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DAYLIGHT & ARCHITECTURE MAGAZINE BY VELUX GROUP AUTUMN 2016 ISSUE 26 10 EURO
DAYLIGHT MATTER(S)

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When asking people what matters most in their lives, they will most likely mention fundamental, immaterial human values like friendship, health and happiness.

Even though people might not mention it at first thought, daylight certainly does a great deal to keep us healthy and happy, and enrich our everyday lives with sensuous pleasure. So daylight does, indeed, matter to all of us, although we only become acutely aware of this fact when it is lacking.

This issue of Daylight/Architecture discusses the vital importance of natural light from a variety of viewpoints.

In the opening essay, Juhani Pallasmaa underlines how daylight, in all its nuances, interacts with our senses, and how great architects have harnessed this interplay to create memorable spaces. In many of these buildings, light becomes almost a material of its own. The impact of daylight on our health and wellbeing is discussed by Deborah Burnett in her article. She gives an update on the fascinating research in recent years that have led to scientists discovering ever more pathways through which light exposure influences our sleep/wake cycles, hormone production, performance and alertness levels, and much more. Based on these findings, Peter Holzer calls for a reconsideration in his article of many established standards and practices in building design. Rather than targeting momentary comfort, Holzer argues that designers should take the long-term health effects of buildings into account. This would imply allowing much more daylight into buildings and employing natural ventilation over a greater period of time during the year than has been done so far.

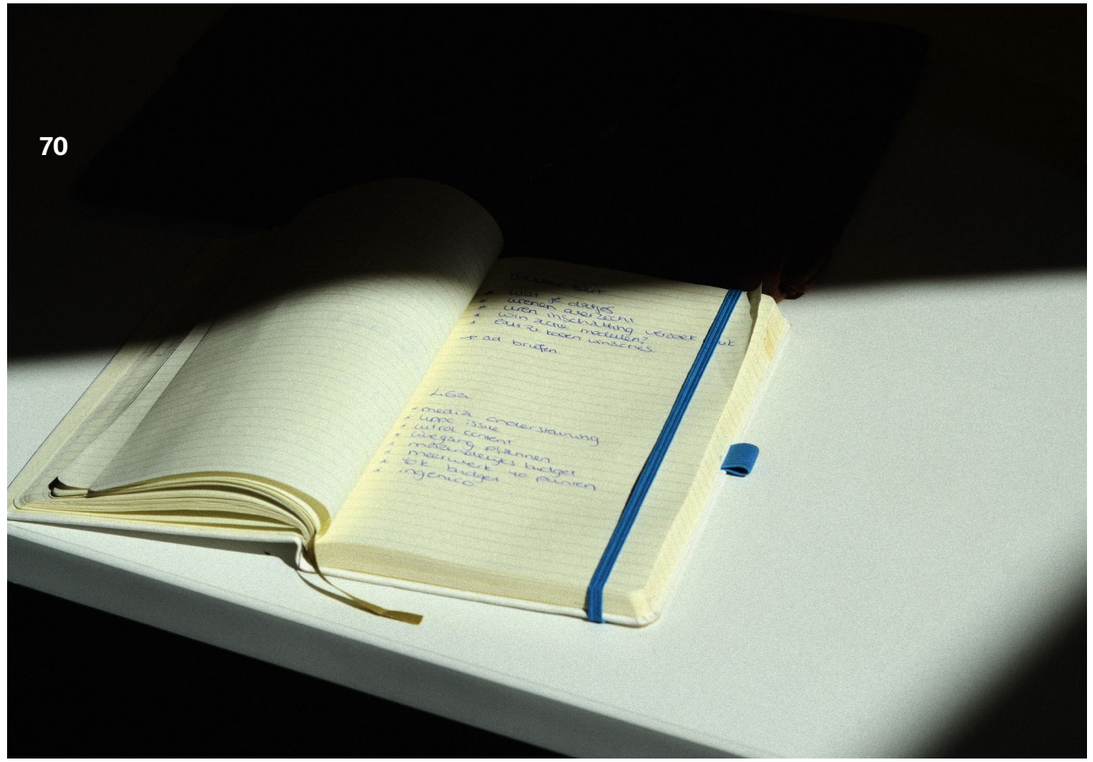
The four projects featured in this edition are recent examples of the interplay of light, human health and wellbeing. In their images and comments in short handwritten notes, the photographers Adam Mørk and Daniel Blaufuks seek to capture the magic that natural light gives to a building's atmosphere and to the bodies and minds of people living, working and learning in buildings.

We hope that some of this magic is conveyed through the magazine.

Enjoy the read!
The VELUX Group

AUTUMN 2016
ISSUE 26

D/A



DWELLING IN LIGHT:

TACTILE, EMOTIVE AND LIFE-ENHANCING LIGHT

Natural light plays a vital role in the symphony of our senses, is a precondition for human health, and gives us a sense of space and time. Yet, most of the time, we are unaware of its importance and take its presence for granted. Great works of art and architecture have the potential to change this. They let us experience light in all its nuances and colours, feel its interaction with material and space, and "make visible how the world touches us," as Maurice Merleau-Ponty once wrote.

Text by Juhani Pallasmaa
Images by Simon Schubert

"... we were born of light. The seasons are felt through light. We only know the world as it is evoked by light, and from this comes the thought that material is spent light. To me, natural light is the only light because it has mood. It provides a ground of common agreement for man, it puts us in touch with the eternal. Natural light is the only light that makes architecture architecture ..." [1]

Louis Kahn

WE TEND TO BE indifferent to the most basic things in our life world, such as gravity, air, water and light, and regard them as self-evident background conditions. We usually become aware of these crucial phenomena only when we are deprived of them. Light and the cycles of the day and seasons are absolute conditions for life, yet we do not grasp the multitude of ways our existence and well-being depend on light. Usually we see light merely as a medium of vision, and architecture is also regarded as a visual art, thus neglecting its deep, existential grounding in lived reality as well as myth. Light is life – we live with light, attune ourselves to light and resonate with the conditions of illumination.

Experiencing space

The experiences of matter, space and light are inseparable. And there is no true architectural experience without light, except the limited and specific experiences of spatiality grasped in darkness through hearing, touch and smell. Even in those cases, the spatial experience usually refers to the characteristics of space acquired through vision and light. In Experiencing Architecture, Steen Eiler Rasmussen recalls the powerful acoustic percept of the underground tunnels in Vienna, the memorable setting in Carol Reed's film The Third Man (1949): "Your ear receives the impact of both the length and the cylindrical form of the tunnel."[2] Significantly, the last chapter of Rasmussen's book is entitled "Hearing architecture"[3].

We can similarly 'hear' the specific shapes of Romanesque cloisters and Gothic cathedrals by means of their powerful and evocative echoes. The dying notes of a Gregorian chant mark the depth and height of the cathedral, and the ascension of a fugue on the organ enhances the weave of the Baroque vaults and ornaments. In the silent darkness of the night, the echo of our footsteps on the paved streets of an old town, reflected back by the weathered walls, creates a pleasurable spatial experience and a deep sense of belonging.

The multi-sensory touch

Our senses interact – we see through our ears as much as we hear and touch through our eyes. We do not sense the world as isolated sensations, we sense it at once as a single entity. The fact that our knowledge of the senses is largely based on isolated experiments has prevented a comprehensive and embodied understanding of our world as well as of ourselves.

All sensory experiences are, fundamentally, experiences of touch; we touch with our eyes, ears, nose and tongue as much as we do with our skin. In addition to the five Aristotelian senses, we measure and touch the world with our senses of gravity, balance, movement, temporal continuum and self. We touch the world most fundamentally by our existential

Sources:

1. As quoted in Henry Plummer, Poetics of Light A+U Architecture and Urbanism, 1987 December, Tokyo, Extra Edition, p. 135.
2. Steen Eiler Rasmussen, Experiencing Architecture, MIT Press, Cambridge, Massachusetts, 1993.
3. Ibid., p. 225.

> “My perception is [therefore] not a sum of visual, tactile and audible givens: I perceive in a total way, with my whole being: I grasp a unique structure of the thing, a unique way of being, which speaks to all my senses at once.”
>
> Maurice Merleau-Ponty

sense, but this basic experience is not regarded as a sense as such.[4]

All real experiences of architecture are embodied and multi-sensory. Maurice Merleau-Ponty gives this simultaneous, multi-sensory essence of experience a poetic description: “My perception is [therefore] not a sum of visual, tactile and audible givens: I perceive in a total way, with my whole being: I grasp a unique structure of the thing, a unique way of being, which speaks to all my senses at once.”[5]

Light and place

Every distinct space and place has its characteristic light, and light is often the quality that most directly conditions our mood. Light is the strongest conditioner of the atmosphere of place, the most comprehensive criteria of the character of space, place and setting. Just think of the joy and revitalising energy of the morning light, or the romantic but weary light of the evening, the cool light of a moonlit night, and the emotive hues of the light of sunrise and sunset. Our senses and body rhythms are attuned and calibrated to the daily and seasonal cycles of light, as with all life on this planet.

Light controls the processes and rhythms of life – even our essential hormonal activities, which also have a profound effect on our moods, activities and energy levels, depend on light. In fact, we have two separate systems that arise from light: vision and the circadian rhythms. The first locates us in space, the second coordinates our metabolic functions with time and the world. Both are equally important, but they require different quantities and qualities of light. However, our technological and utilitarian culture tends to distort our natural relationships with light. In principle, we have too little sunlight during the day and too much light at night.

One would expect the Technological Man, who is conquering the depths of the universe to know himself, but we know very little of, for example, the dizzying world of bacteria in our intestines: we have a hundred times more bacterial DNA in our bodies than human DNA.

Light and shadow

In lighting design, light is the unquestioned protagonist and we tend to forget the role of shadow. Light and its accompanying shadow give volumes, surfaces and spaces their character and expressive power, and they reveal the form, weight, hardness, texture, moistness, smoothness and temperature of material objects. The interplay of light and shadow also connects architectural spaces with the dynamics of the physical and natural worlds, seasons and the hours of the day. “What is there more mysterious than clarity? [...] What more capricious than the way in which light and shade are distributed over hours and over men,” Paul Valery asks.[6] Natural light brings life into architecture and connects the human world with cosmic dimensions. Light is the cosmic breathing of the universe.

Light has its own atmospheres, ambiances and expressions; it is surely the most subtle and emotive of the means of architectural expression. No other medium of architecture – spatial configuration, form, geometry, proportion, colour or detail – can express equally deep and subtle extremes of emotion, ranging from melancholy to joy, grief to ecstasy, sorrow to bliss. The occasional and happy mixing of the cool light of the northern sky and the warm light of the southern sky in a single space can give rise to the experience of ecstatic happiness.

Light and shadow articulate spaces into sub-spaces and places, and their interplay gives space its character, rhythm, sense of scale and intimacy. As Constantin Brancusi notes, “Art must give suddenly. All at once, the shock of life, the sensation of breathing”[7]. In architecture this sensation of breathing is mediated by light. Light directs movement and attention, creating hierarchies and points of importance and focus. Due to its fluttering character, candlelight is especially tactile; it seems to finger objects and surfaces like a gentle massage. Candlelight creates an entire universe of intimacy. No wonder Gaston Bachelard wrote an entire book on the light of the candle.[8]

Architectural light

Light has dramatically varying characteristics in architecture, as exemplified by the singular metaphysical disc of illumination sliding across the coffered walls of the Pantheon, the immaterial foliage of form, ornamentation and light in the Baroque churches of Bavaria, the symphonic ensemble of coloured perforations through the thick south wall of Le Corbusier’s Ronchamp Chapel, and the softly embracing and therapeutic light of Alvar Aalto’s Church of the Three Crosses. The rhythmically vibrating and musical light of Juha Leiviskä’s churches feels as if Mozart himself were playing these rays of lights. His use of reflected colour adds yet another dimension of vibrating sensuality. The finest examples in architectural light turn architectural constructions into delicate instruments to play the music of light.

