux. We live our lives in dim caves. Modern architectural design has the opportunity, by letting light into our lives, to liberate humanity from the gloom and allowing our bodies to use the natural pattern of light and dark to optimise our biology.

Russell Foster is Professor of Circadian Neuroscience and the Head of Department of Ophthalmology at Oxford University. Russell Foster's research spans basic and applied circadian and photoreceptor biology. For his discovery of non-rod, non-cone ocular photoreceptors, he has been awarded numerous prizes, including the Honma prize (Japan), Cogan Award (USA) and Zoological Society Scientific & Edridge-Green Medals (UK). He is co-author of *Rhythms of Life and Seasons of Life*, popular science books on biological rhythms. In 2008, he was elected as a Fellow of the Royal Society.

Further reading

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THE EXPERIENCE OF DAYLIGHT

Views towards the outside are a significant quality criterion for architectural spaces – and not only in office buildings.

A considerable body of research shows that people prefer daylit spaces to those lacking natural light. Why should this be? If there is sufficient light to see, why would people prefer one source to another? To answer this question, we need to understand the evolved relationship between humans and natural light.

By Judith Heerwagen
Photography by Gerry Johansson

IMAGINE YOU ARE on a camping trip that lasts a lifetime. You and your small band of hunter-gatherers wake up with the first light of day. You huddle around the fading embers of the camp fire, eat leftovers from the night before and discuss the day's foraging activities. By the time the sun is fully up, you head into the bush using the bright light of day to identify edible fruits and berries and to track animals. By noon, the sun is hot and you seek the shade of a tree canopy for refuge and rest. As you snack on nuts and berries, conversation is drawn to the horizon where large storm clouds have begun to gather. You're a long way from camp and are concerned about getting back. Dark clouds gather, cutting out the sun overhead but providing dramatic shafts of light in the distance. It rains hard, but briefly, as you huddle under a rock outcropping for protection. As you head back, the clouds begin to break and a rainbow lights up the sky signalling the end of the storm. You get back to camp just in time for dinner. You discuss the day's events around the campfire as the sun begins to set, lighting the sky orange and pink. Dusk brings with it a greyness that hides the details of the landscape, making it more difficult to discern what is happening beyond the campsite. Soon it is dark and everyone gathers around the fire for warmth, light and companionship before going to sleep under the soft light of the moon.

DAYLIGHT FROM AN EVOLUTIONARY PERSPECTIVE

Prior to the advent of buildings, humans lived immersed in nature. Daily activities were aided or constrained by the presence or absence of daylight and by qualities of light that signalled time and weather. Our physiological systems – especially our sleep-wake cycles – were in synch with the diurnal rhythms of daylight, as were our emotional responses to light and darkness. The strong, consistent preference for daylight in our built-up environments today suggests that evolutionary pressures are likely to be influencing our responses.

Although all our sensory systems acting together were important to survival, the visual system is our primary mode of gathering information. Thus, light must have played a powerful role in information processing and survival. In ancestral habitats, light was likely to have had several key functions that are relevant to the design and operation of built-up environments. These include:

- *Indicator of time.* Natural light changes significantly over the course of the day, providing a signal of time that has been crucial to survival throughout human history. Being in a safe place when the sun was setting was not a trivial matter for our ancestors, and it is still important to human well-being.
- *Indicator of weather.* Light also changes with weather, from the dark, ominous colour of storms to rainbows and

beams of light as clouds break up and recede. Attending to the variability in light and its relationship to changes in weather would have been highly adaptive (Orians and Heerwagen, 1992).

- *Signal of prospect and refuge.* The sense of prospect is signalled by distant brightness and refuge is signalled by shadow (Appleton, 1975, Hildebrand, 1999). Brightness in the distance aids assessment and planning because it allows for information to be perceived in sufficient time for action to be taken. High prospect environments include open views to the horizon and a luminous sky ('big sky'). A sense of refuge is provided by shadows from tree canopies, cliff overhangs, or other natural forms. Mottram (2002) suggests that allowing the eyes to rest on infinity (which the horizon represents visually) may be beneficial, even if the view is perceptually manipulated through visual images rather than actual distant views. Thus, our natural attraction to the horizon could be satisfied in many ways through the manipulation of light and imagery applied to vertical surfaces.
- *Signal of safety, warmth, and comfort.* Although we usually think of the sun as the primary source of light in the natural environment, fire also served as a source of light and comfort, both physical and psychological. Anthropologist and physician Melvin Kon-



There is an innate need in human beings to be in touch with nature. The acceptance of buildings is therefore crucially dependent on the extent to which they enable contact with external surroundings.

ner (1982) suggests that the campfire served important cognitive and social functions in developing human societies. The campfire extended the day, allowing people to focus their attention not only on the daily grind of finding food and avoiding predators but also on thinking about the future, planning ahead and cementing social relationships through story-telling and sharing the day's experiences.

- *Peripheral processing aid.* Light also provides information about what is happening beyond the immediate space one occupies. It illuminates the surrounding environment that impinges continually on our peripheral processing system. The importance of peripheral light is evident from the discomfort many people feel when they are in a lighted space with low lighting at the edges, leading to a perception of gloom. Lighting researchers suggest that negative responses to gloom may be associated with its natural function as an early warning signal that visual conditions are deteriorating (Shepherd et al, 1989).
- *Synchronisation of bio- and social rhythms.* As a diurnal species, light plays a critical role in our sleep-wake cycles and also synchronises social activities. Although we can now alter our activity cycle with the use of electric light, research evidence nonetheless shows that night work is still difficult and often results in drowsiness, difficulty sleeping, mood disturbances and increased cognitive difficulties at work (Golden et al, 2005). Some night work facilities are using bright interior light to shift biological rhythms and increase alertness. There is also evidence that people who experience seasonally-related depression prefer to be in brightly lit spaces (Heerwagen, 1990).

To summarise, light provides information for orientation, safety and surveillance, interpretation of social signals, identification of resources and awareness of haz-

ards. Whether it is the changing colour of light associated with sunset or storms, the movement of fire or lightning, the brightness in the distance that aids planning and movement, or the sparkle of light off water – all these aspects of light have played a role in helping our ancestors make decisions about where to go, how to move through the environment, what to eat, and how to avoid dangers.

HUMAN EXPERIENCE OF DAYLIGHT IN THE BUILT-UP ENVIRONMENT

Given Homo sapiens immersion in a naturally-lit environment during our evolutionary history, it is not surprising that building occupants enjoy the very features that characterise daylight in natural landscapes.

Research on office buildings shows a high preference for daylit spaces and for specific features of daylight. A study of seven office buildings in the Pacific Northwest (Heerwagen et al, 1992) shows that more than 83% of the occupants said they “very much” liked daylight and sunlight in their workspace, and valued the seasonal changes in daylight. Interestingly, daylight design generally aims to eliminate direct beam sunlight from entering work areas due to glare and heat gain.

When the data were looked at with respect to the occupant's location, 100% of those in corner offices said the amount of daylight was “just right,” as did more than 90% of those along the window wall in spaces other than the corner offices. Even those located in more interior positions were satisfied with the daylight, as long as they could look into a daylit space.

DAYLIGHT AND WORK

We know that people like to be in daylit spaces and that they like indoor sunlight. However, when occupants in the above study were asked about light for work purposes, only 20% said daylight was sufficient for work. The vast majority said they used electric ceiling light “usually” or “always” to supplement daylight.

Even those who rated daylight as “just right” also used electric lights regularly. Although the reasons for this situation are not clear, anecdotal evidence suggests

Views towards the outside are among the most important criteria for the acceptance of buildings. While providing variety within the everyday routine of life, they also help to prevent feelings of claustrophobia.

that occupants also supplement daylight with task lamps. It is possible that electric light, whether ceiling or task, reduces lighting contrasts on work surfaces that make some visual work difficult.

A post-occupancy evaluation of the first LEED Platinum building in the US, the Philip Merrill Environmental Center, shows very high satisfaction with daylight, despite concerns with visual discomfort (Heerwagen and Zagreus, 2005). This suggests that people may value the psychological benefits of daylight even when daylight creates difficulties for work due to glare and uneven light distribution.

Certainly, the kinds of visual tasks we perform in today's work environments are very different from our ancestors' daily tasks. Cooking, tool making, conversing, foraging, and hunting could be effectively carried out over a wide range of luminous conditions. In contrast, reading and computer work require a much greater degree of visual acuity that may be more difficult in some daylit environments. Yet a uniformly lit environment that may be appropriate for office work lacks the psychological, and perhaps biological, value of daylight.

ATTITUDES TOWARD DAYLIGHT AND ELECTRIC LIGHT

A study of office workers in a Seattle high-rise building asked respondents to compare the relative merits of daylight and electric light for psychological comfort, general health, visual health, work performance, jobs requiring fine observation, and office aesthetics (Heerwagen and Heerwagen, 1986).

The results show that the respondents rated daylight as better than electric light for all variables, especially for psychological comfort, health and aesthetics. They rated daylight and electric light as equally good for visual tasks.

At the time of this study in 1986, there was little evidence connecting daylight to health. Since that time, however, there has been a surge of research on the link between light and health, much of it focusing on the circadian system and seasonal affective disorder. Much of this work has been conducted in clinical settings with

phototherapy. Since a review of this topic is provided elsewhere in this issue, it will not be addressed here.

However, it is worth noting a laboratory study that investigated lighting preferences of subjects with Seasonal Affective Disorder (SAD) compared to subjects that did not experience seasonal changes in mood or other behaviours (Heerwagen, 1990). Those who experienced seasonal changes chose significantly higher levels of brightness for all lighting sources compared to those who did not. This suggests that people experiencing SAD may indeed be 'light hungry' and could benefit from indoor environments with high daylight levels, such as atria, sunrooms and locations adjacent to windows.

But what do we know about other health impacts of daylight in the built-up environment? Research in hospital settings, looking at the relationship between room daylight levels and patient outcomes, found that bi-polar patients in bright, east-facing rooms stayed in the hospital 3.7 fewer days on average than those in west-facing rooms (Benedetti and others, 2001). Similar results were found by Beauchemin and Hays (1996) for psychiatric in-patients; those in the brightest rooms stayed in the hospital 2.6 fewer days on average. However, neither of these studies provides data on the actual light levels in the patient rooms or light entering the retina, so it is difficult to draw conclusions about exposure levels.

More recent research in a Pittsburgh hospital actually measured room brightness levels. Walch and others (2005) studied 89 patients who had elective cervical and spinal surgery. Half the patients were located on the bright side of the hospital, while the other half were in a hospital wing with an adjacent building that blocked sun entering the rooms. The study team measured medication types and cost as well as psychological functioning the day after surgery and at discharge. The researchers also conducted extensive photometric measurements of light in each room, including light levels at the window, on the wall opposite the patient's bed, and at the head of the bed (which presumably would have been at or near the



Natural light at the place of work is not only a question of seeing. Surveys have shown that people place great value on daylight even when it is actually detrimental to vision.

patient's eye level). The results showed that those in the brighter rooms had 46% higher intensity of sunlight. Patients in the brightest rooms also took 22% less analgesic medicine/hr and experienced less stress and marginally less pain. This resulted in a 21% decrease in the costs of medicine for those in the brightest rooms. The mechanisms linking bright light to pain are currently unknown, however.

Other potential benefits of indoor daylight include improved sense of vitality, decreased daytime sleepiness and reduced anxiety. For example, a large-scale survey of office worker exposure to light during the winter in Sweden shows that mood and vitality were enhanced in healthy people with higher levels of exposure to bright daylight (Partonen and Lönngvist, 2000). Another study shows that a half-hour exposure to bright daylight by sitting adjacent to windows reduced afternoon sleepiness in healthy adult subjects (Kaida et al., 2006). In that study, daylight levels ranged from about 1,000 lux to over 4,000 lux, depending upon sky conditions. Kaida et al. found that daylight was almost as effective as a short nap in reducing normal post-lunchtime drowsiness and increasing alertness.

IS DAYLIGHT BIOPHILIC?

E.O. Wilson popularised the term "biophilia" in 1984 with the publication of his book, *Biophilia*. In it he describes biophilia as the human tendency to affiliate with life and life-like processes. Wilson never fully explained what he meant by "life-like processes." However, if we consider the characteristics of life, we can look at daylight as sharing some of these features. Daylight grows over the course of the day as the sun moves across the sky, it changes in colour and intensity, it provides sustenance for life, its absence at night provokes behavioural change, and the lengthening day after the long winter months evokes joy and a sense of well being.

Wilson and others describe biophilia as an evolved adaptation linked to survival. The evidence cited in this article suggests that daylight, in addition to being "life-like," has deeply-seated health and psychological benefits that may be difficult to support in electrically-lit environments. Clearly, we can design interiors with electric light that changes intensity and colour over time and that mimics other features of daylight. But will it feel the same? Can electrically-lit en-

vironments provide the same biological benefits as daylight? We don't yet know the answers to these questions, but we do know that such efforts would be more energy intensive and more costly.

The life-like and life-supporting qualities of daylight strongly suggest that daylight is a basic human need, not a resource to be used or eliminated at the whim of the building owner or designer. The presence of daylight and sunlight in buildings clearly affects our psychological and physiological experience of place. Its absence creates lifeless, bland, indifferent spaces that disconnect us from our biological heritage.

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IMAGINING LIGHT: THE MEASUREABLE AND THE UNMEASURABLE OF DAYLIGHT DESIGN

The art of daylighting involves much more than merely allowing the right amounts of natural light into a building. Acts of great architectural imagination may transform the utilitarian functions of daylighting – the measurable – into places of great beauty – the unmeasurable. To get a better understanding of these strategies, it is helpful to look at masterpieces of daylight and architecture in greater detail.

By Dean Hawkes
Photography by Gerry Johansson

“Architecture comes from the making of a room. A room is not a room without natural light.”

Louis Kahn

IN THIS DECEPTIVELY simple statement, Louis Kahn lays down a profound challenge. The implication is that light in architecture is needed not only to serve practical purposes, but is the key to the definition of architecture itself. One of the most important achievements of nineteenth- and twentieth-century applied science has been to quantify and codify human requirements in buildings. This has been particularly successful in the field of lighting design, where standards of illumination, design procedures and rules-of-thumb are to be found in many design manuals and guidebooks. Familiar rules-of-thumb include geometrical formulae, such as the ‘no-sky line’, where the depth of penetration of the visible sky is taken to indicate the limitation of the daylit area of a room. Others are expressed in simple equations in which the daylight factor in a room is related to the ratio of window area to floor area. These tools are of immense utility and place practical design on solid foundations. In recent years, they have been complemented by the development of computer-based calculation methods and simulation tools.

But there is much more to daylighting design than this and, once again, it is Louis Kahn who gets to the nub of the matter.

“I only wish that the first really worthwhile discovery of science would be that it recognised that the unmeasurable is what they’re really fighting to understand, and that the measureable is only the servant of the unmeasurable; that everything that man makes must be fundamentally unmeasurable.”

Here Kahn presents a conundrum. What is the value of quantification and codification, the measureable, if we are really seeking to understand the essence of architecture, the unmeasurable? How may we solve the puzzle?

It is a truism that architecture is a combination of art and science. This is clearly reflected in the conventional categories of architectural literature and in the curricula of schools of architecture, where the two realms all too often remain firmly separate. But this does not help us to solve Kahn’s conundrum, so where do we look?

CHRISTOPHER WREN:
GEOMETRY AND LIGHT

My solution is that, whilst aspects of art and science certainly pertain to questions of architecture, it is not possible to construct a proper understanding of its true nature by applying a simplistic equation of the form – art + science = architecture. In the search for an answer, we should turn to the evidence of buildings themselves, of works of architecture, and of the statements of architects of substance,

which, if correctly interpreted, provide deep insights into the matter. I propose a mode of architectural analysis that allows us to look directly into Kahn’s architectural unmeasurable.

In my book *The Environmental Imagination*, I made studies of works by significant architects whose work spanned the nineteenth and twentieth centuries, precisely paralleling the period when the quantification of environmental design occurred. In recent work, I have pushed back the historical time frame to explore works from the sixteenth to the eighteenth centuries. In all of this I have argued that the crucial instrument of understanding, of looking into the unmeasurable, is that of the imagination, defined by my dictionary as, ‘the faculty of forming new ideas’. To illustrate my meaning, let’s consider some buildings that demonstrate the application of imagination in the conception of daylight.

The first case is from the works of Sir Christopher Wren. He was both scientist and architect and, before his first works as an architect, he held professorships of astronomy, first in London and then in Oxford. In a forthcoming book I explore the relationship between Wren’s science and his architecture and propose that he achieved a profound reconciliation of these two fields, of the measurable and the unmeasurable. One of Wren’s greatest architectural achievements was the reconstruction of over fifty London churches, following the devastation of the



cd/m²

8000
5800
4100
3000
2100
1500
1100
800

The false-colour images in this article show the luminance distribution in the depicted spaces. Luminance (measured in candela per square metre) is an indicator for the 'brightness' of a surface and therefore an important quantitative measure of the distribution of light in a room. The human eye can adapt to wide variations in luminance: while the clear sky, on average, has a brightness of 8000 cd/m², a computer monitor only emits light with a luminance of some 50-300 cd/m².

P.26-30 In the central exhibition room of the Museo Canoviano in Possagno, Carlo Scarpa designed the windows as independent, plastic 'light bodies'. The cubic glass elements not only light up the interior but also produce directed glancing light on the walls, thus emphasising the surface structure of plaster and natural stone even more clearly. A luminance map showing the distribution of luminous intensities in the room.

Great Fire of 1666. Perhaps the greatest of these is the church of St. Stephen Walbrook (1672-1680). Here a simple rectangular plan is enclosed by a cross section that plays upon the juxtaposition of an aisled and a centralised plan. This leads to great complexity of space and light. The illumination from large windows is supplemented by arched clerestories oriented to north, south, east and west and by the lantern that surmounts the dome. Wren was fastidious in providing the practical illumination needed for acts of worship, but his intentions extended beyond the practical. As the historian Kerry Downes writes of St. Stephen;

"Wren considered geometry to be the basis of the whole world and the manifestation of its Creator; while light not only made that geometry visible, but also represented the gift of Reason, of which geometry was for him the highest expression."

In the building, the alternating patterns of light and shade, the sudden and brief illumination of the shaft of a column, that reshape the space from hour to hour and from season to season reveal that Wren's scientific understanding of light was fused with a remarkable imagination.

SOANE AND SCARPA: POETS OF DAYLIGHT

Another English architect whose work exhibits an imagination equal to that of Wren is Sir John Soane. He worked at the time when the industrial revolution was transforming the technologies of building and was greatly interested in these, but he, like Wren, was simultaneously engaged with the qualitative aspects of light in architecture.

"The 'lumière mystérieuse' so successfully practised by the French artists, is a most powerful agent in the hands of a man of genius, and its power cannot be too fully understood, nor too highly appreciated. It is, however, little attended to in our architecture, and for this obvious reason, that we do not sufficiently feel the importance of character in our buildings, to which the mode of admitting light contributes in no small degree."

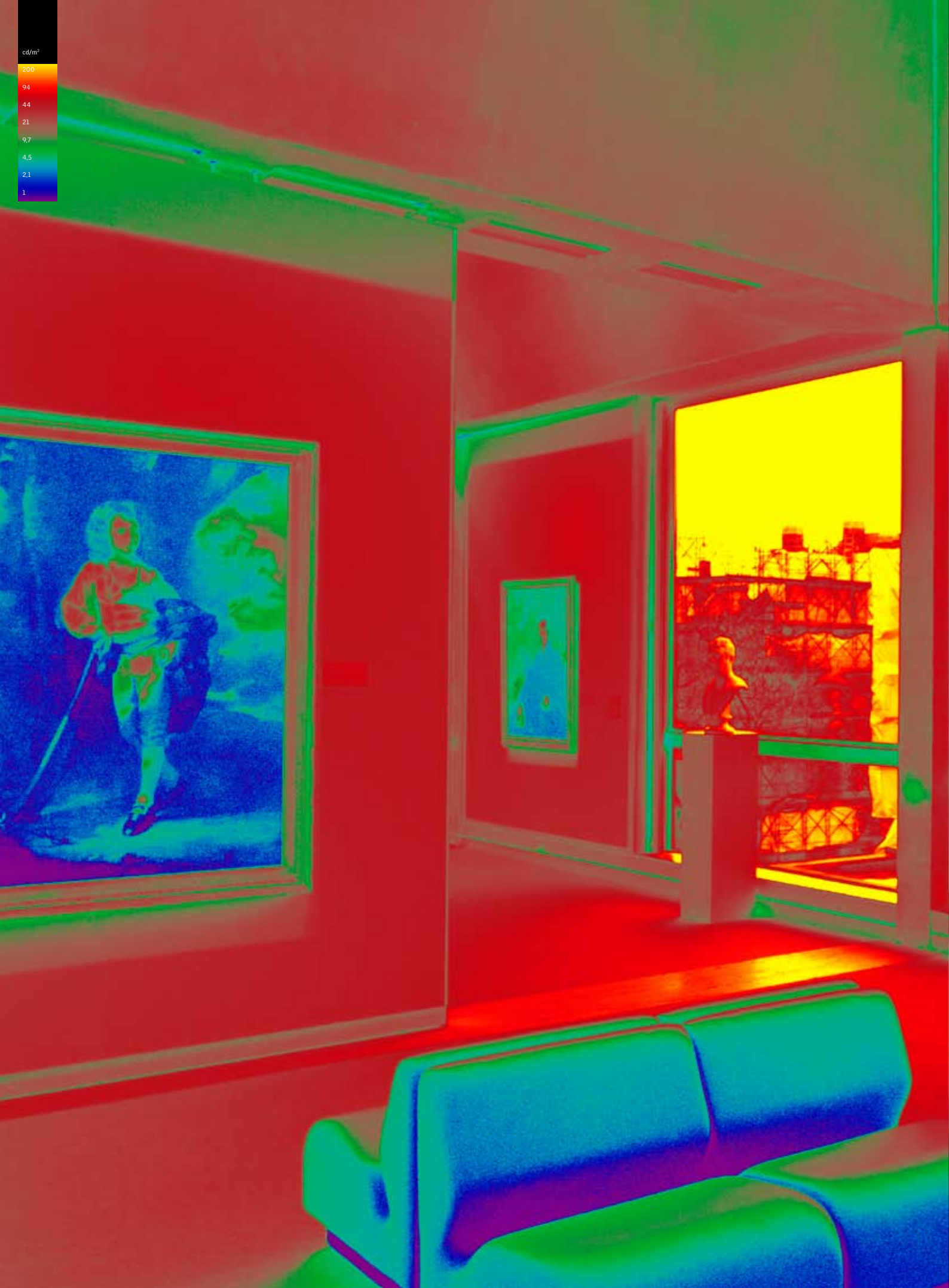
In the design of his house at 12-14 Lincoln's Inn Fields in the centre of London, which he occupied and transformed in the years from 1792 until his death in 1837, Soane seized the opportunity to explore the character of natural light to sustain both the practical and poetic needs of the act of dwelling. These were met by the richest and most diverse architectural means, combining sidelighting with rooflights simultaneously to achieve both practical and poetic ends. The library and drawing room are interconnected spaces at the ground floor of the main body of the house. The library lies behind the principal, south-facing façade and the dining room is lit from an open courtyard to the north. The walls of both rooms are a deep Pompeian red. This absorbs much of the light that enters, but ample compensation comes from the arrays of large and small mirrors that supplement and transform both the quality and quantity of the light. Some of the most significant of these are those that face the piers of the glazed loggia to the south and the sliding shutters at the windows. By these means, the rooms are simultaneously sombre and sparkling, lumière mystérieuse brought to the service of domestic life and of architecture.

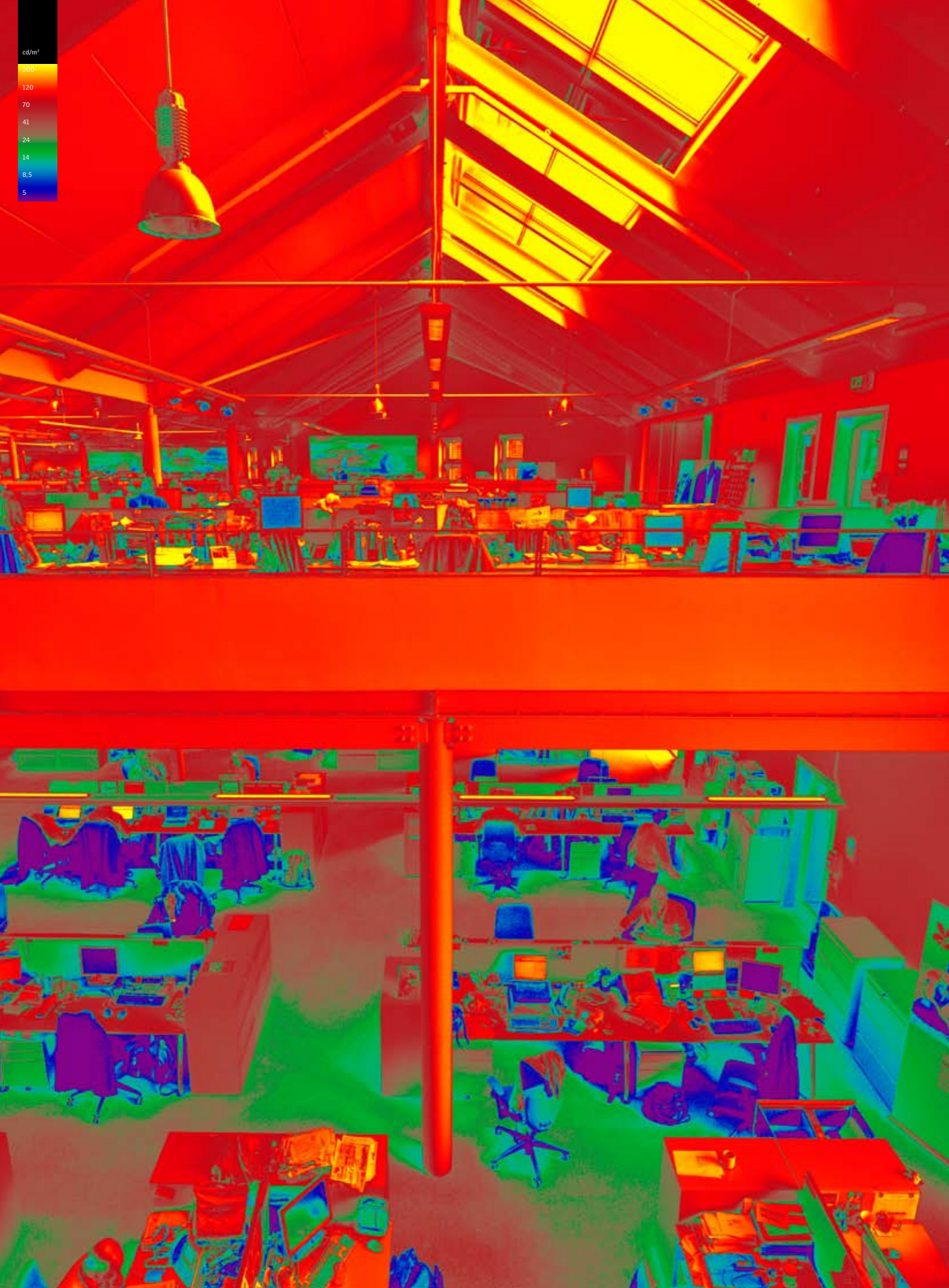
Moving to examples from the twentieth century, Boris Podrecca has written that,

"In (Carlo) Scarpa's work it is not just the physical presence of things that transfigures tradition, but also the light, which is a lumen not of tomorrow but of the past - the light of the golden background, of the glimmering liquid, of the ivory-coloured inlay, of luminous and shimmering fabrics recreated in marble. It is the light of a reflection of the world."

These qualities are fully demonstrated in the tiny addition that Scarpa built to the Museo Canoviano at Possagno in the 1950s. The composition pivots around a tall cubic space lit by four trihedral corner windows placed at the intersection of wall and roof. Two of these face west and are tall and the glazing is concave, the others are to the east and the glass enclosure is convex. This configuration captures light from all orientations and, unlike a con-







The 'Heelis' office building, which Feilden Clegg Bradley designed for the British National Trust not far from Swindon railway station, takes its inspiration from the locomotive sheds in the vicinity. The deep office areas

are illuminated almost exclusively through the roof rather than through the facades, providing views to the sky. Luminance map showing the distribution of luminous intensities in the room.

Previous spread Quadratic roof lights and large façade windows illuminate the Yale Center for British Art by Louis Kahn. They immerse the interior in a dimmed light that is typical of England – the country where most of the paintings on show here originated. A luminance map showing the distribution of luminous intensities in the room.

ventional window set in a wall, casts light across the walls themselves. As the sun moves around the building, the interior and Canova's precious and wonderful plaster figures that it contains become animated in the ever-changing illumination, presenting them to the observer almost as living beings. The corner window was an invention of the modern movement; one thinks of Wright's Prairie houses and Rietveld's Schroeder House, but Scarpa's imagination invested it with new meaning and value. Speaking about the project in 1978, Scarpa declared, "I really love daylight: I wish I could frame the blue of the sky." In this bejewelled building, he achieved that wish in full measure.

how the material of building may be fashioned to capture and project daylight in the service of the uses of his buildings. He has written,

"[One] of my favourite ideas is this: to plan the building as a pure mass of shadow then, afterwards to put in the light as if you were hollowing out the darkness, as if the light were a new mass seeping in. The second idea I like is this: to go about lighting materials and surfaces systematically and to look at the way they reflect the light. In other words, to choose the materials in the knowledge that they reflect and fit everything together on the basis of that knowledge."

BUILDINGS FOR ALL PURPOSES

As one would expect, Louis Kahn made some of the most important contributions in reconciling the practicalities and poetics of light in architecture. Any of his mature buildings would serve to demonstrate this and I have chosen the Yale Center for British Art (1969–1974). The building is an austere composition of exposed concrete frame, clad in stainless steel and lined with panels of American oak and white plaster. It was conceived to be daylight – "a room is not a room without natural light" – and the entire roof plane is covered by a system of square rooflights. The perimeter galleries also bring in side-light from carefully positioned windows. Many of the paintings in the collection were first hung in English country houses and they often depict English scenes under the light of English skies. Kahn performs a remarkable trick of architectural magic by creating the illusion of just such a setting under the very different skies of Connecticut. The layered design of the rooflights, which have external louvres and internal diffusing filters, subdues the bright light to render it appropriately subfusc as it plays on the restrained architecture of the interior. Kahn's extensive study drawings show that these effects were the product of meticulous analysis.

The translation of these ideas is wonderfully demonstrated in the Shelter for Roman Remains at Chur, completed in 1986. This deceptively simple building consists of three rooflit volumes that trace the outlines of the fragmentary remains of the Roman structure. The timber-framed structure is clad with timber lamella and the zinc-covered roof is punctured by three large rooflights. But this tectonic simplicity conceals a deep understanding of the nature and behaviour of light. The walls are opaque to vision, but nonetheless transmit light by the process of inter-reflection through the lamella. The effect is to bring a diffuse glow to the interior, the light warmed by the tone of the timber. This is then dramatised and transformed by the powerful zenithal light that cascades from the rooflights. The tall asymmetrical linings of the rooflight openings are, unusually, painted black and this starkly intensifies their light as it falls upon the pale grey gravel of the floor. All this is a clear consequence of the architect's systematic, objective consideration of the interaction between light and material. The effect is spellbinding and original.