> “Sunlight never knows how great it is until it hits the side of a building or shines inside a room.”[9]
>
> Louis Kahn

Contained light, liquified light

Light tends to be experientially and emotionally absent – we see the illuminated object rather than the light. Light needs to be contained by space, or concretised by the surfaces that it illuminates. “Sunlight never knows how great it is until it hits the side of a building or shines inside a room.”[9] Through a mediating matter, such as fog, mist, smoke, rain, snow or frost, light turns into an illuminating virtual substance. The emotive impact of light is remarkably intensified when it is perceived as a substance; the liquified light feels like a moist veil on the skin and even seems to penetrate into the pores of our skin.

The paintings of J.M.W. Turner and Claude Monet exemplify this embracing atmospheric light made tangible by moisture of the air. Alvar Aalto’s daylight arrangements frequently reflect light by means of curved white surfaces. The chiaroscuro created by Aalto’s rounded surfaces gives light an experiential materiality, plasticity and heightened presence. This light has a specific weight, temperature, touch and feel. This is a moulded light that feels like matter.

The narrow roof slits of Tadao Ando’s and Peter Zumthor’s buildings force light into thin directional sheets that cut through the darkness of space like immaterial veils or blades. In Luis Barragan’s Chapel for Capuchinas Sacramentarias in Mexico City, light turns into a warm, coloured liquid that even suggests sonorous qualities invoking an imaginary humming sound – the architect himself writes about “the interior placid murmur of silence”[10]. The lights, colours and reflections in Barragan’s Gilardi House create a true visual miracle. This architectural abstraction transcends our earthly reality; this light is an annunciation.

Light and colour

Yet even more unexpected transformations, materialisations and miracles of light take place in artistic works. The coloured windows of the Matisse Chapel in Vence and many of James Turrell’s light works turn light into coloured air, invoking delicate sensations of skin contact, temperature and oscillation; these spaces make you feel like you are being submerged in a transparent, coloured substance that turns light and colour into haptic sensations. Steven Holl’s use of reflected light and colour creates the sensation of a pulsating mixture of colour and light, a condition that paradoxically heightens both the immateriality and concreteness of light. This is a caressing, breathing and healing light that connects us with the constantly changing nature of daylight and projects a cosmic ambience.

4. Steinerian philosophy acknowledges twelve senses, and one of them is “the life sense”. Albert Soesman, Our Twelve Senses: Wellsprings of the Soul, Hawthorn Press , Stroud, Glos, 1998.
5. Maurice Merleau-Ponty, "The Film and the New Psychology", Sense and Non-Sense, Northwestern University Press, Evanston, IL, 1964, p. 48.
6. Paul Valery, "Euphalinos, or the Architect", Dialogues, Pantheon Books, NewYork, 1956, p.107.
7. As quoted in Eric Shanes, Constantin Brancusi, Abbeville Press, New York, 1989, p. 57.
8. Gaston Bachelard, The Flame of a Candle, The Dallas Institute Publications, Dallas, Texas, 1984.
9. Louis Kahn, paraphrasing Wallace Stevens in "Harmony Between Man and Architecture", Louis I Kahn Writings, Lectures, Interviews, edited by Alessandra Latour, Rizzoli International Publications, New York, 1991, p. 343.
10. Louis Barragan, Official address, 1980 Pritzker Architectural Prize. Reprinted in Barragan: The Complete Works. Raul Rispa, ed., Thames and Hudson, London, 1995, p. 205.

"We have lost our sense of intimate life, and have become forced to live public lives, essentially, away from home." [11]

Luis Barragan

"Art must give suddenly. All at once, the shock of life, the sensation of breathing."

Constantin Brancusi

Alienating light

In today's ordinary architectural practices, light is regrettably often treated merely as a quantitative phenomenon; design regulations and standards usually specify required minimum levels of illumination and window sizes, but they do not define maximum levels of luminance, or desired qualities of light, such as its orientation, temperature, colour or reflectedness. Besides, our buildings tend to permit too much light and distribute it too evenly, thus weakening the sense of place, intimacy and secrecy. An evenly lit, shadowless space has a nauseating and alienating effect. No wonder a powerful means of breaking the defences of self in political and criminal interrogation and torture is the use of mercilessly bright light.

Ever since the early 20th century, modernity has been obsessed with large surfaces of glass and, consequently, excessively high levels of illumination. No wonder Luis Barragan, the alchemist of modern architecture, argued that most modern buildings would be more pleasant with only half their window surface. "[T]he use of enormous plate windows ... deprives our buildings of intimacy, the effect of shadow and atmosphere. Architects all over the world have been mistaken in the proportions they have assigned to large plate windows or spaces opening to the outside ... We have lost our sense of intimate life, and have become forced to live public lives, essentially, away from home."[11]

In praise of shadows

The irreplaceable value of darkness and shadow is the lesson of Junichiro Tanizaki's delightful book In Praise of Shadows. The writer points out that even Japanese cooking uses shadows and that it is inseparable from darkness: "And when Yokan is served in a lacquer dish within whose dark recesses its colour is scarcely distinguishable, it is as if the darkness of the room were melting on your tongue".[12] This is yet another sensory metamorphosis; darkness turns into taste and fragrance.

Light acquires a heightened value and emotive power in relation to shadow and darkness. In the pitch-black primordial smoke hut of the Finnish peasant, the light of a single tiny window feels like a jewel, a gracious gift presented to the inhabitant in the form of a radiant diamond of light, set on a dark matt background blackened by decades of smoke and soot. In comparison, the excessive light of a contemporary glass wall is usually a source of sensory irritation and often causes a defensive repression of vision due to the painfully excessive illumination level.

Light and whiteness are associated with health and vitality, and the modern era aspires for an abundance of light. Contrary to the prevailing modernist aspiration, the Council Chamber of Alvar Aalto's Säynätsalo Town Hall and the ecclesiastical spaces of Sigurd Lewerentz create a soothing darkness that

11. Alejandro Ramirez Ugarte, "Interview with Luis Barragan" (1962) in Enrique X de Anda Alanis, Luis Barragan: Classico del Silencio, Colección Somosur, Bogota, 1989, p. 242.
12. Jun'ichiro Tanizaki, In Praise of Shadows, Leete's Island Books, New Haven, Connecticut, 1977, p. 16.

> "The world touches us and we touch the world, primarily through the medium of light."
>
> Juhani Pallasmaa

facilitates the experience of concentration and meditation. In both cases, darkness is emphasised by dark, rough brick surfaces that seem to absorb all reflected light. In Lewerentz's St. Petri's Church in Klippan, the deep crack in the brick floor, with water dripping slowly from a gigantic white sea shell into the darkness of the earth, echoes and emphasises the darkness and dizzying depth of the space of the universe, the space of nothingness and eternity. The darkness in the floor is an open grave. But it is also a calming window to eternity.

Deep shadows and darkness are essential, because they dim the sharpness of vision, make depth and distance ambiguous, and invite unconscious peripheral visions and tactile fantasies. "Shadow itself is of the light,"[13] as Frank Lloyd Wright observed. We are not normally aware of the strong haptic and embodied ingredients in our visual perceptions, but twilight reveals these forgotten sensibilities. Sight is activated and sharpened in twilight. As Turrell points out, the evolutionary process has tuned the human eye for twilight rather than bright daylight. Normal illumination levels today are so high that the full capacity of vision is suppressed as the pupil automatically closes. Paradoxically, our culture reveres vision and visibility, but at the same time it weakens the capacity of vision through the use of excessive light.

The thingness of light

Light is understood as a purely optical phenomenon, but it is also connected with haptic perception. James Turrell speaks consequently about "the thingness of light"[14]. "I basically make spaces that capture light and hold it for your physical sensing [...] It is [...] a realization that the eyes touch, that the eyes feel. And when the eyes are open and you allow for this sensation, touch goes out of the eyes like feel".[15] Turrell's light works are completely based on the experiential qualities of light and the characteristics of our perceptual mechanism, but they also give rise to spatial experiences that re-orient our judgement of figure and ground, near and far, horizon and verticality. These works turn light into a substance that seems to have its own haptic qualities and sense of materiality, pressure and weight. Turrell also concretises the age of light. We tend to think of light as a phenomenon of the instant, the very definition of nowness. Yet, some of Turrell's light devices select light from the deep universe that is enormously old; he speaks appropriately of "old light".
We inhabit simultaneously two domiciles: the physical world of matter and sensory experience on the one hand, and the mental world of mental realities, imagination, ideas and intentions on the other. These two worlds constitute a continuum, an existential singularity. In addition to its utilitarian purposes, the profound task of architecture is to "make visible how the world touches us", as Merleau-Ponty writes of the paintings of Paul Cézanne.[16] The world touches us and we touch the world, primarily through the medium of light. "Through vision, we touch the sun and the stars".[17]

Juhani Pallasmaa (born 1936), architect and professor emeritus, has held positions such as Rector of the Institute of Industrial Design, Director of the Museum of Finnish Architecture, and Professor and Dean of the School of Architecture, Helsinki University of Technology. From 2008 to 2014, he was member of the Pritzker Architecture Prize Jury. Juhani Pallasmaa has published 50 books, including: The Embodied Image, The Thinking Hand, The Architecture of Image: existential space in cinema, and The Eyes of the Skin. He is an honorary member of SAFA, AIA and RIBA, Academician of the International Academy of Architecture, and has received five Honorary Doctorates.

13. As quoted in Robert McCarter, Frank Lloyd Wright: A Primer on Architectural Principles, Princeton Architectural Press, New York, 1991, p. 284.
14. James Turrell, The Thingness of Light. Scott Poole, ed., Architecture Edition, Blacksburg, Virginia, 2000, pp. 1,2.
15. Ibid., pp. 1,2.
16. Maurice Merleau-Ponty, "Cezanne's Doubt" in Sense and Non-Sense, p.19.
17. As quoted in David Michael Levin, Modernity and the Hegemony of Vision, University of California Press, Berkeley and Los Angeles, 1993, p.

"Light is the basic, indispensable material of architecture. It has the mysterious but real capacity – the magical capacity – of bringing space into tension with man. The capacity of endowing that space with such quality that people are deeply moved by it."

Alberto Campo Baeza

LIGHT AS A TREAT (MENT)

"Art does not reproduce what we see; it makes us see," wrote the Swiss painter, Paul Klee. The same can be said – with even greater emphasis – of architecture. Great buildings have always rendered things visible that would otherwise pass unnoticed, from the character of a place to the simple beauty of natural phenomena. Daylight, in particular, has a profound influence on our health and well-being. It is both a treat and a treatment that the sun sends us for free every day. Yet we rarely become aware of it until a particular experience makes us reflect on our relation to daylight.

The photographs of offices, dwellings and a university building, as well as the handwritten notes, on the following pages, seek to contribute to this reflection. The two photographers, Adam Mørk and Daniel Blaufuks, have captured both their own sensual experience and the behaviour of people inside these buildings. The photographs thus look inwards and outwards at the same time. How, and where, does daylight enter the spaces? How does it influence where people sit, stand and move? How does the intensity and colour of light change over time? How can the warmth of the sun be felt on the walls and furniture, and on one's own skin? Welcome to a journey to daylight and the everyday miracle that it performs in the buildings we inhabit.

Photography: Adam Mørk and Daniel Blaufuks
Collages and handwritten notes: Daniel Blaufuks

PHOTO: ADAM MØRK

PHOTO: DANIEL BLAUFUKS

PHOTO:ADAMMØRK

PHOTO: ADAM MØRK

PHOTO: DANIEL BLAUFUKS


PHOTO: DANIEL BLAUFUKS

WHERE IDEAS FLOURISH

Storage shed conversion in Tilburg

The light-filled brick building near Tilburg Railway station, where employees of an IT company work and the "de Houtloods" restaurant caters for its guests, was originally erected as a storage shed for timber by the Dutch National Railway. For 150 years, it was closed to the public, as was the entire surrounding area. This did not change until a few years ago, when the city bought up the railway land and began development of a new urban district on the site.

In its original state, the building had been a place full of light and fresh air. The arcades on its south side were open and a line of skylights stretched along the ridge of the roof. The naturally drying wood was supposed to foster the circulation of fresh air.

Later, the building was converted into a workshop, with the sides walled up and all the skylights sealed. In the context of the recent conversion, the architects Bedaux en de Brouwer reversed this loss; large window openings on both sides now admit light for the employees and restaurant guests, while a new strip of skylights set into the pitched roof opens up a view of the skies above. This is especially beneficial for those IT experts who, literally, sit between the roof trusses on the upper floor. In order to create the floor space needed for the offices, the architects placed two large oak-panelled structures in the long hall. On their insides are meeting rooms and desks for concentrated individual working, whereas the "panorama deck" above is used for communication-intensive group work. Between the two structures, there is an auditorium with seating steps for lectures and training courses.

The size of the hall can be best appreciated in the restaurant and in the long corridor on the south side. Here, the architects installed ceiling-high glass facades on the inside of the brick walls. This made it possible to leave the facades of the old building untouched and, at the same time, provide a maximum amount of daylight and views to the outside for the people in the building.

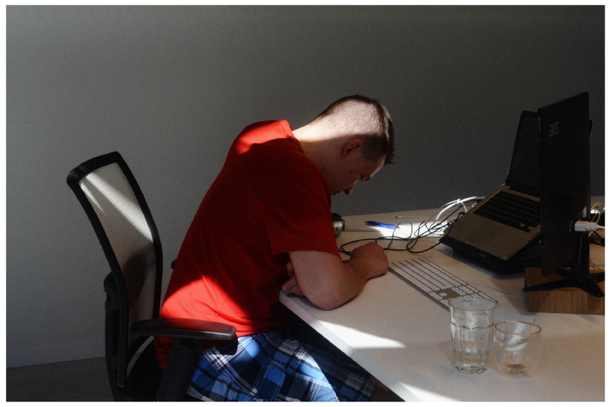
CLIENT:
Stichting de Houtloods, Tilburg, NL
ARCHITECTS:
Bedaux en de Brouwer, Goirle, NL
LOCATION:
Burgemeester Brokxlaan 1041,
Tilburg, NL


41

OFFICE

tilburg, NL

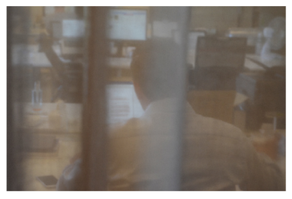
light and colour



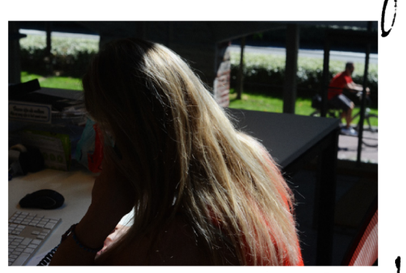
An element of visual space may be white or red,

but can't be either transparent or opaque.

L.W.

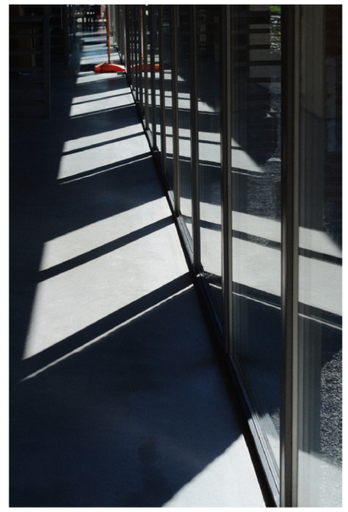


if the word "blond" itself can sound blond, then it's even easier for



photographed hair to look blond.'

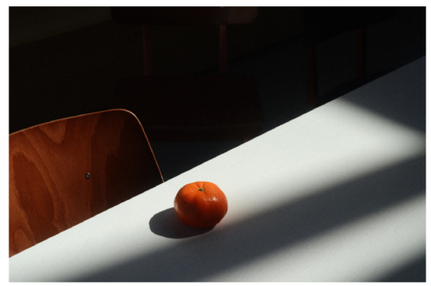
L.W.



in praise of shadows

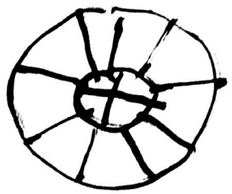
LIGHT IS

A BLESSING



DE HOUTLOODS

restaurant in Tilburg



there is a
crack in everything,
that's where the
light comes in.

L.C.

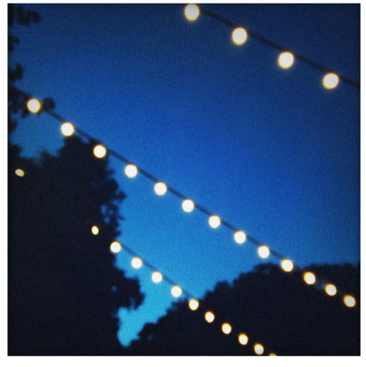
personally I choose
restaurants first
for the light, second
the menu ...

ATHOSPHERIC

LIGHT

the concept of light
should be treated as
a concept of sensation.

there are people
who see



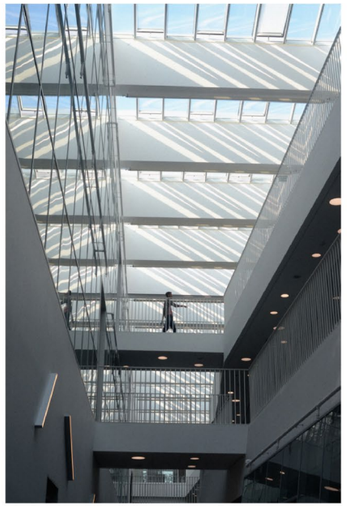
WAYS INTO THE LIGHT

Faculty building in Odense

An entire university under one roof. This was the idea that guided architects Krohn & Hartvig Rasmussen in the 1970s when they created the campus of the University of Southern Denmark on the outskirts of Odense. The new Technical Faculty building, designed by C.F. Møller at the edge of the campus 40 years later, is based on similar principles. Measuring 110 × 65 metres – the size of a football pitch – the three-storey building accommodates three institutes under its roof. The challenge for the architects was to bring daylight into this enormous structure. They therefore divided the interior into four independent edifices that share the same roof but are separated from each other by a network of streets, pathways and squares. Student life takes place on these streets and on the large, copper-clad open staircase in the middle of the building. The bridges and galleries on the upper floors not only connect the different institutes to each other but also serve as important meeting points for informal chats. Here, 700 square metres of modular skylights resting on prefabricated concrete roof girders make for a light and lively atmosphere. On the remaining roof surfaces, 750 square metres of solar modules were installed.

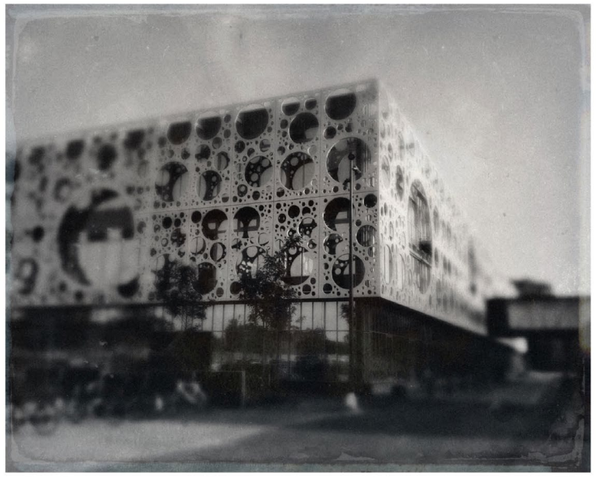
The 3,000 students and 300 employees also profit from the natural light in the laboratories, offices and group workrooms of the individual buildings. Thanks to their large glass surfaces, the rooms offer a generous and clear view of the interior streets and the outside areas, i.e. the rest of the campus. On the upper floors, an ornamental feature consisting of white fibre-reinforced concrete elements, with 15,000 apertures of different sizes, encloses the entire building and offers protection against the sun. This not only provides shade but also frames a variety of different views of the university campus and the forested area neighbouring the faculty on its east and south sides.

CLIENT:
Bygningsstyrelsen, Valby, DK
Technical Faculty of SDU, Odense, DK
ARCHITECTS:
C.F. Møller, Copenhagen/Aarhus, DK
LOCATION:
Campusvej 55, Odense, DK

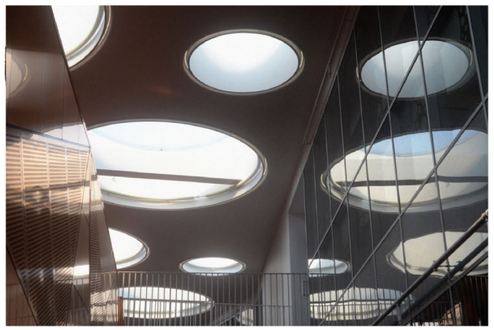


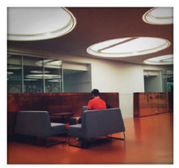
Tekniske Fakultet

Syddansk Universitet
Odense, DK

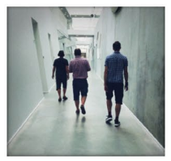


you turn right
and you see it,
it looks like a big
CHEESE!