A living master of imaginative light is Peter Zumthor. In the sequence of buildings that he has built in the last quarter of a century, he exhibits a special awareness of

The codification of the environment in buildings evolved hand-in-glove with the development of the highly engineered building types of the twentieth century. The office building is, perhaps, the most familiar and, to some extent the most successful case in which mechanical plant



Peter Zumthor's shelter for Roman remains in Chur consist of three cubic structures clad with wooden slats. Diffuse daylight trickles into the interior through the diaphanous building skin. The main light accents, however, are created by large

'light cannons' in the roof, located in the centre of each space, diagonally to the pattern of the construction.

Following pages In the church of St. Stephen Walbrook in London, Christopher Wren combined the symmetry and rigid geometry of Renaissance architecture with the metaphysics of light. Large windows in all four facades provide basic lighting, while the

clerestory windows and the lantern in the cupola cast individual rays of light that wander through the interior during the course of the day. A luminance map showing the distribution of luminous intensities in the room.

has become ubiquitous and artificial light has replaced daylight as the principal illumination. There are, however, important exceptions to this rule. One such is the Heelis Building at Swindon in southern England. This is the headquarters of the National Trust, the custodian of much of England's architectural heritage; the building, completed in 2005, is the work of architects Feilden Clegg Bradley.

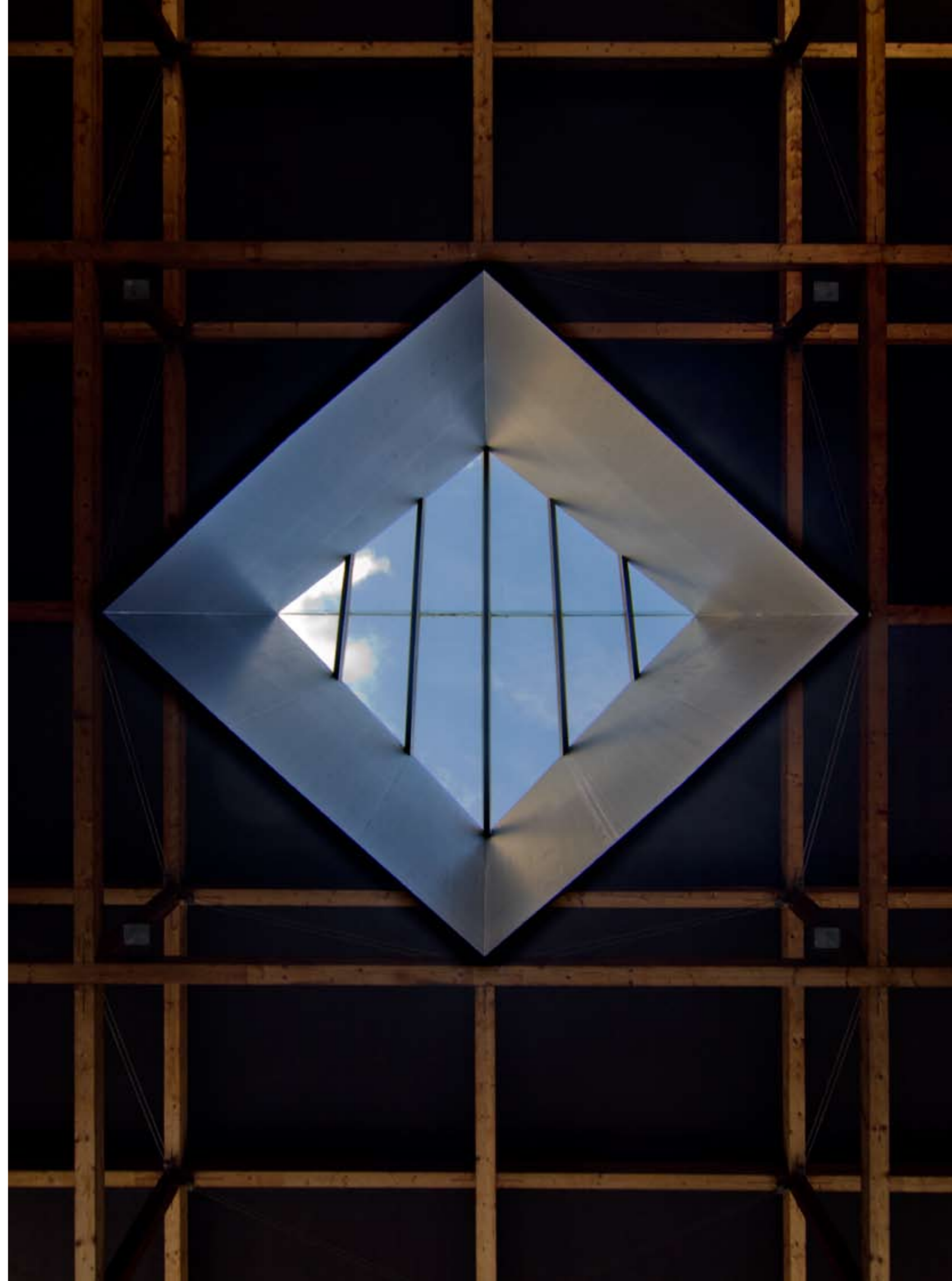
The building is on the site of former railway yards that were first developed by the great nineteenth-century engineer Isambard Kingdom Brunel. In its form it refers to the original industrial buildings. It has a deep plan covered by a series of pitched roofs that provide copious quantities of daylight and promote natural ventilation. They also support arrays of photovoltaic cells to generate valuable electricity. Beneath the roof, two-storey office wings with mezzanines alternate with double-height communal and social places. The design intention was to provide natural light to all the workplaces. The simple strategy was to ensure that every workplace has a direct view of the sky. The standard 'design sky' used in quantitative design is three times brighter at the zenith than at the horizon. This means that 'skylight' is a better source than side lighting. In addition it is a well-understood empirical fact of daylighting under the English sky that a view of the sky provides adequate illumination for most practical purposes. These principles are elegantly applied at the Heelis building, where daylight factors range from 3 per cent beneath the mezzanine floors to an average of 9 per cent on the mezzanines. In the double height spaces, the light is allowed free rein and is animated by patches of sunlight that play over surfaces and bring a dynamic connection with outside nature into the heart of this deep plan building. In its practicality and artfulness the building becomes an appropriate symbol of the National Trust's mission.

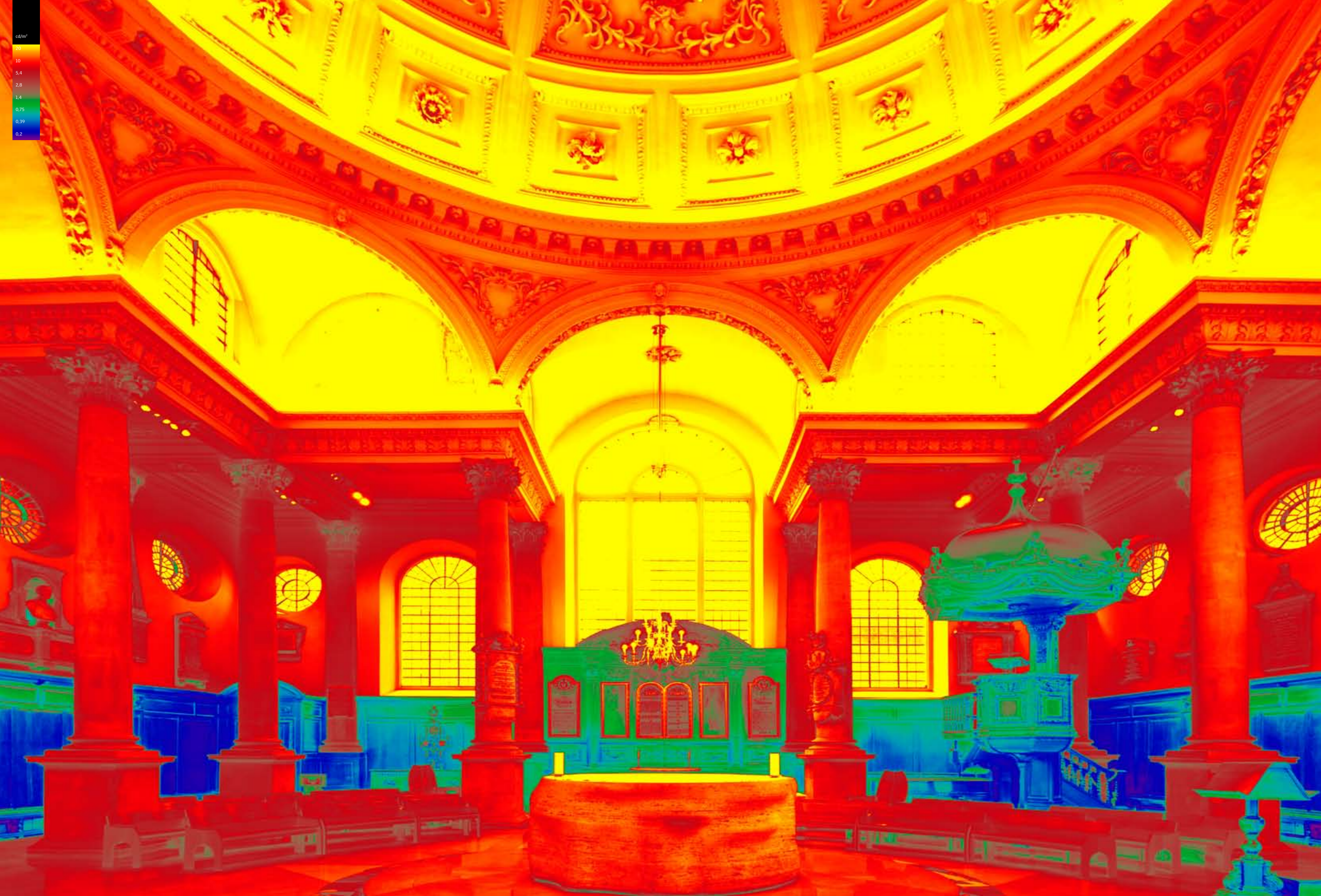
Each of these buildings addresses specific and often specialised needs, be they acts of Christian worship, dwelling in the nineteenth-century city, the display and conservation of rare neo-classical sculp-

ture, the public display of British art in America, the protection of fragile Roman remains, or the practical and social needs of corporate headquarters. In every case objective needs of shelter, protection and illumination are met, but what draws them to our attention is the manner in which the ordinary is made extraordinary by acts of architectural imagination.

However, this process is equally relevant in designing buildings that may be thought to be 'everyday'. There is almost no function in a building, institution, workplace or home, that may not be improved by taking place in a room in which quantitative adequacy is complemented by carefully conceived gradations of light and shade, an awareness of the daily and seasonal cycles of the sun or the rich interplay between light and the form and materiality of a room. These are the tools by which the imagination may help us bridge the gap between Louis Kahn's measurable and unmeasurable. It is thus that buildings may become works of architecture.

Dean Hawkes (b.1938) is an architect and teacher. He is emeritus professor of architectural design at the Welsh School of Architecture, Cardiff University and emeritus fellow of Darwin College, University of Cambridge. His books include *The Environmental Imagination* (2008) and *Architecture and Climate* (to be published in 2011). His buildings have won four RIBA Architecture Awards. In 2011, he received the RIBA's international biennial Annie Spink Award for excellence in architectural education.





cd/m²
20
10
5.4
2.8
1.4
0.75
0.39
0.2



IN SEARCH OF AN ANTHROPOLOGY OF DAYLIGHT

For centuries, architects have been working on ways of capturing the magic of daylight in buildings. They are supported in this by a continually expanding range of building materials.

In contemporary urban environments, daylight is increasingly being restricted and supplemented with artificial light, resulting in a loss of connectedness to the natural environment. If our physiological and the psychological expectations are to be met, architecture will need to develop fresh techniques in working with daylight, as well as create a closer dialogue with science, in order to achieve a true state of well-being in people.

By Brent Richards
Photography by Gerry Johansson

TOWARDS THE LIGHT

Daylight from a human perspective is governed by an intrinsic need to be in the light and not the dark, to be in the warmth of sunlight and not the cool of shadows. This need is also governed by an innate desire for physical and emotional interaction with daylight. These interactions can range from the haptic response of feeling daylight on our skin, or sensing the path of daylight from sunrise to sunset, to the perception of seeing the light of the sky above or the vista beyond.¹ Daylight not only influences the sensorial aspects in relation to our mood – it also affects our behaviour and overall sense of well-being, subject to time of day and geographical context.

Prior to man dwelling in caves, he roamed the savannah living a nomadic lifestyle in the open, reliant on daylight to find food and for safety from wild animals. Humans inhabited a natural world governed precisely by the pattern of day and night. This light and dark cycle framed the flow of daily activities and established a fundamental relationship between the

physiological and psychological rhythms of man to his habitat. In many cultures this relationship was the basis for mysticism and religious worship – and light was considered sacred.

When humans evolved to constructing early buildings, they sought to reinforce the connection with the outside world by positioning primitive openings and windows. These purpose-built apertures provided not only access to daylight and fresh air but also a symbolic interface between inside and outside. Furthermore, they attuned human dwelling habits to the daily rituals of living and to sleep-wake cycles, synchronising the rhythms of light to the twenty-four hour cycle.

Given this fundamental symbiosis between humans and daylight, the language of architecture has exploited the interplay between the built environment and the naturally-lit interior. Architecture has become adept at maximising the comfort-giving qualities of light, emphasising the visual focus and connection, whilst contributing to the sense of well-being. Architecture's objective has been to capture, enhance and articulate daylight using the building's components to filter, reflect, mediate and redirect light. In doing so, architects achieved control over the luminosity, brightness and contrast of light between outside and inside, as well as the relationship of light to interior functions. This relationship to daylight has remained a strong element throughout the history of architecture,

"The allure of daylight is that it becomes the most enduring of memories, which touches our deepest perception and emotions, and affects our notion of time and place. Light falling on the object of architecture does not tell the whole story; it creates an emergent and transient state that draws a veil over architecture's form. Notions of space, transparency, lightness and darkness, solid and void, all emanate from this memoryscape that stirs the senses and brings equilibrium to our being."

Brent Richards

"Daylight does not behave in a linear fashion, but forever plays recurrent games of days and of the seasons as the earth rotates on its axis and follows its orbit around the sun"

Ole Bouman

Modern architecture has means of bringing daylight to almost anywhere in buildings. These means, however, are not always used in such a masterly manner as in this building by Louis Kahn.

"Light is matter and light is basic material. Once you understand how light varies, and varies our perceptions, your architectural vocabulary is immediately extended, in ways that classical architecture never thought of ... an architecture of ephemerality becomes possible."

Jean Nouvel

and has continued to condition our preference for natural daylight over artificial light, irrespective of subsequent scientific innovations, greater lamp efficiency and supplementary lighting systems.

CONSTRUCTING WITH LIGHT

As human civilisation has expanded from individually dispersed buildings to the dense mega-cities of today, the challenge and demand for daylight has become more and more competitive. This trend is likely to gain greater significance as, by 2020, 70% of the world's population will live in urbanised communities. We have become perpetual urban 'cave' dwellers, becoming increasingly remote from the 'naturalness' of daylight (its sequencing, rhythm and rituals) and experiencing a loss in physical and emotional benefits.

In part, we have successfully adapted to this reduction and loss in daylight, by evolving new patterns of living and reconditioning our immediate environments. We have compensated through planning legislation (for example by restricting building heights, legislating for rights to light, and stipulating setbacks on elevations of high-rise buildings), by constructing more of our buildings with glass elevations and supplementing their interiors with the use of artificial light sources and atria. Yet despite these measures, we consistently yearn for a return to natural daylight, and we have not lost the desire for daylight to support our fundamental activities. In addition, it is becoming increasingly evident that however well controlled, uniformly lit and efficient artificially illuminated environments become, they lack the psychological and biological provisions we need and fail to generate the desired sense of well-being². We desire light not only for illumination but also for the stimulation that can only be provided by the sun and daylight.

Natural light changes and increases in intensity throughout the day, and is altered in effect by climate conditions like cloud cover and sunshine hours. Artificial light, on the other hand, is not diverse in colour and lacks many of the phenomenological qualities that are characteristic of natural light effects, due to geographical

features and proximity to water. (Consider the typical characteristics of the soft, hazy light in Venice, for example). The light artist James Turrell has described these phenomena as "the area of spatial and optical tension" – the experience of the awareness of light that is more than merely a source of brightness.³

Given our natural need for daylight, the lack of daylight in our everyday lives has led to an increasing range of health effects and unfavourable psychological conditions. Human behaviour is modulated by the day/night cycle that we can directly observe through the level of ambient light. It is also a fact that our contemporary lives are ruled by time and though we use clocks to moderate our actions, our human biology is paced by our 'circadian clock', which determines sleep patterns, alertness, mood, blood pressure and the alignment of our experience and metabolism to night and day. Setting our body clock to local time is adjusted on a daily basis by exposure to light, and a failure to engage results in a drift or 'free running' circadian rhythms, and a disruption in these cycles.⁴

Disturbances of this cycle can lead to a range of behavioural anomalies such as sleep, eating and mood disorders, and in the winter months this can lead to depression. This range of effects suggests that a specific light/dark cycle exists for humans, including temporal and spectral properties, that optimise and contribute to well-being.

The current mode of living is strongly dependent on the use of artificial light and has tended to isolate us from nature and daylight to a large extent, particularly in cities. There is therefore a contradiction between our lifestyle and the ambient cues we need to maintain a balance in our health and sense of well-being.

LIGHTNESS OF BEING

The scientific findings and everyday observations discussed above provide ample evidence that there is an innate human need for daylight, which cannot be adequately fulfilled by alternative (artificial) light sources. This raises the question of how architecture – and specifically the





Even in the era of electric light, little has changed in the basic human need to live and work in the light of the sun.

Daylight is good for us in more than just the optical sense – people also have an *emotional relationship* to the sun and their psyche and physiology are strongly affected by it. Both need to be taken into account when buildings are being designed.

design of future buildings – can be made more responsive to the interaction between humans and daylight.

Architecture has so far worked within a vacuum, disconnected from scientific understanding about the psychological and behavioural effects of daylight. Rather, it has focused on its function in terms of task relationships (overall Lux levels, task lighting etc), the aesthetic expression of light and the artistic use of daylight to communicate architecture itself. However, as we have come to realise, daylight has a more significant impact on human beings. There is an urgent need for other specialists to contribute to the activation of daylight by promoting new practices and methodologies for future architecture. Notably, the areas of environmental psychology, chronobiological and social anthropology, neuroscience and visual neuroscience are all key areas for architecture to engage with – and without delay.

However, for this transdisciplinary development to take place, the relationship between science/research and architecture/practice has to be better facilitated. These two fields have traditionally been two sides of the same coin, but contained in their separate professional silos and only meeting through the use of technology and the application of building components and products. Science asks questions and, through focused research, develops a pragmatic examination without necessarily finding answers or conclusive solutions. Architecture, on the other hand, straddling the science and the arts, is based on a trial-and-error approach and on a sequencing of responses that are iterative and proactive. Often architecture requires leaps of faith to redefine the known, and relies on creative intuition rather than scientific reasoning.

Clearly one of the main challenges is the greater promotion of 'knowledge transfer' between the worlds of scientists, daylight specialists, psychologists and neuroscientists on the one hand and the architectural profession on the other. The latter will have to become more diverse and take on the task of integrating built form, building construction and the over-

all environment into a controlled but aesthetic solution. There is little doubt that architecture could have a greater positive effect on the built environment and have a more substantial influence on human well-being in terms of rhythms, behaviour and mood. However, what is needed if this is to happen is a flow of ideas and knowledge both ways, from scientists to architects and vice versa, to allow knowledge transfer to take place every day, and for the effects of daylight to be studied in greater depth. So far, it seems that we have hardly begun to scratch the surface of the non-visual effects of light on the body and cognitive system. This is exciting and significant new territory to be explored and exploited.

All these considerations have major implications for architects and lighting designers. The first is that lighting in buildings can no longer be considered solely in terms of its effects on the built form and on space, i.e. its visual effects. The non-visual effects are just as real – and just as essential. In addition, the spectral effects have to be taken into account. Light is not only a source of natural energy in the physical sense, but its duration, intensity and spectral composition have a decisive influence on the circadian system, which has evolved alongside our human visual system for thousands of years. Artificial light, however well-conceived (and to be naturalistic it has to be designed as natural white light) has only been available for a short time and has not therefore had the same impact on our physiology.

The second consideration is that architecture cannot be designed on general principles or non-specific locations, but rather has to be designed with very specific coordinates in mind. Buildings have to be related not only to orientation but also to latitude, in order to optimise exposure to light, to the number of sunlight hours in their specific location, to the proximity of natural features like woodlands, lakes and the sea, and openness of the site.

Thirdly, as architects we should be prioritising highly-lit spaces in buildings, such as sun seats in bay windows and sun





Even in introverted buildings, daylight can establish an important link to nature. Its variability and continuous changes have a positive connotation in human perception and are very difficult to emulate with artificial light.

shafts in deeper spaces, and integrating greater exposure to daylight, particularly in dwelling/living spaces to significantly increase levels of daylight.

A FUTURE VISION

Architecture's connectedness to light has always been both physical and aesthetic. Architects have used daylight to accentuate and focus on the articulation of architectural language, or to dematerialise the building elements to counteract materiality and promote spatiality, as a poetic intersection between place and space making.⁵

Modern architecture has been preoccupied with capturing the physical properties of daylight and liberating light and space. Using glass as the basic building material, the architects of Modernism addressed the notion of connectedness. This can be seen in works such as Bruno Taut's Glass pavilion at the Werkbund exhibition in Cologne (1914), Mies van der Rohe's Tugendhat House in Brno (1928), his German Pavilion in Barcelona (1929) and Pierre Chareau's Maison de Verre in Paris (1931). Other well-known examples are Le Corbusier's Villa Savoye in Poissy (1931) and Mies van der Rohe's Farnsworth House in Illinois (1946). These architects successfully explored daylight in terms of reflections, transparency, translucency and luminosity, and worked empirically towards a 'dematerialisation' of architecture to reach a sublime space.

In the second half of the twentieth century, a range of internationally acclaimed architects such as Rafael Moneo, Toyo Ito, Stephen Holl, Peter Zumthor, Herzog & de Meuron, Erick van Egeraat, SANAA and John Pawson extended this preoccupation with dematerialising space by focusing on the phenomenology experience of daylight itself, seeking to capture a metaphysical response to architecture.

So far, architects' concern for daylight has been driven by a need to control the indoor climate, to maintain comfort, and to penetrate the shell of the interior space to admit light. The primary interface and filter for daylight, has been the window. Glass permitted the window to fuse into the architectonic form, to provide encl-

sure, to control indoor temperature and to transmit and celebrate the qualities and benefits of daylight. Glass has also been the measure of how individual architects have related their architectural vision to the well-being and comfort of users and inhabitants.

In contemporary terms, the windows have now become the building, and glass the interface for future engagement between daylight and living, between the physical and the psychological, between comfort and well-being. Building on the legacy of Frank Lloyd Wright and Mies van der Rohe to present day Peter Zumthor, we are now seeing a new era of humane and sustainable architecture. This era speaks of the architect as a professional polymath, capable of embracing complexity and change; and as a humanitarian who is concerned with the value of daylight as a life-giving substance.

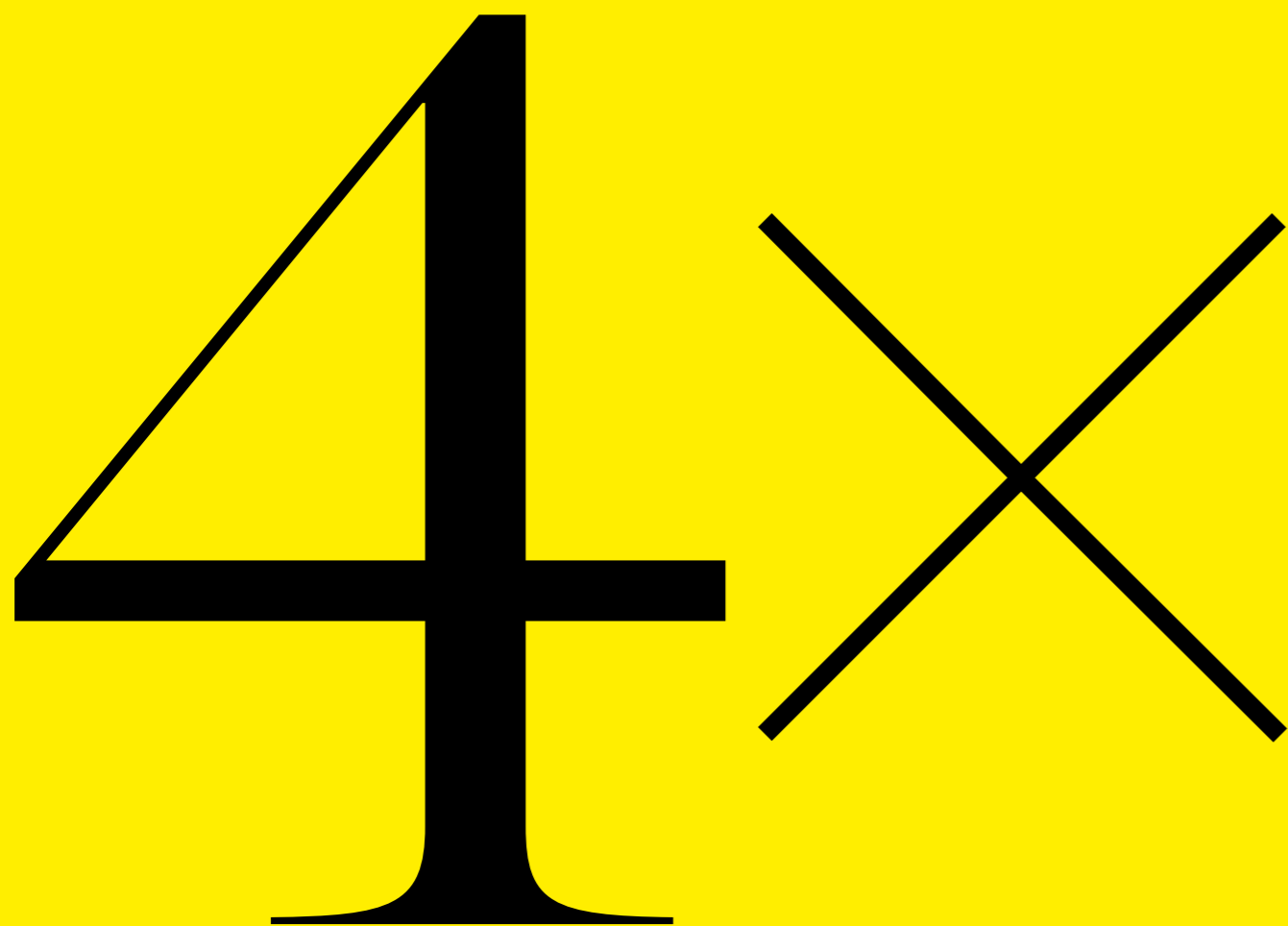
We now need to initiate advanced research into a new field that we might call the 'anthropology of daylight', or the 'culture of transparency' in all buildings, and to seize the opportunity to enjoy a greater sense of well-being. But in doing so, we must also recognise that this task cannot be left to architects alone. We need teams of specialists to contribute and expand our knowledge and develop new methodologies and carry out live rather than laboratory experiments. It is time to conceive of buildings that totally embrace daylight for its power and energy, for its visual delight and beauty, and for its healthy environmental effects.

After all, daylight is freely available and, as far as we can judge, timeless, and the only truly sustainable way to live in the future.

Brent Richards is an architect, designer, academic, and polymath. He is currently CEO of The Design Embassy Europe, a transdisciplinary creative consultancy in London that focuses on architecture, spatial design and experiential environments. Brent is also Principal – Europe & Scandinavia, of Transpolis Global – Urban Designers and Architects. He has conducted pioneering work on the advanced use of glass technology, for which he was awarded the International Benedictus Award (USA) in 1995 by Du Pont and the American Institute of Architects (AIA).

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ARCHI- TEC- TURE & DAY- LIGHT

Every building has to mediate a new between a specific site with its climate and daylight, and universal human needs. How this can be done successfully is shown on the following pages by four architects' offices from all over the world: Will Bruder from Phoenix, SANAA from Tokyo, Jarmund/Vignæs from Oslo and Lacaton & Vassal from Paris.

The be-all and end-all of design – especially when it comes to working with daylight – is always the human being. Why this is so is illustrated succinctly by the photographs by Thekla Ehling, which visualise the buildings of the four architects in their interaction with the user. The multi-faceted manifestations of life that are apparent in the illustrations are impossible to foresee during the design process. However, architects can give space to them in their buildings and thus ensure that they exert a really sustained effect on people and the environment.

"Your eye is drawn up along the surface of the building, towards the line where it kisses the sky. And that line tells you everything. [...] Our best buildings are the ones that form a perfect dialogue between shadow and light, and between the earth and the sky."

Will Bruder

"We wanted the ceiling surfaces in the building to be completely undisturbed. The ceiling changes constantly with the changes in daylight."

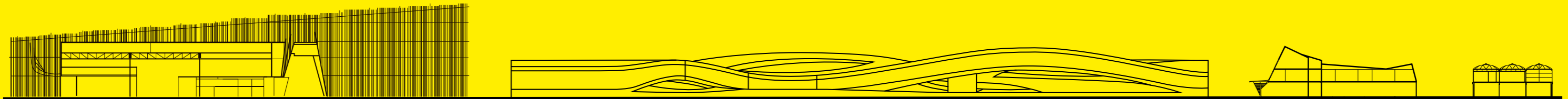
Sanaa

"Mind you, light is something that there is not too much of in Norway, especially in winter. Also, the light often comes in at low angles and it is quite an architectural challenge to bring this light into buildings."

Håkon Wignsnes
Jarmund/Wignsnes

"Daylight relates to lightness, to feeling the climate, to being very close to your environment. We always try to use the building elements that will allow us to maximise the amount of daylight in a building."

Anne Lacaton
Lacaton&Vassal



Will Bruder
Agave Library, Phoenix

A narrow budget and a muddled urban context were the starting points for this library building in a suburb of Phoenix. Will Bruder designed an open hall that is made of bare, industrially manufactured materials and that acquires its unique character primarily through daylight and relatedness to the adjoining desert garden.

SANAA
Rolex Learning Center, Lausanne

Library, auditorium, workplace, cafeteria – the Rolex Learning Center of the Ecole Polytechnique Fédérale de Lausanne (EPFL) is many things combined. All these functions are gathered together in a single space 166 × 121 metres in size that the architects have turned into an adventure landscape with inner courtyards, hills and valleys.