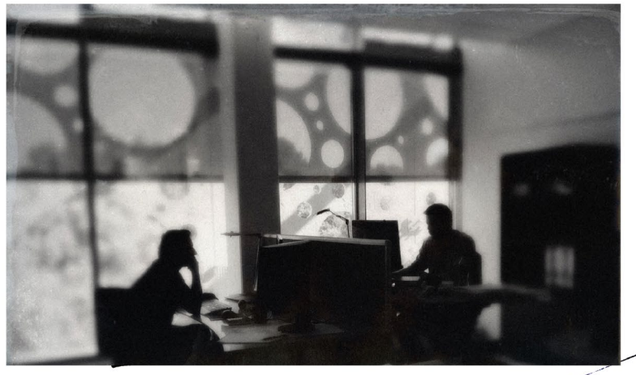


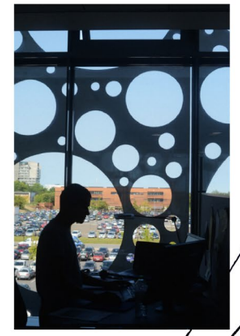


there is a light that never goes out



as light, wisdom seems to come
from above.





awareness

learning

ENLIGHTENMENT

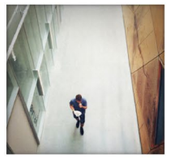
education

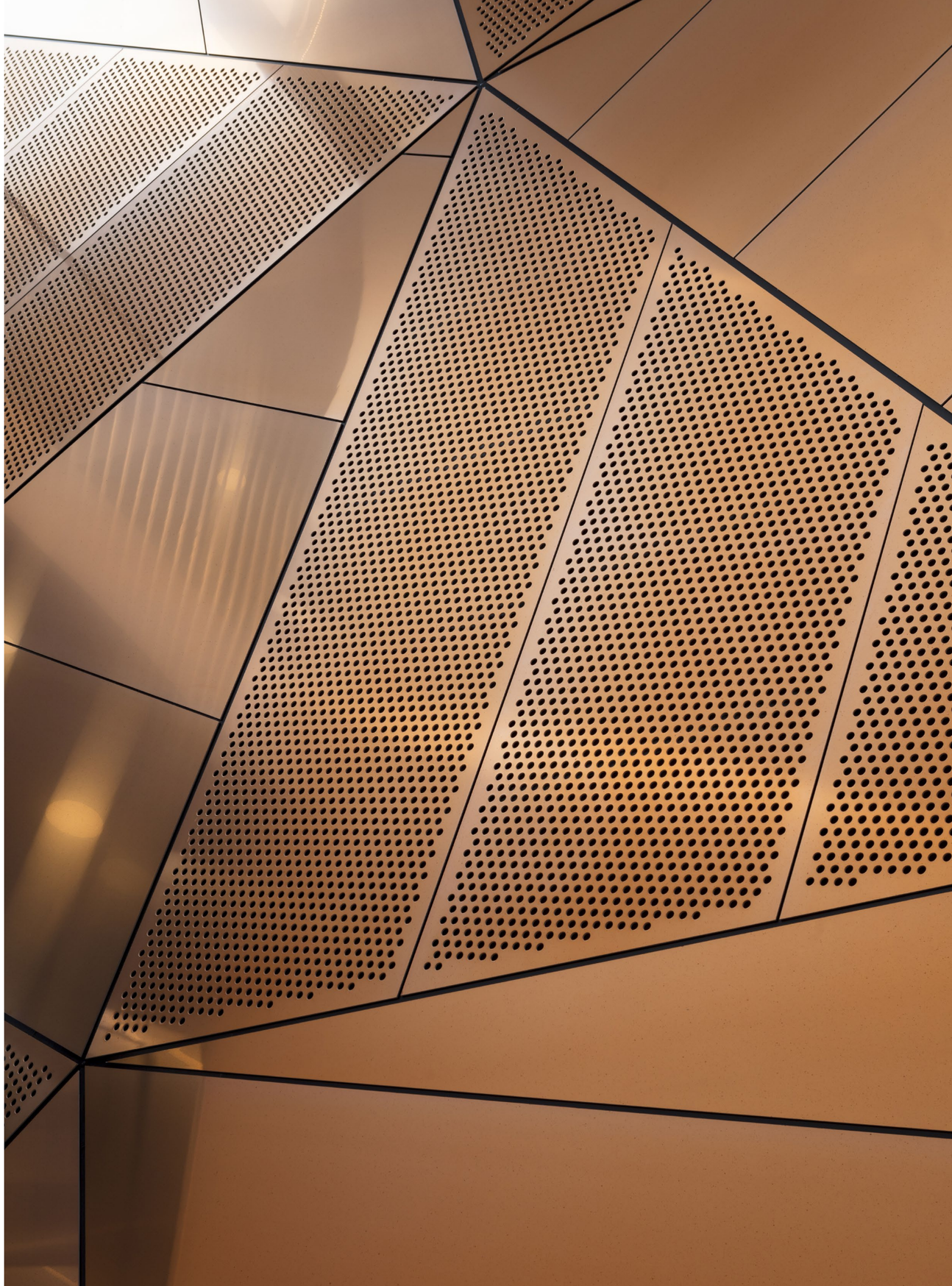
understanding

knowledge

information

erudition





RESURRECTED FROM THE RUINS

Terraced houses in Sesto San Giovanni

Architects Gino Guarnieri and Roberto Mascazzini have erected a chameleon-like terrace of houses in Milan's north-eastern suburb of Sesto San Giovanni. Gabions cover the majority of the facades and roof whereas on the north and south sides of each home, a broad strip of copper sheeting stretches from the building's base upwards beyond the gutter line. Windows seem almost entirely absent at first glance, with the exception of the roof windows that supply the rooms on the uppermost floor with daylight. On the northern side, a combination of roof and facade windows offers residents an excellent view over a nearby landscaped park.

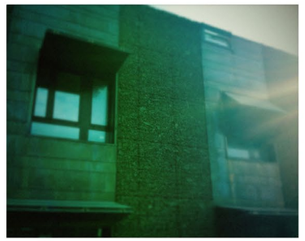
A closer look at the houses reveals that their intelligent construction has much in common with that of traditional residential homes in the north of Italy. Mechanically operated folding shutters can be opened in the copper cladding, revealing generously sized windows and glazed terrace doors. When open, these shutters protect the residents from the scorching summer sun as well as from the rain. The massive external walls of the houses act as a thermal buffer that keeps the daytime heat out of the rooms in summer.

Both the shape and materials of the new builds are a reminder of the history of the site. Centuries ago, the Cascina Gatti neighbourhood used to be a farming village, little of which remains amidst the large residential blocks and commercial buildings in the area today. One exception used to be a large, derelict barn that stood on the building site and partly lives on in the six new homes. Not only is their length, height and width equivalent to that of the old barn but also the facade materials are partly the same: the gabions are filled with brick rubble from the agricultural building, as well as with former porphyry paving stones.

The protective stone cladding is only a few centimetres thick. Behind it, a layer of aluminium trapezoidal sheet metal serves to drain off the water from the roof and facades. This is then stored in an underground tank and reused to irrigate the grounds. A lot of detailing that is otherwise found on residential buildings, such as eaves, gutters and downpipes, was dispensable due to this method of construction. Chimneys are also missing in the houses as they are heated in a climate-friendly way by electrical heat pumps in combination with underfloor heating.

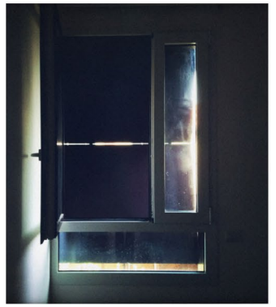
CLIENT:
Immobiliare Bandello, Milan, IT
ARCHITECTS:
Gino Guarnieri, Roberto Mascazzini, Milan, IT
LOCATION:
Via Verona, 6,
20099 Sesto San Giovanni, IT

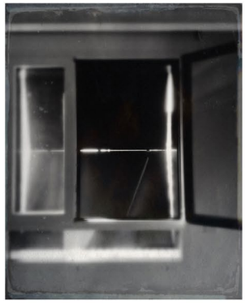
housing project in



Sesto Giovanni, Italy

bedroom

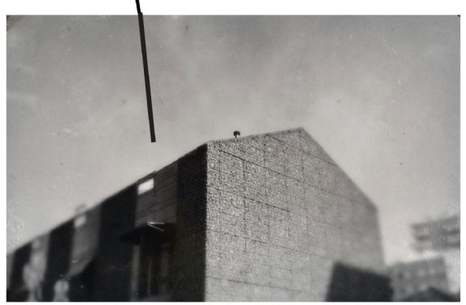




windows

baby room

recicled materials



attic

suspended shadows


ALE ♡
TIAMO

GREEN OASIS

Office building in Haelen

Everyone was to profit when the mechanical engineering company Geelen Counterflow decided to expand its headquarters with a new office building in the industrial area of Haelen. Here, 50 new workstations were created for the office staff, the workers from the adjacent factory hall acquired new changing rooms and the workforce as a whole was given a new canteen. The emphasis in each case was on very high quality. In the BREEAM-NL certification system, the new building was given five stars, the highest achievable rating. The main reasons for this were the healthy interior climate and the highly ecological design of the new building, in line with cradle-to-cradle principles. Supports, load-bearing walls and ceilings are made of solid timber elements from the Black Forest that were made using wooden dowels rather than glue. Most of the construction was prefabricated and, at the end of its life cycle, can be easily dismantled and recycled. Geothermal heat pumps, solar collectors and more than 330 photovoltaic modules on the roof supply more energy than the building needs during the course of the year.

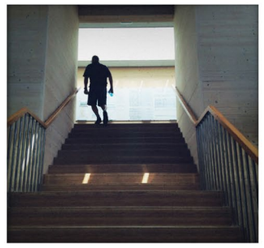
Ceiling-high windows in the wooden facades allow an abundant amount of light into the offices. They are merely an initial foretaste of the openness and transparency existing in the interior of the building. Only glass walls separate the individual areas, so that oblique views through the entire building and into the neighbouring factory hall are possible. The daylight, which enters through three modular skylights, reaches the training rooms and corridors deep in the interior of the building. The architects placed one of the skylights above the two-storey atrium in the middle of the building. This benefits not only the people who are present there but also a huge, two-storey wall of plants. The naturally grown work of art is more than an impressive eye-catcher; in harmony with light and wood, it transforms the space into an unexpected oasis of tranquility and helps to pleasantly improve the quality of the air in the building.

CLIENT:
Geelen Counterflow, Haelen, NL
ARCHITECTS:
Architecten en Bouwmeesters, Herten-Roermond, NL
LOCATION:
Windmolenven 43, Haelen, NL

LIGHT AS A TREAT(MENT)

Counterflow

Utrecht, NL

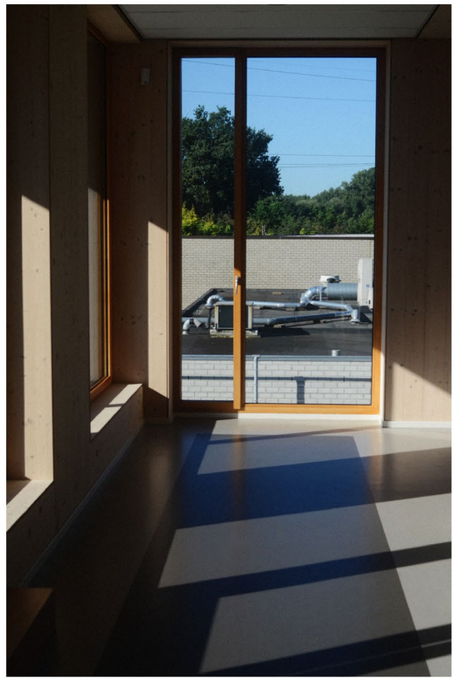


the shadow is
part of light

COOL AND DRY
CLEAN AND LEAN

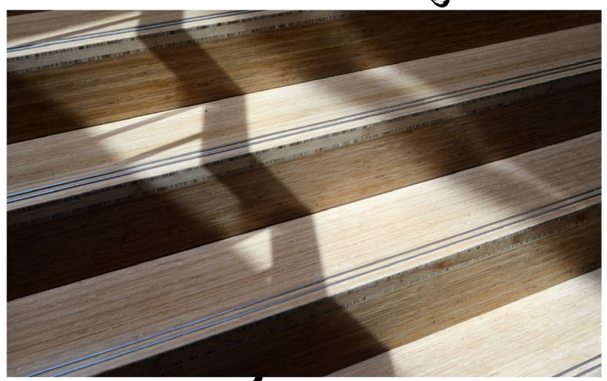
dryers and coolers

Lichtenau



Space and light seem to be ONE.

the building reflects



lightness

DAYLIGHT:

NATURE'S PRESCRIPTION FOR HEALTH, PRODUCTIVITY, AND SLEEP

Daylight enlivens interior spaces, saves energy and provides us with important time cues. It is a source of sensual delight that most of us would not want to miss in our everyday lives. To fully understand the importance of natural light, however, one must take into account how daylight directly affects our biology; an impact that goes far beyond vision.