Jarmund/Wignsnes
Turtagrø Hotel, Sognefjellet

The hotel is located in the cradle of Norwegian alpinism and replaces a building that was burned down in 2001. The roof silhouette of the building, which is half house, half tower, imitates the shapes of the surrounding mountain range. Recessed deeply into the building, the large windows symbolise closed-off security and an openness to the outside world – two extremes that Jarmund/Wignsnes attempt to reconcile in all their designs.

Lacaton & Vassal
Low-income housing complex, Mulhouse

Providing a great deal of space and light with a limited budget – this is the goal pursued by Lacaton & Vassal in all their projects. Their building complex in Mulhouse combines 14 single-family houses, whose upper floors consist of greenhouses made of steel and polycarbonate. Living room, dining room, bedroom and garage are each part of a spatial continuum that stretches out over two floors and over the entire approximately 18-metre depth of the complex.

WILL BRUDER





“LIGHT DEFINES THE JOURNEY OF OUR LIVES”

For the last 40 years, the American architect Will Bruder has been living and working in Phoenix, Arizona. His architecture is a reflection of the surrounding desert landscape, its shapes and colours, and its daylight. In a conversation with Daylight & Architecture, Will Bruder explains how daylight connects people – to each other, to their surroundings, to nature, to time and to the universe.

Interview with Will Bruder
Photography by Thekla Ehling

Will Bruder, it is now 6 a.m. in Phoenix, Arizona, where you live and work. Is early morning your favourite time of day?

Yes, it is. I usually get up around 5:00 a.m. because I like to see the first light and the sun rise. I am energised by the light, and the time around sunrise is my best and most creative time of the day. However, as we are currently approaching the shortest day of the year, the sun has not risen yet – it will be more than an hour until it does.

Is there such a thing as an architecture for the dark seasons of the year?

I first saw Alvar Aalto's work, back in the early '90s, during a few days in February. I realised then that Aalto's architecture is as much about the light of day as it is about the absence of light in the Scandinavian winter darkness. In this extended dusk, these buildings become not only 'lanterns' to the communities that they serve, but also 'sky catchers' to amplify the little light that is there during the cusp of no light. It was very informative: everyone talks about Alvar Aalto's architecture in the summer, but being there in the winter reminded me a lot about the subtleties of the light and the dark – the greys in between.

You built most of your buildings in Arizona, a landscape that is very different from the one Aalto worked in. What makes this landscape and the daylight that belongs to it so special?

The landscape here in Arizona is very much defined by its edge. It is a desert, yet it is very lush and has a lot of vegetation. Therefore the air is so clear that you can always see the horizon, even if it is 70 miles or further away. This is even true of the city of Phoenix, where I live and work at my studio. Moreover, the colour of the light and the shadows on the surrounding mountains always tell me what time of the day it is.

What gives the desert light around you its clarity?

Due to the vegetation, there is relatively little particulate matter in the air. This is very different from other desert places, such as in the large cities of the Arabian Peninsula, where your field of vision often ends at the edge of the city. On the other hand, there is enough particulate matter in the air to substantially soften the light. This is due to our relatively low altitude. Further up in the atmosphere, in more mountainous places, the air is much clearer and the light becomes very strident, almost crystalline.

Sun angles also dramatically influence the light quality in Arizona. Due to our low latitude, there are about four months in summer where sunlight will graze the north face of a building. All of these factors have a great influence on our architecture. In the desert, light is as powerful a material as anything that you can work with as an architect.

“The air is so clear that you can always see the horizon, even if it is 70 miles or further away. This is even true of the city of Phoenix, where I live and work at my studio. Moreover, the colour of the light and the shadows on the surrounding mountains always tell me what time of the day it is.”

Previous spread Almost the entire southern facade of the library opens onto the adjacent desert garden on the level of the ground floor. Slender steel columns hold the solid brickwork wall that makes up the upper part of the facade.

Right Will Bruder compares the library with an 'open book' in which architecture can be read and understood. Nearly all elements of the interior, including the in-house technical equipment, are visible; hardly anything has been pannelled over..

"When you build in a place of light, you cannot disguise any defect or any imperfection of the construction. All qualities – good and bad, the truth of the wall – are revealed by the power of the light."

How do your buildings react to the light of Arizona?

I had an early experience with the light here that left a lasting impression on me. Having grown up in Milwaukee, Wisconsin, I first came to the Arizona desert as a young man, in my early 20s, to work with Paolo Soleri in his Cosanti Studios. Later in my apprenticeship, I worked on a small gymnasium for a school – a very simple building constructed essentially of masonry blocks. It was not part of the programme to bring daylight into the building. Yet one day, I walked into the half-finished building when the walls were already up and the precast concrete T slabs of the roof were in place. It was solar noon, and the light was coming right from above. Since there was no insulation or roofing on the building yet, there was a slight gap – maybe half an inch – between the roof slabs and the masonry walls. Through this gap the daylight entered, bleeding all the way down the wall to the ground, and showing every nuance of the texture of the blockwork. I realised that with this simple structure, a 'temple' had been created. It was the most amazing room I could have dreamt of having made.

Just one week later, I came back to the construction site. By then the roof was on, and the 'temple' had been darkened forever. But I kept the memory of this experience alive until, several decades later, I started designing the Phoenix Central Library and had the chance of re-creating the 'temple'. The effect created through the use of daylight is virtually the same here – by intention, not accident. Precast concrete wall panels each eight feet wide and almost without textural imperfections, flank the large reading room. Here there is an intentional six-inch gap between the roof and these walls. In normal light, the walls look perfectly smooth and flat. At solar noon, however, when the sun passes over the building and bathes the walls in light, every imperfection is revealed and transformed into a beautiful landscape 'painting'. The walls become the most interesting irregular surfaces in the path of the light that tracks across them. Yet when the sun passes, the walls

look perfect again. This taught me that when you build in a place of light, you cannot disguise any defect or any imperfection of the construction. All qualities – good and bad, the truth of the wall – are revealed by the power of the light.

Some fifteen years after Phoenix Central Library, you recently completed the new Agave Library, which is also documented in the photographs on these pages. What ideas about daylight, material and space guided you in the design of this building?
Like Phoenix Central Library, the Agave Library combines a simple, pragmatic solution with the poetry of light. There are three primary architectural elements that determine this building. The first is the urbanistic idea of a large scrim that is both sculptural and structural and gives the library an important civic presence. It functions like the 'false front' of an Old West building, making the library more visible behind the suburban strip buildings adjacent to the site.

The scrim was also inspired by the legacy of the drive-in theatres that stood as huge canvases in the middle of the natural landscape of rural America. It is made of sections of galvanized metal channels mounted on a warping cantilevered steel frame.

On the scrim, the word 'Agave' is written in huge letters, with the same reflective plastic film that is commonly used for freeway signs. Whenever the light hits the scrim at certain angles, passers-by are able to read the name of the building. And not only then. There have been days when I have flown in to Phoenix early in the morning or late in the afternoon, and was able to read the word 'Agave' looking out of the plane window, from an altitude of five thousand feet. That was a pretty powerful experience.

The second basic design element is the building itself, and the desert garden on its south side to which it is closely connected. The library building is a simple masonry volume that achieves its architectural expression through very rigorous articulation of concrete block masonry units and daylight apertures. For the exterior walls, we used aggre-





On the inside, Will Bruder combined two important sources of daylight: circular skylights for the diffuse basic lighting and vertical wall slits in the southern facade in order to project sharply contoured 'light beams' onto the floor.

gate blocks in a slightly greenish colour, to blend in with the landscape. However these blocks are not laid in a traditionally coursed manner, but post-tensioned with steel rods. This allowed us to go beyond the idea of a traditional, flat wall. On the north side, facing the car park, we introduced vertical slots in the wall at pedestrian level, and 'wobbled' entire sections of blocks out of the plane of the wall to create an almost Mondrian-like pattern of surfaces and (shadow) lines on the façade.

The south front of the building is the exact inverse. Here, a massive block wall appears to float on glass. The façade is entirely glazed at pedestrian level, with only slender steel columns holding up the pre-tensioned blockwork above. You thus enter the building through its closed north facade, only to find that it opens up in total transparency to the unexpected joy of the garden on its south side. The apertures in the wall above are all about selectively sculpting the light to enter the building, and about capturing this amazing overall panorama of spaciousness towards the garden. The garden becomes one with the library.

The third design idea is about the interior of the building, which is essentially one continuous space that all revolves around an elliptical white service desk, and a suspended sky lit sculpture at its centre. Agave Library is rather unique in America in that it has only one point of service, which is visible from all parts of the building and from which one can see all the different areas at once.

In the interior, as on the facades, the library presents itself as a simple, industrial 'box' with exposed masonry and framing. The timber structure of the roof is all visible, along with the ducts that run through and below it, and is enhanced by the daylight coming in through the skylights above it. Throughout the building, we employed two different kinds of daylight openings: on the one hand, the skylights, to bring in diffuse light, and on the other, the vertical slits in the facades, which allowed us to 'paint' with bold strokes of light on the interior walls and floors.

To what extent does Agave Library build on earlier experience you made with Phoenix Central Library?

The 'familial bonds' between the two buildings, I think, are evident – you could say that Phoenix Central Library is the parent and Agave Library is the child. Both buildings share the same intuitive simplicity. Both are like open books in which to 'read' architecture; they are honest expressions of their construction to the core, and almost case studies for the users on how a building functions. Yet both buildings share the same poetic quality that comes from the careful sculpting of material and light. They enhance our perception of daylight and how it reveals the subtleties of the desert beyond.

You were originally trained as a sculptor, and were influenced by the great American land artists such as Robert Irwin, James Turrell and Walter de Maria. In what ways is this reflected in your architecture?

I am very much attracted by the dialogue between the pragmatic of making things, and the poetic of experiencing them. I always work to let the ordinary become the extraordinary. Whether I work with a concrete block, a piece of wood or with 'ordinary' light, the key question is always, "how do you transform that ordinary thing into spaces and memories that achieve the sense of something extraordinary?"

Another aspect is how my buildings relate to their surroundings. When you look across the Arizona desert, your first perception is of how the buildings emerge from the earth. Your eye is drawn up along the surface of the building, towards the line where it kisses the sky. And that line tells you everything. This phenomenon is common to the desert places of the world, whether it is Morocco, the Middle East or Arizona. Our best buildings are the ones that form a perfect dialogue between shadow and light, and between the earth and the sky.

What influence do issues such as daylight and views have on your residential buildings?

Again, let me answer with a concrete example. The Hill/Shepard Residence,

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The library screens itself off from its surroundings with a permeable scrim composed of hundreds of individual metal sections. At the same time, this huge 'canvas' endows the building with presence in its commercial environment.

"Workers' attitudes and the patterns of work environments are definitely changed by the creative use of light."

which we designed back in 1993, is located in a mountainous district of Phoenix. Less than one kilometre away from the house – and half a kilometre above it – is a mountaintop, which became a sort of focal point for the views from the residence. The entry sequence is along an east-west axis, from street level up an exterior staircase of stone treads and simple walls of concrete block with weeping mortar. This mortar both catches light and casts shadows in a dynamic pattern differently throughout the day and the seasons. The main living and dining room has a skylight aperture that also runs east-west. It functions like a kind of sundial that indicates the time of day.

In the more private quarters of the house, we placed a series of smaller apertures, all of them square in format. To me, these are not windows but rather like apertures of a camera lens. Our intention with them was to provide the owners with a new experience of their surroundings, which would otherwise only appear as a familiar environment. We did not define the position of these windows in the design phase, but merely put a note in the drawings saying that 13 windows would be placed later. Once the timber frame structure of the house was up and the plywood sheeting put on the walls, I walked through the house with the owner couple and their son to decide where to put these windows. I had a hammer and a large nail with me and wherever we considered it appropriate to have an opening, I would put a nail-hole in the wall through which we would look out, and discuss whether the position was right. In this way we placed, amongst others, a 30-inch window right next to the floor in the library of the house, a 10-inch window exactly at eye level, next to where Linda – the owner – would later have her desk, and a 3-inch square at the line of the ceiling.

These windows are like paintings on the wall, but they are not static – they are living 'art' windows.

This is rather an unusual way to determine the fenestration of a building. Why was the number of windows decided beforehand? It just seemed an appropriate number. Putting too many of these apertures in the building would have meant that you lose the power of discovery. If you had too few of them, you would not realise that there was something happening at all. Besides, we had a budget that was somewhat limited.

When I recently remodelled a former movie theatre into an art museum in Scottsdale, Arizona, I took a similar approach using inexpensive standard roof windows to light up the exhibition space. The placement strategy here was a rational and organised plan study, calculating orientation, size, and sun angle effects on the spaces and adjacent wall surfaces.

In art galleries, there is always this discussion about whether the daylight will potentially harm the works of art. Yet if we look at the great museums of the world – like Louis Kahn's Kimbell Art Museum or Peter Zumthor's Art Museum in Bregenz – we all know what natural light can mean to art. So we convinced the director of the museum in Scottsdale to allow small apertures into the roof. With only 2,000 dollars out of our 2-million budget having been dedicated to these apertures, we went to Home Depot, bought eleven standard, 150-dollar skylights and put them into the galleries. Sometimes they are covered during exhibitions, sometimes not. The effect that they create is simply amazing.

What buildings, other than your own, and what places have particularly inspired you due to their daylight conditions?

It is interesting to stand in a street in Manhattan, with the orientation of the city grid, to look across the city between the East River and the Hudson and observe how these canyons of buildings funnel the light across the passage of the day. The light that I find in a place is always a great source of inspiration to me, but this is by no means limited to urban architecture.

Last fall, I was driving through Indiana, in the American Midwest, looking at tobacco barns. These vernacular sheds where tobacco is dried are very porous buildings, with open joints between the siding boards on all sides to let the air pass through and dry the tobacco leaves hanging inside. Once inside these buildings, you will find that they are totally remarkable in the dynamic quality of how they filter and capture the light. They are uniquely beautiful like a Gothic cathedral and their beauty is of the unintentional and ordinary becoming remarkable.

Apart from its purely visual aspects, what is the significance of daylight to you?

Light defines the journey of our lives. You can already experience this by watching the path of the sun in a room. Right now, I am sitting in our office space, which was formerly a dance studio. Originally the space had only one window, which faced east. I added another opening in the north facade, right next to my drawing board, and five small skylights in the roof. The window in the east is the one through which we greet the day, but the skylights tell us when it is winter outside and when it is summer. During daytime, we shade the east window with a perforated scrim, but the skylights still provide enough light to energise the space and yet not make it a hot room.

Through this design, we realise the added value of not just perceptual but functional light that comes at no cost. Also, workers' attitudes and the patterns of work environments are definitely changed by the creative use of light.







SANAA





A SPATIAL INVITATION TO PRESENCE

Far from all the possibilities of use in the building are predetermined. As is often the case in the architecture of SANAA, many areas are not concretely defined until the users are present.

In the best work of the Japanese architectural firm SANAA, daylight forms architectural space. Their work advances a new relationship between structure and light that offers a distinct spatial/daylight identity, a diversity of connections between inside and outside, and a strong awareness of context and its spatial potential.

By Per Olaf Fjeld.
Photography by Thekla Ehling

GLANCING OUT of my corner window overlooking a dimly lit street in the centre of Oslo, I watch a neighbour slowly cross the road avoiding the icy patches and making a quick second check for passing cars. It is a specific urban scene in a Nordic winter light, but inside, the light at my desk is from the laptop. It emits the same blue submissive rays that illuminate desks, trains, buses, and teenagers' rooms after bedtime all over the world, but do we regard it as a source of light? The perception of one's immediate physical world and the differentiation of its various layers grow increasingly complex when technology and the global world of commodities function as one. Each new technological object rapidly becomes part of the backdrop to everyday life; equally the framework around modern life and its light is also transforming and shifting focus, without scale, floating between public and private.

And then... there is Japan ever so slightly playing technology's potential in another key. Perhaps the country has been able to encapsulate at least some of technology's global sprawl. Instinctively, but at the same time collectively, the Japanese know when to move forward and when to pull back. The human aspects within the public domain of everyday life still actively retain and support traditions, services, handcrafts, access to natural settings and room for contemplation. All this thrives within a busy modern society and its technology. There seems to be a tacit

shared understanding of what is important for the common good. The built environment, even in the most densely populated urban areas, is curiously able to retain a human scale, and within this multi-layered urban society, there is a clear discipline in relation to private and public space. The accessibility and diversity of the public domain ensure that individual private space remains very contained. The common denominator in this situation is a clear frame of reference directed towards nature.

The architectural office SANAA mirrors an image of modern Japan. The office is a common ground embracing architecture, where the individual talent respects the value of the group. It gains its strength and vitality through an ongoing, long-term questioning into the core of architecture, its integrity, and the essential role of daylight within this complexity. It is not a search for light and shadow pressed into an artistic expression or entertainment, but rather a focus on light's potential as a spatial condition that enriches or further interprets well-being. However, to release its inherent spatial energy, human participation is a necessity. The spatial presence and the time aspect of the inhabitant work together as a situation, one that also generates a social awareness. It is a very precise architecture where there is nothing to add or subtract. At the same time, the work as a spatial object contains a sense of absence that unobtrusively entreats participation. It is not complete

before it connects to its user, whether a museum spectator, a home owner or just a person passing by, and it is the daylight both inside and outside that serves as a connector.

LIGHT, STRUCTURE AND THE INHABITANT

For daylight to form architectural space, as is found in much of SANAA's work, the physical form must offer a unique relationship between structure and light in which one's perception of mass changes. In a number of projects the use of many slim steel columns stitches together a very open yet defined spatial integrity. Here, the key issue is that the thin structural columns collectively offer a different relationship between structure, shadow, and daylight. It is clearly the light that establishes the space, and not the physicality of the column and its shadow. In this translucent mutable space, daylight sets the conditions, and transforms the spatial sequences over and over again. For the user this situation is open to new interpretations, and there is a fluctuation of focus between the inhabitant's presence and the space set by light.

It is important to stress that daylight is not the only element vital in forming spatial context in SANAA's built work. Plants, trees, grass and rocks, new additions or existing elements, are understood and treated with the same precision. The Japanese relationship to nature and architectural culture is, although modified, still

At the borders between inside and outside, light is continuously refracted and reflected in new ways. Depending on the time of day and the weather, the interior and exterior are sometimes part of a continuum and sometimes clearly separated from each other optically.

very present in their work. But, the office brings changes and a shift in focus. Definitions of protection, comfort, the view, light and time are reshuffled and weighed in again. The results offer a dense spatial energy that demands a user in present time. An informed sensitivity towards nature encompasses far more than focusing on protection from natural forces, serving humans, or storage of commodities. The architects do not shy away from this complexity, nor do they separate daylight from nature's integrity.

INSIDE, OUTSIDE

Much of SANAA's work reveals a deep concern with strengthening and uncovering the latent potential found in connecting the interior to the ever changing context of the exterior. The border between the inside and outside may be understood one day as absolute, and later, under another light condition, the same border is interpreted as diffuse. Once inside, the room's spatial energy holds the user's concentration and sets in motion his participation, but what unfolds outside still influences how the interior is perceived. Different light conditions created by this interplay shape a variety of spatial sequences. These in turn affect the way the inhabitant moves and utilizes the interior. It is a diversity arranged through daylight, and the given programme and the client's brief serve only as a base or outline for this spatial diversity.

The open interior courts often found in SANAA's work perform as mediators between the interior and the exterior, between culture, set programmes and nature. In addition to allowing daylight to enter deep into the spatial fabric, the courts also sustain a spatial condition of their own. Therefore, there is no competition between the building and the particular spatial identity of each court and its light. Much of this is achieved through a very careful choice of materials and a consideration of each material's capacity to enhance or change the quality of light. A wide range of glass materials from transparent to opaque to individual ceramic print patterns is used to filter and alter light. The complex relationship of layers

between inside and outside directly influences the interior space and its light. But this also changes and influences how the surrounding landscape is perceived from the interior. The façade and its material are regarded as a resistance force with the capacity to abstract the view. The substance of the façade is not a determinant of the border, but an activator.

LIGHT THROUGH SPACE RATHER THAN THROUGH TECHNOLOGY

The use of technology as a means to gain precision in relation to natural light has a long architectural tradition, particularly in Japan. But the impact and influence of modern technology and its global marketing on today's architecture is far more complicated and layered. Unfortunately, over the past decades technology has often been used as compensation for the inability to draw out a maximum energy from the relationship between built space and natural light. What is at first understood as energized space is in fact a conglomerate of the latest fittings, lighting and imagery, and this spatial experience seldom ages well. SANAA's work is also very technologically oriented, but it is controlled and directed towards a clear spatial end. The technology will grow outdated, but the spatial strengths and ever-changing natural light give the work its individuality and respond to a context in transformation. This focus overrides technology's aging process and instead puts pressure on and questions how a product responds to a given spatial task.

The 21st Century Museum of Contemporary Art in Kanazawa reveals some of these important elements. The different exhibition rooms, the interior/exterior courts, and the interstitial spaces between the programmed spaces offer a layered spatial variety where the visitor creates his or her own sequential path. The daylight room of the artist James Turrell is clearly integrated into the centre of this spatial fabric, and serves as a moveable still life, a chamber of light open to the sky. Daylight, evening light, the moon and stars at night rehearse an endless story. Each visit is different. Rain, wind, stray leaves and snow also participate in this

room, but the actual opening is pure light. Each visit is unique, and the depth and intensity of the experience rely on nature, its light and the individual. Another element within the museum's spatial concerns is the relationship to the ground. The floor and the earth's surface are the same. The earth as a base sets an inescapable context. The museum's horizon is the earth's horizon, not an illusory one designated by a second or third floor.

Of SANAA's built work outside Japan, the Rolex Learning Centre reveals many of the same spatial interactions found in the Kanazawa museum, but they are discussed anew. Light is still manipulated through structure and material, but the section of the building has an active relation to the ground. The looping form offers a continuous spatial sequence through movement. The inhabitant is both on the earth and hovering above it. This generates interesting consequences in terms of context. Since the spatial path floats above the site, there is a slight disconnect between the horizon and the ground, which also directs and influences how the building interacts with its surroundings. The adjacent exterior space finds definition not only through its confrontation with the new façades or from one façade to another, but also from the interstitial spaces created by the movement of the user and the light courts set by the loop.

LIGHT AS PART OF THE EXISTING CONTEXT

Respect for and comprehension of context are key to SANAA's creative approach, as their work also attempts to highlight the qualities of existing buildings and their surroundings. Destruction or a "clean slate" is not an issue, rather there is a focus upon finding strategies that have the capacity to both explore and strengthen what is already in place, and this includes pre-existing light conditions. Their transformation of the Japanese pavilion for the 7th International Architecture Biennale in Venice (2000) was beautifully handled. There was essentially no hierarchy in the architects' assessment of what is and what is to come; thus their response



Library, café, working space and auditorium – many functions are incorporated together in this building. Interior walls for demarcating them were needed almost nowhere. Only the 'wave crests' and 'troughs' visually divide the interior into different sections.

Following pages The interior courtyards play an important role in the overall concept of the building. They not only provide the adjacent spaces with light but, due to their different sizes, they also determine the feeling of proximity or distance between them.

to the site was layered, fluid, questioning, and reached out to the public.

However in some of SANAA's work abroad, the interaction between the existing context and the new structure lacks perhaps some of the unique precision that is so fascinating in their work at home. To a certain degree, The New Museum of Contemporary Art in New York illustrates this enigma. The building reaches out with all its tangible and intellectual vulnerability, and New York is unable to respond with equal openness. It would be easy to blame the lack of energy on the actual museum building, but I do not think this is a constructive response. The situation touches upon a deeper architectural issue about how well architecture travels. The notion of permanence and how it is understood in Japanese culture differs from the West, and this is an important element in understanding contemporary Japanese urban space. SANAA's work reveals an architectural precision that defines a spatial openness which is able to accommodate an ever-changing context and its light. On one level Western cities, New York included, are stuck in an image of permanence, and as such their architecture remains an object acting on and reacting to this image, and the potential of their interstitial spaces also remains tied to this process.

LAYERED LIGHT, PRIVATE AND PUBLIC
SANAA's architecture demands and initiates new relationships between public and private, not just in official buildings, but also in private homes and apartments. In urban Japan, the private zone is always defined by and cognizant of its adjacent public zones. Conversely, these common or shared spaces also define their identity through the private zones. It is inevitable in Tokyo and other large cities that the limitations and minimal sizes of building sites for private homes promote a layered and abstract, but just the same reciprocal, sense of space. An awareness of this condition and its spatial capacity has inspired many Japanese architects over the years, including SANAA. It is often the interstitial zone between public daylight and private daylight that plays

a crucial role in their architectural compositions as a whole. In the small 1997 M. House in Tokyo, where the entire site is excavated, there is a spatial zone that can be regarded as private, but the site takes its visual stimuli and energy from the adjacent public zone.

Once inside a house or apartment, the inhabitant has to face an intimate and direct relationship between body and space. This is a Japanese reality. Individual privacy is more a mental space, a room that originates from within the user, and SANAA's domestic work reflects this condition. Each specific space finds an extension through its communication with other spaces. Whether inside or outside, each space is part of a larger sequence of connecting context, both private and public. Daylight is always present, and serves as a mediator with the potential to change and manipulate, through layering, the interior light's intensity and colour. This is very evident in their small private homes. Within this layered interior, personal objects become active instruments. The form of a chair or the placement of a table or object can easily change the spatial sequence and its light, but reflexively it is also the spatial sequence that limits the number of objects.

A NEW TWIST

The American architect Louis I Kahn often talked in his classroom about "order is", and he said that after many attempts to describe order as content he gave up and simply stated "order is". But he also added that order in this sense can never be regarded as a static instrument, but rather as one with a capacity to change in accordance with the desired relationships between body and space. In the best work of SANAA, I experience an awareness of, or rather a sensitivity to, an order that generates new relationships between structure, shadow and light. Daylight becomes the space, but it is shaped with precision through a structural lightness. In some of their work, I have sensed a new twist to "order is", and it was a very strong architectural experience. These spaces are not demanding, but are rather strangely alluring, since they offer an ever-changing

spatial context that blurs the relationship between private and public, and between everlasting and present. Yet, these spaces are also generous enough to house the vulnerable private inner space of the individual. In SANAA's architecture, I sense a whisper of something essential, a fluid exchange between context, space and light working towards a stronger social consciousness.

Tonight the blue light will occupy my desk in the corner window and transmit its peculiar identity to the rest of the world. Patiently, I will anticipate the next email to reassure my sense of existence, a form of contact. I could be anywhere. Inside SANAA's work, I am not waiting for a response, real or virtual. Daylight as space carefully tucks me in and invites me to participate, and with that simple gesture architecture works at its best.

Per Olaf Fjeld took his Masters Degree under Louis I Kahn at the University of Pennsylvania. He is a professor at the Oslo School of Architecture and Design. He has written a number of articles and books on architecture; his latest book is "Sverre Fehn, The Pattern of Thoughts" (2009). Per Olaf Fjeld was a guest professor at Cornell University and the University of Arizona, and served as president of The European Association of Architectural Education for 3 years from 2005. Per Olaf Fjeld has run a small practice with his wife Emily Randall Fjeld since 1975.

Further readings

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JAR-
MUND/
VIGS-
NÆS



“WE NEED TO REDISCOVER THE ECONOMY OF DAYLIGHT”

The work of the Norwegian architects Jarmund/Vignæs is firmly rooted in the Norwegian culture and landscape. In an environment that is often determined by stark contrasts, their buildings seek to establish a balance – between sheltering and opening up, between opaqueness and transparency, and between different qualities of daylight and views.

Interview with Håkon Vignæs
Photography by Thekla Ehling

Mr Vignæs, many of your works – and much of the best contemporary Norwegian architecture – seem to have a particularly close relationship to the Norwegian landscape and to its light. What significance does this landscape have for the Norwegian culture and for you as architects?

Norway has never had a very strong urban culture – not even today. Traditionally, the settlement patterns in our country are not very dense. The typical historical dwellings were small houses or farms, which were always self-owned as we never had a feudal system in Norway. Many people made their living from farming or fishing, or a combination of the two.

Even today, more than half the population live in their own houses, often in the countryside or in some way related to the landscape. It is also very normal for a Norwegian family to have a summer or winter cabin in the countryside, usually quite small and simple. The Norwegian culture has thus remained very connected to the nature that surrounds it, both in terms of everyday activities and use of space.

Another important aspect of the landscape is the climate and, along with it, the daylight. Quite often you can see that Norwegian architecture is dynamic in its position between sheltering and opening up. On the one hand, our buildings have to protect the inhabitants – both physically and mentally – from the harsh climate around them. But on the other, it is very important for us to ‘bring’ the landscape – and especially the various daylight conditions – into the house.

This traditional dynamic influences Norwegian architecture today. People both want to be protected from the climate and to open up to the landscape and its light. Mind you, light is something that there is not too much of in Norway, especially in winter. Also, the light often comes in at low angles and it is quite an architectural challenge to bring this light into buildings.

What strategies has Norwegian architecture evolved to harness this low and often minimal Nordic light?

Modern Norwegian architecture has always tried to achieve the balance I mentioned, between sheltering and opening up. We do not build fully-glazed buildings for housing in Norway in general – both because they would make little sense in terms of energy use and because people want buildings to ‘embrace’ them. Although Norwegian houses have always had a strong relationship to nature, historically they had quite few openings – at least until the evolution of a specific ‘holiday’ architecture from the 1870s onwards, when glass verandas became fashionable.

You can also observe this differentiated relationship to daylight in our own buildings, such as the skiing cabin in the Nordmarka region just outside Oslo that we built in 2004. Here we tried to let the light in as equally as possible from all sides. Similarly, in many of our buildings we try to achieve a mixture of light from different directions that is as rich and varied as possible.

“We do not build fully-glazed buildings for housing in Norway in general – both because they would make little sense in terms of energy use and because people want buildings to ‘embrace’ them.”

You have designed buildings for very northern latitudes, including the Svalbard Science Centre in Spitsbergen. In this location, it is literally dark for almost half of the year and light for the other half. How did you react to this challenge?

Here again, the climate was a starting point for our design. First and foremost, the design was influenced by the need to avoid snow piling up around the building. We therefore gave the building a very aerodynamic shape, which was tested digitally to assess the expected wind patterns and snowdrift on the site. Because the Science Centre is located on permafrost, we also raised it above the ground on stilts to allow air to circulate underneath it. This is because if a building stands directly on permafrost, it will melt the ground with the heat it creates and risk sliding away. In the building envelope, we tried to achieve the same balance between sheltering and opening up as we do in our buildings in Norway. However we could not use too many windows because the temperature difference between inside and outside is often 50 to 60°C and the





In the rooms, lime-washed paneling, wooden floors and furniture made of oiled oak convey a warm and natural atmosphere.

Previous pages The hotel is in one of Norway's most important winter sports areas. Its roof shape reflects the silhouettes of the surrounding mountain chains.