By Deborah Burnett
Photography by Daniel Blaufuks

THE NATURAL SCIENCE of physics tells us that daylight is the only visible part of the electromagnetic spectrum. It is organised into wavelength bands represented by familiar colours, each of which contains a different amount of energy. The short wavelengths (380–492 nm) represented as violet-blue bands are the most stimulating for biological response, so we only need a relatively small amount of them. The long red wavelengths are a less powerful source of energy but needed for providing biotic counterbalances throughout the 24-hour daylight/dark cycle. It is the blue bands that stimulate alertness, while the red wavelengths trigger relaxation and the act of sleep. Overall, daylight is the only source of light that provides the perfect blend of wavelength distribution at the right times of the day in order to keep us healthy throughout our lifespan.

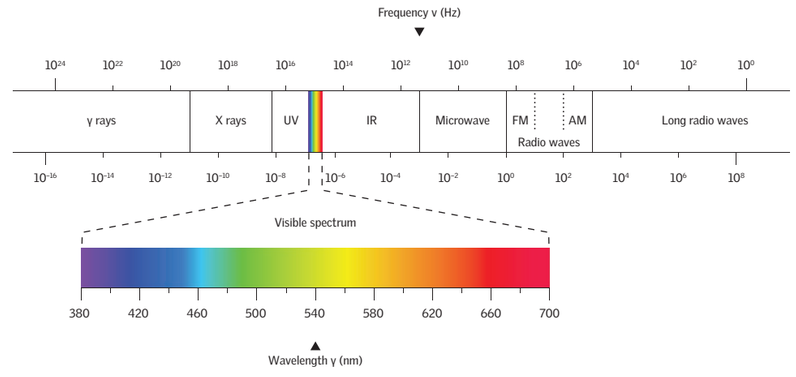
Although modern light sources try to replicate natural daylight distribution, they fall short as the primary signature of daylight – a consistently high distribution of all wavelengths throughout the day. Additionally, natural daylight provides evolutionary mandated qualities of light intensity, duration, timing, location and, the all-important dynamic, motion – something that our current electric light sources do not provide. The artificial spectral wavelength distributions, by contrast, are static and missing entire bandwidths due to the way the light source and luminare are manufactured. It is important to note that every cell in our bodies, including those that comprise organs, muscles, glands and even blood cells[1], responds to exposure to ambient light and darkness, also that provided by electric light, via the circadian system. This innate biological system, as you will soon learn, provides the means for how we are able to function and survive on the planet we call home.

Daylight: delivery system for biological stimulation

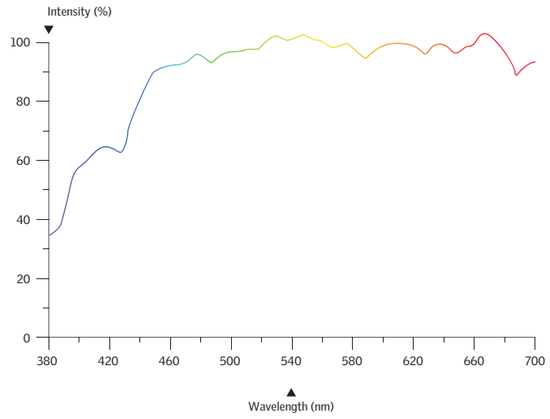
Daylight can be described as the preferred delivery system for encoded organic information that initiates, governs and controls all life functions necessary for our survival.

Since the early 20th century, medical science has demonstrated the healing power contained within a good dose of daylight; wounds heal faster, the immune response is strengthened to fight off disease, and emerging tumours are weakened or destroyed. Daylight exposure

Different types of electromagnetic radiation with their corresponding frequencies and wavelengths. Visible light constitutes a relatively small fraction of the electromagnetic spectrum.



Typical captured spectral power distribution (SPD) of natural daylight, with the relative percentage of energy contained within each wavelength. Emerging research is suggesting that for fixed electric light sources, short wavelength radiation should be limited to the 12% range; a typical problem for white LEDs, which emit a much higher proportion of blue short wavelength radiation. Since daylight is dynamic, with constantly changing proportions of short wavelength to long wavelength radiation, the correct emission percentage of short wavelength energy is always the right light, at the right time, in the right percentages.



is now even credited with controlling obesity by enhancing the production of the body's 'good' fat[2 3]. But it is only since the mid-1990s that we are beginning to understand how it all works.

It has long been understood that our eyes are the organ of sight via the reception of visible light by the rods and cones (light/dark photoreceptors). However, since the 2002 discovery of a third ocular photoreceptor, commonly referred to as the circadian system's non-visual receptor or iPRGC cells (intrinsically Photosensitive Retinal Ganglion Cells), we now attribute the eye as being the primary organ of biological timing[4].

Although new discoveries are still emerging, science has conclusively demonstrated that the job of the iPRGC non-visual photoreceptors, via the opsin called melanopsin, is to: send, receive and transmit light signals to the master biological clock, initiate pupillary light response, contribute to pupil size, and regulate the activation and suppression of a key hormone, melatonin, from the pineal gland. This hormone, once thought only to promote the onset of sleep, is now recognised as the primary DNA protectant and the body's major tumour suppressant.

The iPRGCs are also unique in that they are extremely sensitive to the presence of short wavelength light accrued over a long period of time. They capture this information, transduce it (i.e. change its form of energy) and then transmit it to the brain via a specialised path. This neural pathway is called the retinohypothalamic tract and leads directly to the master biological clock. Although we have a number of secondary clocks located throughout the body, the master pacemaker, identified as the suprachiasmatic nuclei (SCN), receives these secondary clock signals along with those from the iPRGC to regulate and control all our biological functions.

The SCN is an important 2.5-billion-year old evolutionary brain structure designed to keep our biotic functions optimised, our daily strength and vitality maintained, and our reproductive viability strong – in other words, to do everything we need to survive and continue our species[5]. This brain formation is comprised of a tiny collection of about 40,000 master oscillator cells located behind the eyes and is responsible for ensuring that our overall biology is correctly aligned with the Earth's light and dark cycles. It also acts as a major input source for delivering neuronal signals to the brain for further processing and direction.

It is important to note that some of our genes are also aligned with the 24-hour pattern of daylight and darkness. Genes with catchy names such as CLOCK, TIME and PERIOD respond to the varying light conditions by either expressing (turning on) or by silencing (not responding) when appropriate). This can be either a good thing or a bad thing, depending on the time of day the dose of light is received.

Circadian system: nature's gift to keep us connected

The circadian system is a complex series of environmental stimuli receptors, dedicated pathways for biotic messaging, secondary timing oscillators and light receptive genes that provide timing protocols for every cell, gland, muscle and organ of the human body, including the brain. At the centre of this network is the SCN (master biological clock), which translates the incoming information into neurochemical and physiological responses to govern and control every aspect of our being, including blood pressure, heart rate, urine output and muscle strength.

Consisting primarily of the circadian rhythm and the sleep/wake cycle, this cadence-producing design supplies us with what can be described as a biological 'perpetual motion machine', using ambient light conditions as fuel.

The circadian rhythm is an innate 24.2-hour biotic timing cadence that must be recalibrated to the Earth's 24-hour rotation cycle. This is necessary for us to be in constant biological sync with the planet we call home. The process of aligning the circadian rhythm to the Earth is called entrainment and is instrumental for controlling a number of functions we sometimes take for granted. These include sleeping at night, puberty arriving in time for our teenage years, and maintaining our daily energy levels, which keep us alert and active throughout the day. This process is accomplished when ambient light is received by the iPRGC cells and the corresponding wavelengths are sent to the master pacemaker. Based on this information, the SCN recalibrates and synchronises the rhythm so that it aligns perfectly with the 24-hour solar day.

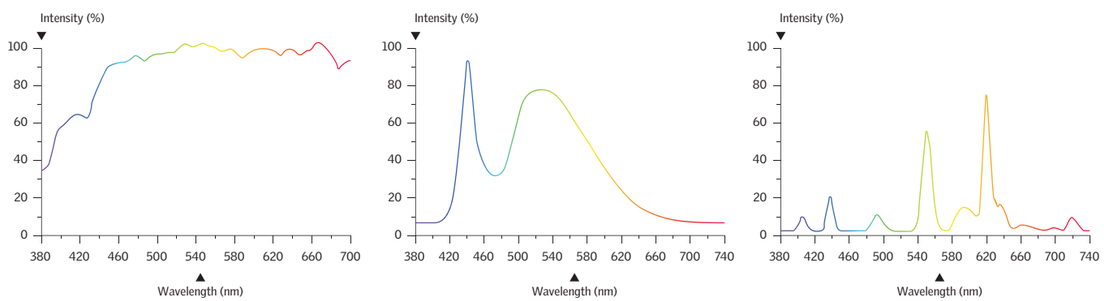
As mentioned already, the circadian rhythm is only a part of the overarching circadian system. Another major component is sleep, a function by which all the daylight received during the day goes to work at night.

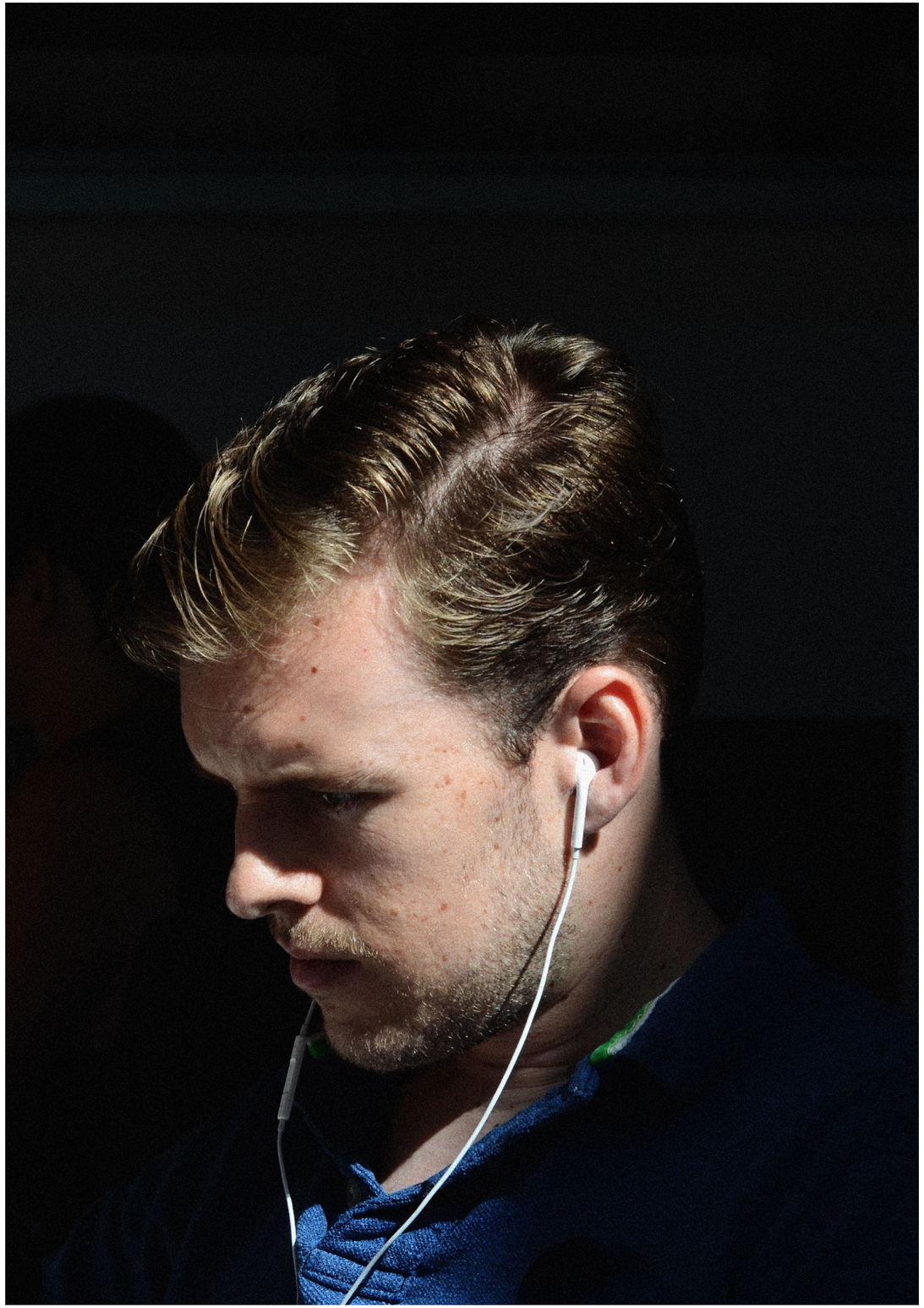
As humans we are naturally diurnal, which means that we are awake during the day and naturally disposed for sleep during the evening hours. Simply explained, sleep is the circadian system's counterbalancing activity, comprised of two parts: the innate process of sleep, which begins about 2 hours before you get up in the morning and continues throughout the day so that the act of sleep can happen at night.