"The architecture itself is an expression of the dreams of the owner, who had always wanted a kind of tower in the mountains."

heat losses would become too extreme. We therefore shaped and positioned the openings according to the primary functions they had to perform: for the elongated sides of the buildings, where the offices are located, we chose long horizontal windows to provide the users with the best possible view of the horizon; in the public areas, the windows are more vertical, and we also added openings in the roof because it was as important to get a lot of light into these spaces as to provide views.

Let us talk a little about Turtagrø Hotel, a project that is also documented in the photographs in this article. What were the key factors that influenced the design of this building?

Turtagrø Hotel has quite a special history because the previous hotel had burnt down. The owner literally lost everything he owned in the fire but he decided to use the insurance money to build a new hotel. As he could not afford to spend more than a year without revenues, the entire project had to be finished in just one season. It was therefore an extremely 'fast' project for us, which we started building from sketches rather than elaborate working drawings.

The architecture itself is an expression of the dreams of the owner, who had always wanted a kind of tower in the mountains. Obviously the hotel that we designed is not a tower, but it does kind of tower over the landscape if you view it from a certain angle.

For the construction, we used mainly traditional materials such as natural stone and wooden cladding. We treated them in a way that relates the building to its annex from the turn of the 19th century, with its kind of 'embroidered' wooden patterns on the verandas. On the other hand, the material palette and overall shape clearly

relate to the harsh location of the building in the mountains, providing a feeling of safety and shelter to the inhabitants.

A third important aspect of the architecture is the positioning of the openings, which often face slightly upwards rather than sideways. This is because in the mountains, you very often want to look up to the mountaintops and to the sky from your room, rather than sideways or down into the valley.

In general, would you say that you design your buildings 'inside out' or 'outside in'? It's always a balance between the two. You can best observe this in our Triangle house in Nesodden, where the overall design follows the shape and positioning of windows in the facade. In an almost romantic way, these windows frame different views of the surrounding landscape and of the nearby fjord, and we tried to relate these views specifically to the indoor spaces. The timber cladding of the facades, in turn, also relates to the windows: it is divided into areas with horizontal and vertical patterns aligned with the edges of the window openings.

You often use very complex sections in your buildings, almost in the sense of a Raump lan by Adolf Loos. Why is this?

The spatial complexity or 'flow' of the interior spaces is important to us for various reasons. Firstly, the relationship between spaces of different heights increases the dynamic of the architecture. But it has also proven a useful strategy to avoid square metres in a building that are not actually used. Many of our houses are built with relatively restricted budgets.

If a client has the choice between a prefabricated house of 200 square metres and, for the same price, a simple, yet individually designed house with some 140 square metres, we have to convince him that 140 square metres is really sufficient for him and that he should commission us with the design. To achieve this, we have to deal with the use and the 'flow' of the interior spaces in a smart way, for example by not placing spaces next to each other but rather letting them intersect each other.

Apart from your own designs, what buildings or places have particularly impressed you with their daylight conditions in the past?

Rather than mention a specific building, I would like to point out that there is much to be learnt from traditional building culture. The rising demands on energy efficiency and thermal comfort mean that nowadays we can no longer design fully-glazed buildings. In my opinion, this is highly beneficial for architecture, as it makes us reconsider how to balance mass and lightness, and walls and windows. Traditionally, this kind of focus has led architects to develop very fine details around windowsills and devise ways of painting and profiling window openings. These details deal with light in a much more intelligent way than today, when it has become so easy just to insert glass panes into walls. So, in many ways, traditional architecture can provide us with clues about the architectural 'economy' of light.

When, and on what occasions, did you come to realise how much daylight can influence human behaviour, and well-being?

In the North, we can get tired and moody, and feel a lack of energy during the dark

"This kind of understanding of our own health and how it relates to the daylight quality and the wish to be outside are important elements of our physical and mental tradition, and every one of us is accustomed to them from an early age."

season. So for me, it is often important just go outside and see and feel the sun around noon, or to get home from work early enough to experience some daylight outdoors. This kind of understanding of our own health and how it relates to the daylight quality and the wish to be outside are important elements of our physical and mental tradition, and every one of us is accustomed to them from an early age.

The hotel rooms are relatively wide and shallow and thus receive a large amount of daylight. Roof windows provide the rooms with views over the valley and the surrounding mountain ranges.

Next spread "Our buildings are intended to strike a balance between exposure and protection," say Jarmund/Vigsnæs. The facades of the hotels, with their large roof overhangs and relatively deeply recessed windows, reflect this contrast.

"We discuss daylight with our clients very often and generally what they want is views to all sides and daylight coming in from all sides."

Have you spoken to clients about their daylight preferences or received feedback from clients and users about the daylight in your buildings?

We discuss daylight with our clients very often and generally what they want is views to all sides and daylight coming in from all sides. The only worry that they tend to have is about walls on which to put their favourite paintings – but that is not an architectural issue as such. We often tell our clients that in order to experience different light qualities and views, it is very important to balance them, to be 'economical' with them in an architectural sense, and not to let everything in at all times. Sometimes we have to convince a client that a very low window – that you can only see out of when you are sitting in the bathtub, for example – may be favourable, and that sometimes a window that offers no views out at all but casts light onto a wall or the floor might be important. Persuading clients to believe in these architectural issues is often difficult – but necessary.

Daylight is highly dynamic. It changes all of the time. How do your buildings react to this changeability, also in terms of how you design the envelope?

Take a look at our project Farmhouse in Toten, west of Oslo. The house was built next to an abandoned farm for a family that moved there from the city. The clients had two important desires: firstly, there was a barn on the site that we had to tear down but that the family wanted to keep a memory of. So we used the 100-year-old cladding of the barn for the new house and left the remaining wooden construction on the site to be burnt, and to heat the new home for free for the next 20 years or so.

The other desire had to do with the topography of the site and its light. The

family had previously lived in a rather small and dark flat in Oslo and were now dreaming of this site with its daylight conditions. They carefully studied the movements of the sun during the different seasons, and decided where they would cut small clearings to open up views and how they would relate their lives to the path of the sun. The house has a continuous horizontal band of windows across all four facades, which clearly reflects the family's desire for a continuous relationship to the changing daylight. The strip varies in height and position and thereby relates the indoor spaces to the light conditions outside, and also to the lack of light in some positions.

Daylight conditions in cities are often different from those on the countryside. Do you pursue a different approach to dealing with daylight in urban settings?

In urban conditions, there is not only often less daylight than in the countryside but there is also the issue of views into the house. The placement of windows therefore becomes crucial once again in order to establish a balance between 'holding back' and 'giving away' one's secrets to neighbours.

We have built a lot of large projects in urban settings but only one private home, which is located in a backyard in a historic part of Oslo. Here the task was to visually control the backyard. The house – quite a small house, actually – is therefore very open to the courtyard but entirely closed to the other three sides by existing walls that we were not allowed to penetrate. The design of the house was, on the one hand, clearly determined by this restriction. On the other, this kind of 'friction' between the new-built and the existing conditions is also exciting to work with. The worst scenarios for us as architects, in a way, are perfect sites with unlimited budgets. That is really too much to cope with. On the other hand, we very often build in steep terrain, with the sunlight from behind and the view stretching out to the other side. This is a good cross-section for us to work with and more interesting than having the light and the view in the same direction.





LACA- TON & VASSAL





“LIGHT IS FREEDOM”

Interview with Anne Lacaton and Jean-Philippe Vassal

“Freedom is something we try to accomplish with all of our work,” says Anne Lacaton of Lacaton & Vassal architects. With her partner Jean-Philippe Vassal, she has proven again and again that flexible and generous spaces full of daylight can be created with surprisingly simple means and at low cost. For their work with daylight, the VELUX Foundation has awarded Lacaton & Vassal the 2011 Daylight and Building Component Award.

By Brian Woodward
Photography by Thekla Ehling

“We have to consider daylight in two directions,” says architect Jean-Philippe Vassal, 57, running his hand across the panorama of Parisian rooftops that surround his atelier. “Daylight, of course, means light that comes from the outside, but it is also what we can see from the inside to the outside.”

He explains that the boundaries of a home extend as far as one can see and that maximising daylight from the inside to the outside is one of the fundamental design paradigms Vassal and his partner of 24 years, Anne Lacaton, consider when approaching a new project.

Lacaton & Vassal projects have often involved refurbishment of existing structures. From the redesign of the Palais de Tokyo in Paris, to their extensive work with refurbishing social housing across France, all of their projects are characterised by appropriation of non-standard materials, such as greenhouse structures, corrugated aluminium and polycarbonate, in the building process.

This economical and transformative use of materials and a consistent focus on daylight have earned Lacaton & Vassal the recognition of the VELUX Foundation’s 2011 Daylight and Building Component Award. They were recognised with a €100,000 honorarium at a ceremony on 7 March in Copenhagen.

“Transformation is one of our interests. But it is really about freedom. Freedom is something we try to accomplish with all of our work,” says Lacaton, 55. “Not framed

daylight, but pure exposure. That is what daylight can do. It can free. We like total freedom.”

Are there any common denominators in the way you consider daylight in your buildings?

JPV: One thing we always try to do is to avoid walls. We have to produce floors, columns and beams. No walls.

We think that being able to look outside is the best thing that can happen to someone in the place he lives in. Even when what people have to look at is not so beautiful, we want to give them the freedom to filter their views rather than not having any views at all.

It is a question of freedom and maximising capacity. Each time we design a building we ask, “what could be the maximum degree of openness for a bedroom or a bathroom?” These questions not only have to do with daylight but also with the possibility of going from inside to outside. So even if you live on the 13th floor you should still have access to a balcony or a winter garden. This improves the climate, it allows you to have plants in your winter garden and it makes daily life easier. It has made a big difference in our projects, especially in our social housing projects. AL: I also think that daylight is something really necessary for well-being. Trying to bring the maximum amount of daylight inside a building is an interesting challenge. This is why we often put greenhouses on the top of our buildings. Be-

Previous spread The machine-like aesthetics of the greenhouse construction and its controls characterise the conservatories up to today – in spite of all the efforts of the occupants to give them a homely character with individual furnishings.

The conservatories are unheated all year round. Horizontal textile awnings under the ceiling provide the only protection against sunshine. Nevertheless, these spaces are used for hours at a time for large parts of the year.

“Every time we we had contact with the client later on they told us, ‘you cannot imagine how much our life has changed because of this house ... we are always in daylight!’”

cause they have to be so open to daylight, greenhouses are very light structures that do not cast any shadows on the floor. This lightness related to daylight is something crucial in our architecture because we always try to avoid the feeling of heaviness of a building. Daylight relates to lightness, to feeling the climate, to being very close to your environment. We always try to use the building elements that will allow us to maximise the amount of daylight in a building.

Can you give us an example of how the use of daylight influenced one of your project designs and how?

JPV: It is difficult to point to a specific project because our job as architects is not to produce concrete or steel or glass. We just have to ‘build’ the void in between – the space, the air, the climate and the ambiance in it – and this includes daylight. Daylight is in everything we do. I do remember one project, however, a refurbishment of an existing home in a very dark part of Bordeaux, where the client told us, “In this house there will never be a ray of light!”

But we worked hard and set ourselves the goal of finding at least one day when there would be a little triangle of sun entering the house at one specific time. We told our client that on this day, at this hour, there would be this triangle on the floor. She waited for it, and it worked. And she was happy.

AL: There was also a small country house we did in the south-west of France ten years ago. It was for a couple who worked in a vineyard in Bordeaux. They had previously lived in an even smaller house, in the shadow of the home of the vineyard owner, that had tiny windows, poor ventilation and, in general, very bad living conditions.

The couple asked us to design a new house for them on a very large piece of land that they had been able to buy for almost nothing. We built two big greenhouses on the site, adjacent to each other, and inside one of them we put a wooden ‘box’ to contain the heated rooms of the house, such as the living room and bedroom.

It was a simple concept but every time we had contact with them later on they told us, “you cannot imagine how much our life has changed because of this house. We are always in daylight.” When the lady died of cancer a few years later, the only thing her husband told us was, “you can not imagine how the last days of my wife’s life were beautified by your house.” So that is how daylight influenced their life – and it continues to influence our designs.

What other aspects of daylight, apart from the visual ones, do you consider in your projects?

AL: Daylight is something very important in buildings, because daylight includes the possibility of using the sun’s rays for comfort and of allowing views outside. If you use daylight, you also need less artificial light. Still, it is quite easy to protect yourself from daylight if you need or want to.

So in our buildings we very often do not use walls, but work with open frameworks made of columns, floors and platforms. To this we add transparent facades that include all the necessary systems for protection – from glare and heat, from people looking in, from the cold of the night, and so on.

These transparent glass facades and glass partitions extend from floor to ceiling because ventilation and views are very important for us.

Lastly, we also very often use greenhouses as a ‘second envelope’ inside which we can create spaces with different climates. Obviously, the question of climate is linked both to daylight and to the question of comfort – bioclimatic comfort.

Which is your favourite daylight building – or which place or building has most impressed you with its daylight conditions?

JPV: I remember one building, the Hans Scharoun Library (State Library) in Ber-

lin, which is incredibly large. Nevertheless, from any point inside the building you can still see the far-off light of the facades.

In the school of architecture at Nantes we tried to achieve the same effect. The building is 120 metres long and 18 metres deep, and light enters only through the facade, which is six metres high on each floor. Although there is not much daylight there, when we stand in the middle of the building we can see everything that happens outside. We see the people moving, and we always see the light coming in from the facade. So even when there is just a ray of light that touches a few specks of dust, it is very beautiful.

Can you tell us about a situation when you realised how space – and daylight – can influence people’s behaviour?

JPV: A good example is the first house we designed, the Latapie House in Bordeaux. It was a very cheap house. We built a greenhouse of 60 square metres around the actual house and, as architects, we imagined that it would be a tropical garden full of flowers. But what the owners have done with this space is ten times better. They have put most of their furniture in there and use the place – which we had intended to be used only 30 per cent of the year – 90 per cent of the time. They have really taken this space and done something with it, because it is airy and filled with light.

In many of your buildings, you use daylight not just to benefit people but also to grow plants. Where does your interest in plants and horticulture come from?

JPV: It is probably me who is most interested in horticulture. I have an orchid collection here in the office that fascinates me because orchids are the kind of plant that can get the most from a minimum. They do not need any soil to grow, but have everything right in their roots.

What role does economics play in your buildings, and how do you relate economy of means to quality of life?

JPV: Just after I finished my studies in Bordeaux I spent five years in Niger, which very much influenced my thinking





Loft living in low-cost housing – this seemingly 'impossible' combination was achieved by Lacaton & Vassal in their project in Mulhouse. Even the two-room apartments are more than 100 square metres in size.

Following pages Living, cooking, working, sleeping – On the ground floor of the houses, everything takes place in a single continuous open space. The architects intentionally refused to predefine functions for individual areas.

about the relation between economy and quality of life. I always say that I studied for five years at the School of Architecture in Bordeaux but then got five more years of education in Niger.

In Africa, I saw the life of people who really are in difficult situations most of the time – without food or water. Yet their ability and their sheer intelligence to invent things all the time has stuck with me. I learned how to create something out of nothing and how this can even be done with a poetical gesture and with humour. Whatever they did seemed to be light – never heavy or difficult. But it was always done with a minimum of means.

A car that is discarded in Europe or France, for example, will be able to run for 20 more years in Africa. You see children who invent their own little toys and 'play cars' in the sand with some scrap steel or rubber. You see houses built of branches poked into the desert sand and covered with cheap, corrugated aluminium sheeting. There is a freedom in the way these people do things.

We try to work in the same way. You don't have to rebuild everything – you just have to cope with the existing urban situation. There are a lot of buildings that people think should be demolished – we consider them merely unfinished. Buildings have more capacity if we can preserve them and transform them.