Known as the Homeostatic Sleep Propensity (HSP) this dual function is a reoccurring neurochemical and physiological pressure rhythm that works counter to the circadian rhythm.

For the architectural community, it is important to understand that the day-

Spectral distribution of daylight compared to LED and fluorescent light sources. Note the lack of energy bandwidth for all power densities as compared to daylight. For human health, well-being, sleep and productivity, we need a light source that contains a full array of all energy bands.





time sleep process happens while we are awake. It is a largely a neurochemical process dependent upon daytime exposure to high light levels in order to maintain alertness throughout the hours leading up to bedtime. The process is also responsible for initiating the alerting stress response in the early morning of the next day. This too is dependent upon the previous days' light exposure and activity levels. Without this response we would not be able to 'jump start' our daily wake cycle, thus leaving us tired and groggy all day unable to function optimally. Daylight naturally provides the right percentage of short wavelength radiation needed to keep the HSP going strong, as well as to suppress daytime circulating melatonin levels thus ensuring a quality daytime sleep process and act of sleep at night.

By contrast, the rejuvenating act of sleep, which is designed to occur between the approximate hours of 10 p.m. and 6 a.m. depending upon age and health, optimises our nervous system for proper brain function and immune system response. This planned biological 'refresh' is also vital for fighting disease and maintaining night-time levels of melatonin, a darkness-derived hormone now recognised as a major breast cancer tumour suppressant, in addition to triggering the act of sleep.

Since both the process and act of sleep are now credited with delivering behavioural benefits, spending our waking hours without the bright light of day to suppress melatonin or the darkness of night to express melatonin, can have noticeable consequences, such as overwhelming daytime fatigue, increased workplace errors, and decline in individual productivity, performance and concentration.

Although the complete neurochemical and genetic purpose of sleep is not fully understood, most scientists now believe that the night-time act of sleep 'defrags' or cleans up those brain areas that convey information from our daily lives and previous days' immediate environment. By compartmentalising and compressing this information during sleep, we start the next day with enhanced memory recall, improved cognition and heightened alertness.

Sleep is also instrumental for optimising our metabolic and immune systems, which we need to fight diseases, control inflammation, control our weight and heal our wounds. Considering these facts, it is understandable that the sleep component (HSP) of the circadian system, with all the health and well-being benefits it delivers, is now recognised as a wellness benefit by employers worldwide[7]. Additionally, the monetary benefits of better sleep are also noted, as many studies are citing improved productivity and performance. The bottom-line factor is now estimated to be USD 1,967 per employee per year simply by getting one hour more sleep each night[8].

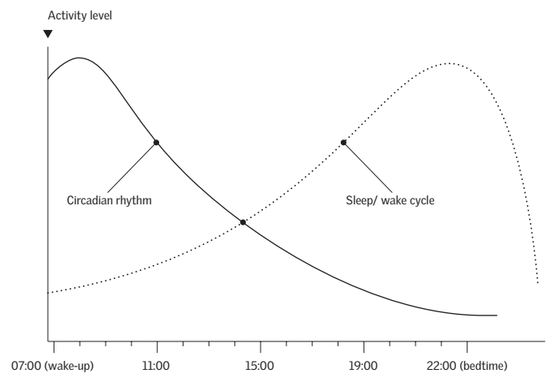
Eyes: designed to use light, not look at it

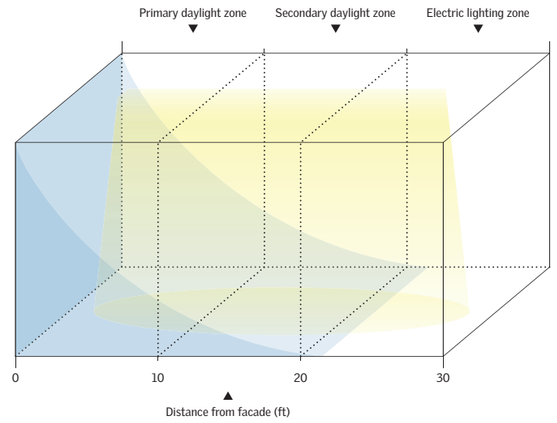
The primary receptors of the circadian system are the eyes. Since the mid-1990s, science has made tremendous advances in the body of knowledge about the circadian system. These include light qualities, received by the eyes, that trigger optimised blood pressure, heart rate, and the negative circadian-related stress response caused by glare.

To understand glare, we first have to understand that the visual process depends upon light capture, while the act of sight depends upon environmental contrast conditions for definition and enhanced visual acuity. Also important to note is that the circadian system plays a role in both vision and sight. Alongside their visual function, the cones and rods of the visual system also contribute information to the biological clock. Furthermore, the response of our pupils to overtly bright light sources is controlled by the same non-visual iPRGC cells that send information about how and when we sleep. In both cases the eye is using light rather than looking at the light itself; to do that would actually cause the biological stress response we recognise as glare.

Here's how it works. Whenever we experience a sudden light intrusion of higher luminous intensity within our direct line of sight, e. g. when looking into a bright light source such as sunlight streaming in through a poorly shielded window opening, the body and brain go into an instantaneous high alert mode. Research tells us that our aversion to overly bright light conditions is actually a whole body stress response in which multiple body sites respond with protective biological reactions. We can begin with the eyes. The pupils are the first to respond and will constrict due to the iPRGC release of a stress-response neurochemical from the adrenal glands, lo-

The Homeostatic Sleep Propensity is an innate rhythm of biological consequence which operates counter to the circadian rhythm in order to maintain our diurnal predisposition of daylight activity and sleep at night.





Daylight through vertical windows provides only limited natural light penetration, thus causing the dependence on electric light sources to provide light necessary for visual acuity alone. Additionally, daylight through windows requires a 'defensive' placement of furnishing and/or light-blocking shading devices in order to reduce the eyes' exposure to direct light and to prevent excessive glare conditions.

cated on top on the kidneys. This initiates a 'whole body alert' that involves blood pressure, heart rate, and muscle coordination. During a glare response, the eyes will also blink or temporarily close, thus reducing visual acuity. Additionally, the visual photoreceptors produce an excessive amount of cellular waste in response to the overtly bright light. Waste builds up behind the retina and causes the sensation of pressure or pain depending upon the intensity and duration of the glare conditions. And, finally, facial muscles contract and shoulders twist slightly, resulting in a change of centre-of-balance that disrupts concentration and causes us to momentarily lose our eye-hand coordination; a devastating consequence contributing to potential workplace injury and increased error rates. If allowed to persist, glare conditions exacerbate existing problems with sleep, migraine and neurological diseases, such as epilepsy and Parkinson's. Furthermore, excessive exposure to glare-producing light sources may introduce a whole-body photosensitivity, which plays a role in a number of health conditions, such as lupus and chronic fatigue syndrome to name but two.

Architectural daylighting solutions: top daylighting is best

For the architectural and design community, continual awareness of the biological aspects of daylight is critically important when it comes to how we justify our daylighting designs. Providing the right daylighting solution is instrumental for enhanced occupant health and well-being; a much larger payback consideration than merely saving energy – and with greater potential. Here's what science is telling us about daylight solutions delivered from above and the side.

Although the research is still emerging, most scientists seem to feel that receiving copious amounts of ambient bright light, with a high luminous intensity of at least 1,250 lux throughout the day, is enough stimulus to sustain the iPRGC (melanopsin) response needed to maintain heath, well-being, and sleep. Daylight provided from above (e. g. through roof windows or skylights in particular) provides the high levels needed and allows for energy-saving daylight harvesting throughout the entire floor plate, regardless of depth. And because zenithal daylight comes with a markedly reduced risk of glare, no light is lost due to window shading devices that would otherwise be needed to mitigate glare conditions.

'Top daylighting' solutions, such as skylights, tubular skylight devices, modular skylight ceilings and interior light shafts, also impact on human biology via continuous dynamic light information. The dynamic pattern of daylight on the floor and that which is broadcasted onto vertical surfaces initiates the eyes' detection of motion within our peripheral visual field. This contributes to the functioning of our circadian system (via the rods' reception of motion) and plays a vital role in determining time passage, enhanced wayfinding ability and heightened memory recall. Additionally, being exposed to dynamic sunlight, and to the ever-changing colour shifts of the skydome via top daylighting features, provides occupants with information about seasonal changes in day length, as well as about the weather conditions outside.

By comparison, 'side daylighting' solutions, such as windows and other facade openings, do not seem to offer the same health benefits. Restricted by a window-to-wall ratio of 50–65%, the side-daylighting solutions are seldom enough to illuminate the adjacent walls, let alone 'bathe' the entire floor plate in natural daylight. A simple guideline to understanding the penetration of daylight into a space through windows is easily accomplished by multiplying the height of the window by 1.5. Thus a 30-foot-wide office space with 12 feet high windows will only provide usable daylight back into the space for a depth of less than 20 feet. Additionally, limited exposure to the skydome, which is often blocked by adjacent buildings and/or window shading devices, reduces light levels. Furthermore, in most cases side daylighting solutions only provide daylight from one cardinal direction, again limiting light penetration even during winter months when low solar angles prevail. However, 'side daylighting' solutions do play a vital role in the process of sleep.

Sleep: the primary beneficiary of daylight

Since the late 1980s, windows with a direct view to the outdoors, and especially those that offer occupants a horizontal line-of-sight to the earth's surface and horizon beyond, have come to the attention of design professionals worldwide. This was mainly due to the positive health and behavioural benefits reported from hospitals, workplaces and schools[9][10]. These include reduced length of hospitalisation, reduced absenteeism and enhanced scholastic test scores. Little is known, however, as to how these benefits, delivered through windows, are biologically produced; mounting evidence is pointing in the direction of sleep.

It seems that the unique benefits provided by windows with outside views contribute to two brain regions where the act of sleep is instrumental for the next day's memory recall and cognitive abilities. Although not completely understood, early research is directing its attention to how viewing the natural environment contributes to the expression of ZIF-268, a gene which initiates a night-time sleep state known as REM (Rapid Eye Movement). It is during this sleep phase that the brain's hippocampus and cerebral cortex prepare for the next day by paring back neuronal synaptic gaps (the brain's 'defragging process' mentioned above) in order to safeguard against a number of negative lifestyle and health-threatening conditions. These include productivity drags, such as excessive fatigue and reduced hand/eye coordination, as well as health-related issues, such as worsening disease conditions and expanding waistlines.

Now for the hard part. How can we, as design professionals, use the biological information contained in daylight to promote architectural daylighting solutions in order to foster occupant health, well-being, and sleep at night? That, dear reader, is up to you. But for me, it seems to work best when I mention that sleep and sexual performance go hand in hand with daylight exposure. I wonder why this is.

Deborah Burnett, ASID, CMG, AASM is an internationally acknowledged interior designer, lighting practitioner and member of the American Academy of Sleep Medicine. Together with lighting designer and engineer James Benya, she heads the professional lighting and epigenetic consulting practice, Benya Burnett Consultancy in Davis, California, USA. Deborah Burnett's work includes clinical and academic research on the human circadian system, academic lectures, and presentations in the popular media about light impacts on human wellness, sleep and disease. She has been a speaker at various VELUX Daylight Symposia and delivers memorable keynote presentations at conferences worldwide.

Sources:

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HEALTH MATTERS: BEYOND INDOOR COMFORT

For decades, our buildings have been designed for optimal thermal, acoustic and visual comfort. But does this make them healthier for our species, which, after all, has evolved outdoors for tens of thousands of generations? Taken seriously, the design of healthy buildings calls into question many established standards and parameters in building design, from indoor temperature levels to how much – and what kind of – light we let inside our offices and living rooms.

By Peter Holzer
Photography by Ola Bergengren
Set design by Iwa Herdensjö

Indoor comfort versus indoor health

Indoor comfort is a core issue in both building design and building science. It is also a mega-seller in the construction business: the HVAC industry has an annual turnover of roughly USD 100 billion world-wide, recently growing at more than 5% p.a.[1]

Indoor comfort addresses a variety of issues, including thermal, visual, and acoustic comfort as well as air quality. Comfort, by definition, is a state of mind, defined by the Cambridge Dictionary as "a pleasant feeling of being relaxed and free from pain". Indeed, comfort is the personal sensation of feeling comfortable. It is simply the absence of discomfort, which is certainly a feeling nice to have.

Health, on the other hand, is more than a state of mind. It is also a state of physical well-being that includes the absence of disease or infirmity, as explained by the WHO in its well-known definition:[2] "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." This is significantly more than 'nice to have'.

Given this differentiation between indoor health and indoor comfort, the question has to be raised as to whether our commonly accepted indoor comfort targets are consistent with basic physiological needs.

There is a good reason to raise this question now – the historically recent development towards an 'indoor society'. Members of post-industrial urban societies spend more than 90% of their lifetimes indoors. This percentage has grown rapidly, essentially driven by the invention of cheap and flicker-free light. For the first time in history, gaslight and electric light made it possible to move most human professional and private activities inside.

Furthermore, the question should be taken extremely seriously, as possible misjudgements may pose a significant health risk. Comfort provides instantaneous feedback. If you feel uncomfortable, you know it at once. Health, on the other hand, doesn't give rapid feedback. If you expose yourself to unhealthy conditions, you might feel the consequences only years later, often through unspecific symptoms, and sometimes too late.

Our Institute of Building Research in Vienna has conducted numerous research activities and studies to investigate the connections and gaps between indoor comfort and health issues. Initially these activities were focused on visual comfort and photo-physiology but have recently been expanded to the field of thermal comfort and health. This article gives a brief summary of our recent findings and their possible consequences for building design.

From the savannah to the indoor society: a brief history of mankind's evolution

Our complex human physiology is the result of millions of years of evolution. For most of the time, this evolution took place in exterior spaces. The genus Homo is considered to have developed around 2.8 million years ago in east Africa. According to the Out of Africa theory, members of the most successful species, Homo sapiens, spread from East Africa not earlier than 200,000 years ago, displacing other representatives of the genus Homo, which had already reached Southern Asia and Europe in earlier waves of migration. From around 12,000 BC onwards, Man started to turn into a sedentary species, a phenomenon first documented in the area of today's Israel and Palestine. But it was only a few hundred years ago, with the invention of gaslight and electric light, that social and commercial life started to move indoors, with very few exceptions.

Evolution does not react within two hundred years, however. We are outdoor creatures in an indoor society. In fact, by settling indoors, our species has undergone a deliberate and artificial change of micro-climate that significantly exceeds the (again, man-made) macro-climate change that is the topic of so much discussion right now.

This is an important observation: knowing where we come from gives an idea of what we are trained for. Yet this observation has to be treated most carefully and without any romanticism: we are no longer results of biological evolution alone. There is scientific agreement about the existence of an additional cultural evolution[3]. Not everything that is natural is good for health. Statistically, we live significantly longer lives than our ancestors ever did. "Young brains in evolutionary old bodies" fittingly sums up the duality between mankind's natural and cultural evolution.

COMFORT PARAMETERS DISCUSSED FROM A HEALTH PERSPECTIVE

1. TEMPERATURE

Numerous standards define the 'thermal comfort zone' for living spaces and office work within a temperature range of 20° to 26°C. Observations from Europe have repeatedly proven the validity of the lower limit, as long as building occupants choose a set of indoor clothing suited for winter, with long legs and sleeves. Recently however, people increasingly prefer higher indoor temperatures, together with a tendency to wear medium to light clothing all year round.

As regards the upper limit of 26°C, reliable observations have proven that it is well applicable to air-conditioned buildings, but too low for 'free-running' buildings without active cooling systems in warm climates.[4] The 26°C upper temperature limit has no physiological basis but a technical one: it is as young as the invention of the compression chiller, which dates back to 1906.[5] In many situations, people accept temperatures even way beyond 26°C. Whether they do so depends strongly on cultural agreements about clothing style, on attitudes towards sweating and air movement and, last but not least, on the long-time acclimatisation to outdoor temperatures.

From a medical point of view there is no evidence for a lower benchmark such as 20°C. The only existing evidence is linked to much lower levels of temperature: living constantly at less than 12°C leads to health issues, which are especially relevant for elderly people with systematically decreased metabolism, and hence heat output. Constant temperatures below 12°C have also been reported to cause psychological problems and to increase the risk of falls. On the other hand, an increasing number of experts claim that frequent training of short-time 'cold stress' increases the biological resistance to these health issues.
As regards the upper limit, there is medical evidence that heat stress increases the risk of mortality due to cardiac infarction. However, there is evidence that heat is something one gets used to. So heat stress is not merely a question of temperature levels but also depends on how frequently people are exposed to warm temperatures.

Without quantitative proof, it is increasingly accepted that there is no such thing as a 'natural' comfort temperature. Adaptation and acclimatisation, together with a powerful thermoregulatory system, enable mankind to live comfortably in a range of temperatures significantly wider than modern definitions of a static 'comfort zone'. There is emerging medical evidence that our thermoregulatory system can be trained on both sides by temporary exposures to (mild) cold and heat. The old rule of "use it or lose it" seems to apply here as well.[6]

A frequently raised question is whether night temperatures in our sleeping rooms should be lower than daytime temperatures. One might conclude this from the fact that, in every climate of the world, the outdoor temperature drops by at least a few degrees during the night, and our core body temperature also drops while we sleep. However, there seems to be no clear medical evidence that would give a medical call for 'cold bedrooms'.

Recommendations:
These challenges need to be faced with a systematic, climate-sensitive architectural design, accompanied by passive means of heating and cooling. Only when these are exhausted should active heating and cooling systems come into play. All active systems ought to be designed for hybrid building control, i.e. switchable between controlled and 'free running' mode. The best results can be achieved by providing occupants with personal adaptive options such as access to personally operable windows, personal control over sunscreens, and possibly desk fans and other devices. In general terms, buildings should connect people to the outdoors as much as possible and provide shelter from it only as much as is necessary. And for the sake of your health – get out of your comfort zone sometimes!

2. HUMIDITY

There is sound medical evidence that relative indoor humidity should not be constantly lower than 30%. Our respiratory system, our eyes, our skin, as well as all kinds of biological membranes inside our bodies that are exposed to ambient air, are prepared for this limit. Again, the comparison with outdoor conditions helps: there is not a single place in the world, not even the deserts, where relative humidity is constantly lower than this level.

On the other hand, there is no direct medical evidence for limiting the relative humidity to an upper value. The frequently applied maximum of 60% relative humidity in building design is an invention of HVAC companies, but is not related to physiology. A health risk exists only if high indoor humidity levels exist alongside poor insulation levels or cold bridges in walls and roofs. In this case, mould might occur on cold surfaces in indoor spaces.

A similar, indirect correlation exists between indoor relative humidity and allergic asthma. House dust mites, which are one of the possible triggers of allergic asthma, reproduce strongly at a constant humidity of 65 to 75% in combination with temperatures between 21°C and 27°C. Again, the comparison to the outside climate proves that, in most areas of the world (at least at night), levels of relative humidity up to 80% are absolutely common, physically inevitable and neither a health nor a comfort issue.
Finally, there is evidence that as vapour pressure (which is proportional to absolute humidity) increases, the effectiveness of sweating decreases. This is not directly a health issue but leads to an increased moisture cover on the skin and contributes to heat stress.

Recommendations:
Once again, the best advice is to apply a climate-sensitive architectural design that, wherever suitable, uses hygroactive materials to buffer humidity, and high air-exchange rates to withdraw humidity from indoor spaces. If necessary, active humidity control (e.g. through ventilation devices with moisture recovery) must be added. These devices should again be prepared for hybrid control, designed for easy adjustment, and accompanied by good airtightness of the building envelope.

In general terms, the advice given above can be reiterated here: buildings should connect people to the outdoors as much, and for as long, as possible, and shelter them from the outdoors only as much as is necessary.

3. DAYLIGHT

In the field of daylight, there are numerous – and medically well-proven – contradictions between visual as well as thermal comfort targets and photo-physiological needs. One of them concerns illuminance levels. While the standards for visual comfort demand 500 lux at horizontal planes, full activation of the circadian system calls for at least 1,000 lux at the eye. This requirement is met outdoors at any time of the day, starting at early dawn, but extremely hard to fulfil in interior spaces.

Another contradiction is the restriction of wavelengths of radiation. While facility managers welcome the absence of ultraviolet (UV) radiation to prevent bleaching out furniture and fabrics, photo-physiology is very much aware of the crucial importance of UV-B radiation to trigger the synthesis of previtamin D3. And while building physicists welcome the absence of infrared (IR) radiation to limit solar heat gains, physiologists are aware of the importance of IR-radiation as the trigger for cytochrome C oxidase, an essential process in cellular respiration.

Recommendations:
Daylighting design is a core responsibility of any architect. It can only be supported, but never replaced, by artificial lighting. Be aware that in interior spaces we always suffer from a lack of light, both in terms of quality and quantity. So high quality, easily accessible outdoor spaces should always be offered, both in residential and in commercial buildings.

4. AIR VELOCITY

An upper limit to air velocity is a key concern of both thermal comfort research and the HVAC industry. A risk of draft is considered to occur at an air velocity above 0.2 m/s. This has no equivalent in medical science however. Even during an easy walk, our body is exposed to a relative air speed of 1 m/s, without any ensuing health damages. On the contrary: air velocity is, and has always been, a major means of thermoregulation in hot climates. An airspeed of only 1 m/s lowers the perceived temperature by about 3 degrees.[7] It is most important to reintroduce the comfort potential of air movement into today's building design.

A lower limit of airspeed is not under discussion, either in comfort science or in medicine.

Recommendations:
Personally controllable air movements during the day (through windows or using ventilators) can contribute greatly to summer comfort. Furthermore, buildings should be designed for ventilative cooling, which relies on high air exchange rates during night hours to cool down the building's fabric.