AL: In many projects, the relation between the cost and the scope of the project is inappropriate. As architects, we can create something very generous and luxurious at low cost, but this requires an understanding of what increases the costs in the construction process. To keep costs low, you have to get the maximum performance out of everything you are working with: out of every construction system, and every material. Our goal is not to build cheaper but to achieve the maximum with a low budget. We do not aim to simply reduce the price of a building but to get more for less.

Your own buildings, such as the recent architecture school at Nantes, are often very open for reconfiguration and later adaptation by the users themselves. Have you observed how users actually adapted these spaces to their needs?

AL: We go there quite often and it is amazing to see that sometimes nothing happens in the building and the spaces are completely empty. Then sometimes they are full of activity, whether it is students working or events. We don't really understand why this is but it is amazing to see that everything becomes possible if you liberate yourself from programmatic spaces that are devoted to specific functions. It is great to see the things that happen when you have space that is 'free to use'.

With each visit, the school becomes something different for us. We gave the students freedom and now they keep are repaying us with new interpretations of the space. This provides the building with a certain kind of richness, somewhat different from the traditional meaning of the this word, and we have the feeling that we can continue in this way.

Do you think there is a demand for such open buildings that users can continuously reconfigure according to their needs?

AL: I don't think people have a natural demand for such buildings but when I speak with them, they tell me they feel very happy. They never imagined it before but being inside these buildings does make a difference to them. So we are convinced that is not a mistake to create this kind of architecture and think about open-plan floors and to maximise light and freedom. At the same time, we have to consider all the different systems that protect people from the sun and protect their privacy. If you create these layers that allow you to achieve any degree of openness, from maximum transparency to daylight to total darkness, a building works perfectly.

"It is just about giving maximum performance to everything you are working with: to every construction system, to every material."





IWA

A WORLD OF LIGHTS

The 2010 edition of the International VELUX Award attracted 696 submissions from all five continents. Beyond their architectural quality, these students' works illustrate how daylight influences our perception of place, our rhythms of life, our social behaviour, and our individual wellbeing. The following pages show the winners and honourable mentions of the award, as well as the thoughts and impressions of the jury members.

"I think there is a cultural element in light, and there are social aspects that relate to the region, its climate and to the seasons. In the competition, it became evident that a lot of projects from Japan or other Asian countries dealt with light in very different ways from the way that the Europeans did. And the Africans and Americans had different approaches again, because African light and American light are also very different. [...] With climate, it is the same: in Japan it becomes very hot and humid in summer, which is very different from here in Europe. But if you do not come to Japan yourself, maybe you will not be able to understand that."

Momoyo Kajima

"[Working with light], you can be poetic or pragmatic, and it touches upon many aspects of architecture and urban design that are of interest. In general, I like it when daylight is also seen as an architectural parameter [...], which can never not be in the project, but is also taken to a [...] level of solution. This might sound very abstract. But in fact we found many practical solutions to practical problems among the entries, as well as solutions that were still hypothetical but where you could feel that the students were addressing really vital questions. You could sense in their solutions a foretaste of the future."

Natalie de Vries

"I found a lot of my concerns about creating a better quality of life in cities being dealt with by the students. They looked at left-over spaces in the city and how they can be improved, at connections to the infrastructure that allows us to move above and beneath and through the fabric of the city, and at retro-fitting. There were re-purposing solutions. There was the idea – an old idea – of a typical shutter as a method of controlling light at a window, at an aperture, taken to a whole new level so that it could virtually be universal in application. That was really exciting for me."

Will Bruder

"I saw, and was very happy to see, in many of the projects [...] a great sensitivity towards urban design. We have rapid urbanisation in many parts of the world, with ever higher densities, creating new environments in which we have to live and in which we have to create nice cityscapes. Light is one of the most important aspects of making liveable spaces in big metropolises."

Natalie de Vries

All projects are available at iva.velux.com

Prize winners



1st prize
Constellation of light fields



2nd prize
Condensation of Variational Sunlight Influences



2nd prize
Lightscape between gaps

1st prize

Constellation of light fields

Students: Park Young-Gook, Kim Dae Hyun, Choi Jin Kyu, Kim Won Ill
Hanyang University, Seoul
Teacher: Masanori Tomii

The team from Hanyang University designed an immaterial roof over an outdoor stage in the Marronnier Park in Seoul. Consisting of Moebius strips of fabric that can be bent and twisted, this roof lets every type of light flow to the area below. This variety of daylighting situations corresponds to the wide variety of activities happening beneath it. The students explain: "Light is the immaterial architectural element that humans react directly to through the senses. By eliminating the material elements, light can create diversity within a given space."

"The project addresses the big urban space – it addresses the very important issue of controlling light rather than magnifying light. The project addresses structural, urban and social issues by looking at how to revive a space and how to make it habitable and viable. The jury found that the project idea was very strong and intriguing. The comprehensiveness of the project made it to the top as reliable and viable – and by discussing an idea that could also be applicable in other climates. Everything shown in the project is about testing – beautifully represented in a series of renderings and photos." (From the jury report)

2nd prizes

Condensation of Variational Sunlight Influences

Students: Ma Xin, Wang Rui, Yang Meng.
Architecture School of Tianjin University. Teacher: Jianbo Zhao

This project considers the interaction between sunlight and people's behaviour in urban life. It suggests the re-organisation of an open-air market in Kashgar, northwest China, by introducing a double-layered roof. Each of the layers has a number of square openings that produce a dramatic, ever-mobile interchange between illuminated spots and shadows.

"The work with the urban plaza has a social perspective. It investigates how light can be used to organise activities and behaviour, and perhaps help something that otherwise would be chaotic – to be ordered and more workable. The way roof patterns and the combination of the two levels have been investigated in a scale model is appreciated by the jury. The project is well presented and shows a simple idea that can easily be applicable in an urban context – not only for the interchange between sunlight and shadow but also to provide natural ventilation with the double skin." (From the jury report)

Lightscape between gaps

Student: Joe Wu
Delft University of Technology
Teacher: Daliana Suryawinata

Joe Wu's project is based on a memory of a window from when he was living in a Hong Kong apartment building in his childhood. The window was seldom opened and it was blocked by a neighbouring wall, but the effects of diagonal sunlight reflections created the most beautiful paintings in time.

The project itself is composed of reflective tiles that can be fastened to any building façade and are individually shaped to reflect sunlight into a window on the opposite wall at a given time during the day.

"The jury finds the project very workable, sensitive and simple as well as very well presented. It contains a series of reflections about privacy and how to make a space special. It works with a solution that could be universally applied to major cities all over the world – in dense urban spaces on the dark side of buildings that never receive light. Many other projects proposed the same problem – but not as clearly." (From the jury report)

Honourable Mentions

Beauty in the UnDaylightable

Students: Yan Shi, Chung-Kai Yang
Delft University of Technology.
Teacher: Lei Qu

Window shutters

Students: Ieva Maknickaite, Antanas Lizdenis, Lauryanas Vizbaras.
Vilnius Gediminas Technical University. Teacher: Linas Naujokaitis

Light in side/Inside

Student: Jiayi Zhu. Anhui University of Science & Technology, Beijing.
Teacher: Yunfeng Huang

Instant impressionism – light as a painter

Students: Wang Fei, Zheng Kaijing
School of Architecture, Tsinghua University, Beijing. Teacher: Xin Zhang

Sub-Terra apertures

Student: Stephen Kaye. Parsons New School for Design, New York.
Teacher: Philip Gabriel

Section of light

Student: Berte Daan. Eidgenössische Technische Hochschule Zürich, Switzerland. Teacher: Michael Umbricht

Fluxional light under urban scaffolds

Students: Yan Wenlong, Sheng Xiaofei, Fang Erqing, Kang Xiaopei.
Tongji University, Shanghai. Teacher: Bin Hu

Buoyant Light

Students: Claire Lubell & Virginia Fernandez. University of Waterloo School of Architecture, Cambridge, Canada. Teacher: Lola Sheppard

Wang Fei
Beijing

THE EVERYDAY POETICS OF LIGHT

For each one of us, home is a unique place. This is due to many reasons: its location, the memories we associate with it, the items we keep in it – and the distinct light inside our home. This light was explored by the winners and runners-up of the International VELUX Award 2010 in their photo project 'The light in my room'.

By Louise Grønlund

How often do we stop in the middle of our home – in the spaces that surround us every day – and try to see the light – and moreover not 'just' see but really try to sense the light? How does it affect the space? What is the orientation of the space: north, south, east or west? What time of year and what time of day is it? How is the sky outside – are there clouds? What is the colour of the light? And how do the changes of light change the atmosphere of the space?

These are just some of the questions that the students of architecture from all parts of the world, have reflected upon while making their very own portrait of the specific light in their room.

The idea

There were several ideas behind the project, but the overall idea was for the students to develop a sensitivity to see and observe the light in their surroundings. Once they have changed their way of sensing the light, their views about light will be permanently changed. So the intention was to pass on an awareness of light which they can use when designing architecture.

Another purpose of the project is to illustrate one of the qualities of light: that it is ever changing and will never appear the same way twice. The project thus serves to clarify the quality of the transitions between different light conditions during the day and during the different seasons.

Yet another interesting aspect is to show how very differently we arrange our homes all over the world. This includes the different design of

windows or light-openings, as well as the things in front of the windows, such as filters or curtains. It even includes the furniture we place near the window(s) – in the space of the window.

The frame for the project

The place for the project was the home of each student, and the assignment was to stay inside for 12 hours and document, reflect and observe the light in the room. Each student had to produce at least 12 photographs taken from the same position over a day. The photos should only be of natural light. The students were also asked to think about the framing of their photo and examine how much or how little of the space should be framed in the photo in order to show the light.

The light in their rooms

The students that were invited for this project were the winners and honourable mentions from the International VELUX Award 2010. A total of 19 students from all over the world contributed with their view upon the specific light in their room.

In general, the projects can be divided into two categories of photographs. The first one shows the openings or windows themselves, which let the light into the space. The second category of photographs shows the light which is created by the openings. Both categories are essential, and they supplement each other very well to describe the phenomenon of light.

Looking at the images that the students produced, it is fascinating

both to see series of photos where the light changes significantly throughout the day, and series where only nuances of light are changing the space. Another set of differences between the series consists in the light openings and filters such as curtains, which modulate the light and thereby make its many qualities visible.

Louise Grønlund graduated as an architect from the Royal Danish Academy of Fine Arts, School of Architecture, in Copenhagen in 2006, and subsequently taught there for three years. In summer 2009 she started her PhD entitled 'Light Space – the spatial potentials of the facade' at the School of Architecture in Aarhus, Denmark. She also works as an architecture photographer for the Danish magazine Arkitekten and for several Danish architects. In 2006, Louise Grønlund won the first prize at the International VELUX Award with the project 'A museum of Photography'. In the context of the International VELUX Award 2010, she organized the student workshop 'A portrait of the light in La Rochelle', as well as the photo project 'The light in my room'.

Wang Fei
Beijing





01 Virginia Fernandez
Cambridge, Canada



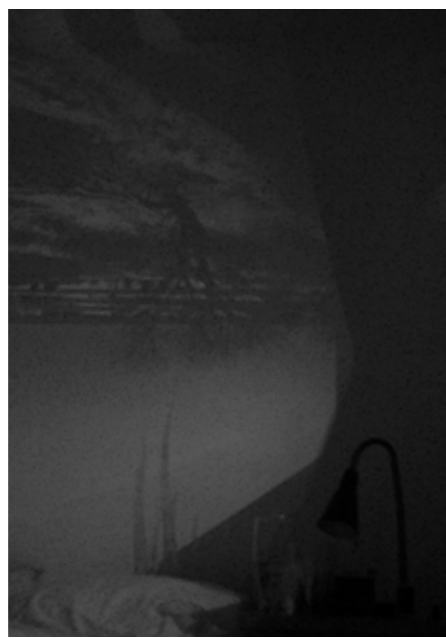
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01 Leva Maknickaite
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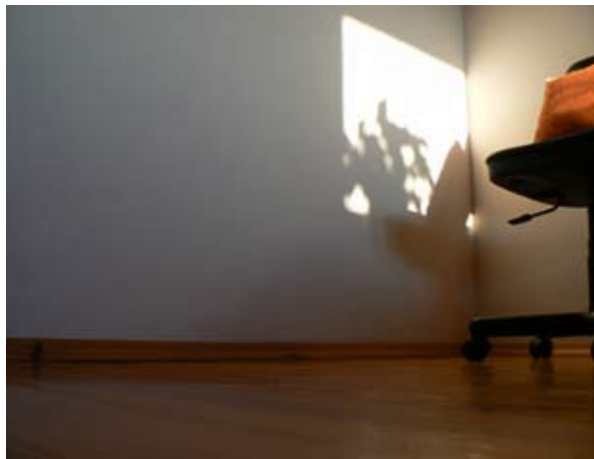
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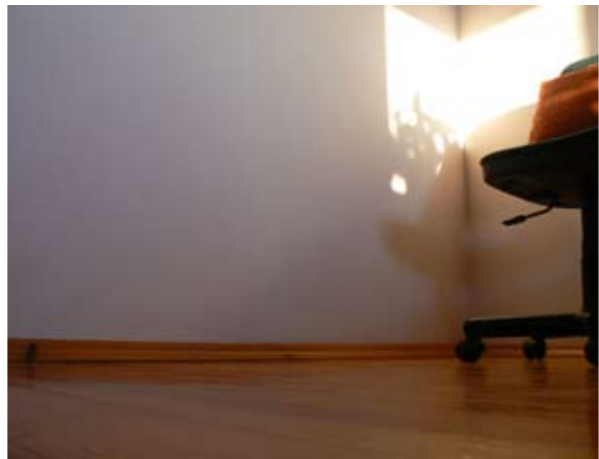
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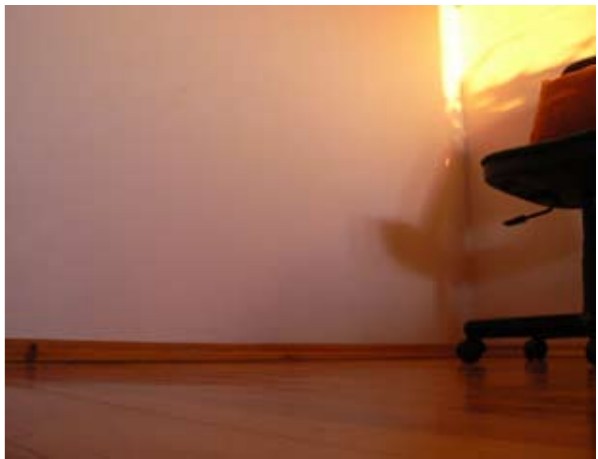
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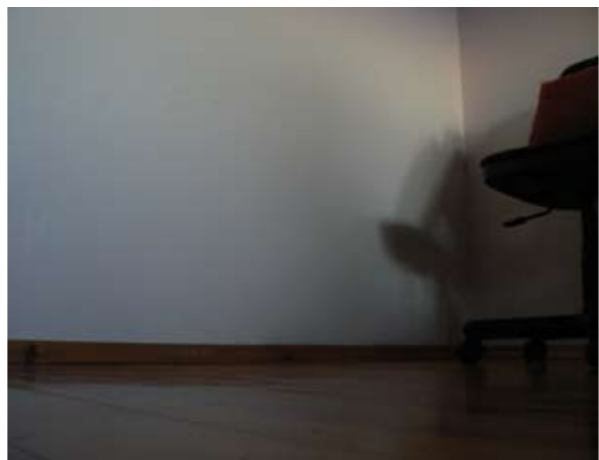
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Tinyiu Fung
Delft



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