5. FINE PARTICLES AND NOISE

Fine particles and noise are two comfort and health criteria of increasing importance. Both issues are, without any doubt, highly health relevant. They are typically problematic in polluted urban areas with a high density of motorised traffic.

Recommendations:
Outdoor noise and pollution are unacceptable as they can preclude the otherwise reasonable opening of buildings to the out-of-doors. They must, however, be prevented on a community level, outside the building itself, and ideally at their source. Nonetheless, outside spaces should still be created for at least a short time stay wherever possible, even in highly trafficked areas.

CONCLUSION

- Indoor health is not necessarily in line with indoor comfort. Our being an indoor society calls for careful building design that addresses physiological needs beyond the desire for comfort.
- Several well-established comfort definitions turn out to be too narrowly defined from a health point of view.
- As regards thermal comfort, the approach of adaptive thermal comfort and of hybrid building control is promising.
- There are increasing indications for our thermoregulatory system positively reacting to periodic exposure to (mild) cold and heat.
- As regards photo-physiology, there is clear evidence for a systematic lack of light in interior spaces, both in terms of quantity and quality. This has to be met by good daylighting design and by offering high-quality, easily accessible outdoor spaces, both in residences and commercial buildings.
- Generally, building design must find a new balance between giving shelter from the outside space and providing connections to the outdoors.
- Outdoor noise and dust, together with security issues, form severe obstacles to these targets. They have to be forcefully dealt with on the levels of urban design and the building site.

Peter Holzer is an engineer, researcher, teacher and consultant for sustainable building design. He holds a degree in Mechanical Engineering from the Technical University of Vienna, Austria, where he also completed his doctorate thesis on the quality and quantity of daylight in interior spaces. From 2008 to 2013, he headed the Department for the Environment and Construction at the Danube University in Krems, Austria. Today, he directs a consultancy office (www.jung-ingenieure.at) and is an associate of the Institute of Building Research & Innovation, both in Vienna.

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SEEING LIGHT — UNDERSTANDING LIFE

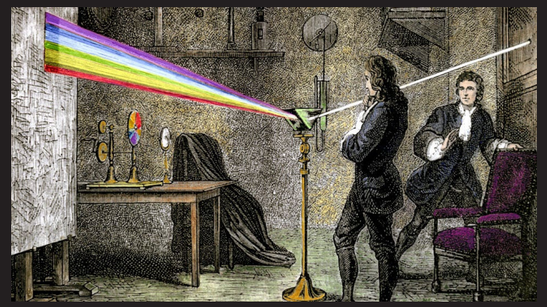
It was around 1665 that Isaac Newton, then still a young student at Cambridge University, performed his first experiments with glass prisms and the sunlight entering his studio. Through his observations, he found not only that white is the sum of all colours, but also that a ray of white light can be broken down into its constituent components. Many natural phenomena, from the rainbow to the fact that a cloudless sky appears blue, can be explained by the fact that light is refracted when it crosses the boundary between two different substances.

300 years after Newton's discoveries, a new wave of fascinating research has arisen, one that investigates the effects of light crossing the boundary of the human body. Once again, the intensity and spectral composition of light play a crucial role in this emerging research. As Deborah Burnett explains in her article in this magazine, only the full-spectrum light of the sun provides our bodies with the information that initiates and controls all life functions necessary for our survival.

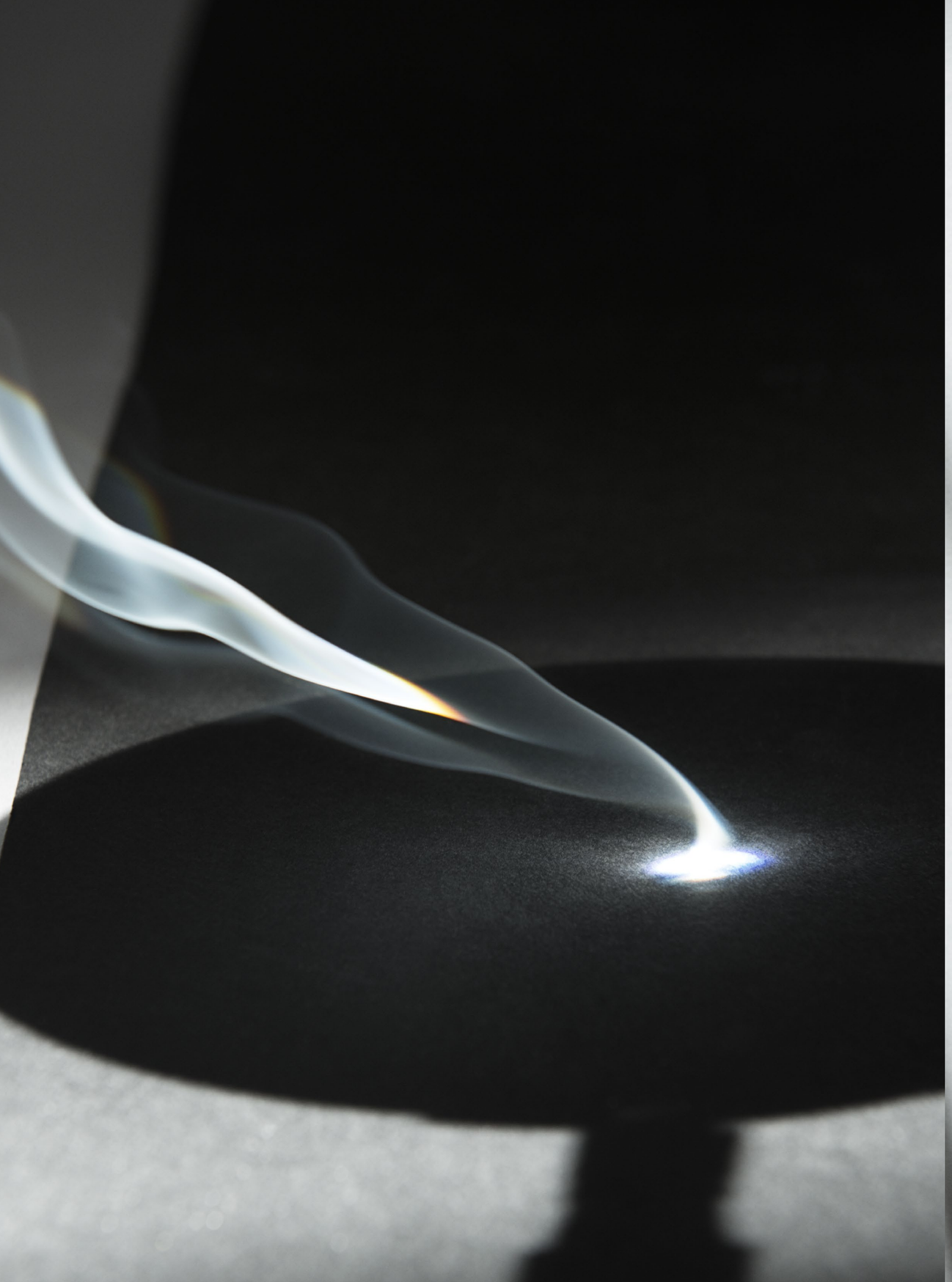
When photographer Ola Bergengren set out to perform the experiments shown on the photographs overleaf, it was impossible to produce a full spectrum of colours with artificial light. Only sunlight would do the trick. Hence these simple experiments also indicate in their own way just how irreplaceable natural light is in our lives.

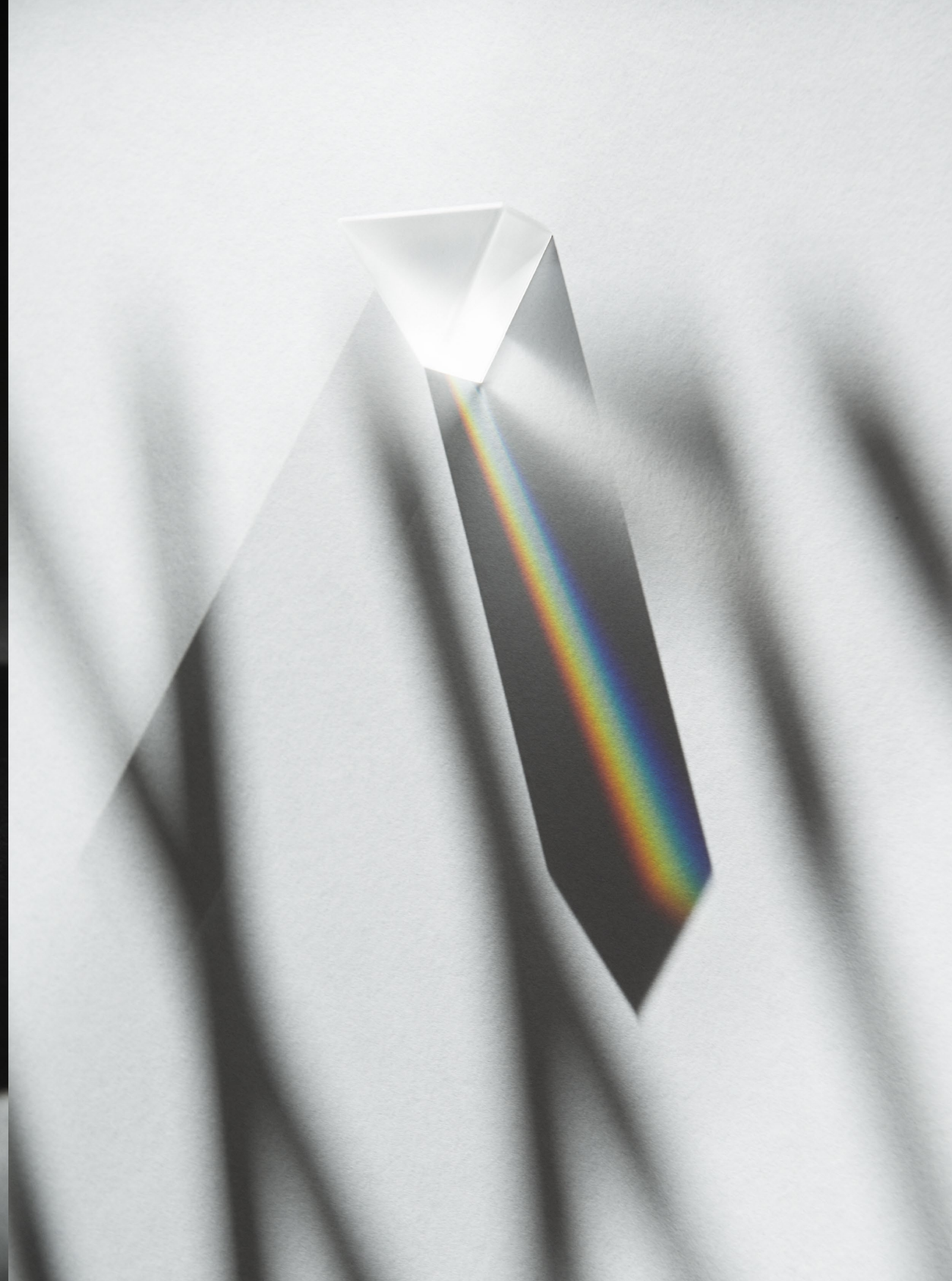
What if buildings focused our attention on these natural phenomena to a much greater extent? What if architecture became a 'perception tool' that allowed us not just to study the nature of light, but also the effects that it has on ourselves? Understood in this way, architecture can contribute not only to a greater appreciation of nature and its magic, but also to a higher level of awareness of the conditions of our own life on Planet Earth.

Photography by Ola Bergengren
Set design by Iwa Herdensjö



With his experiments with glass prisms, Isaac Newton (1642–1727) became the first scientist to understand the laws of light refraction.





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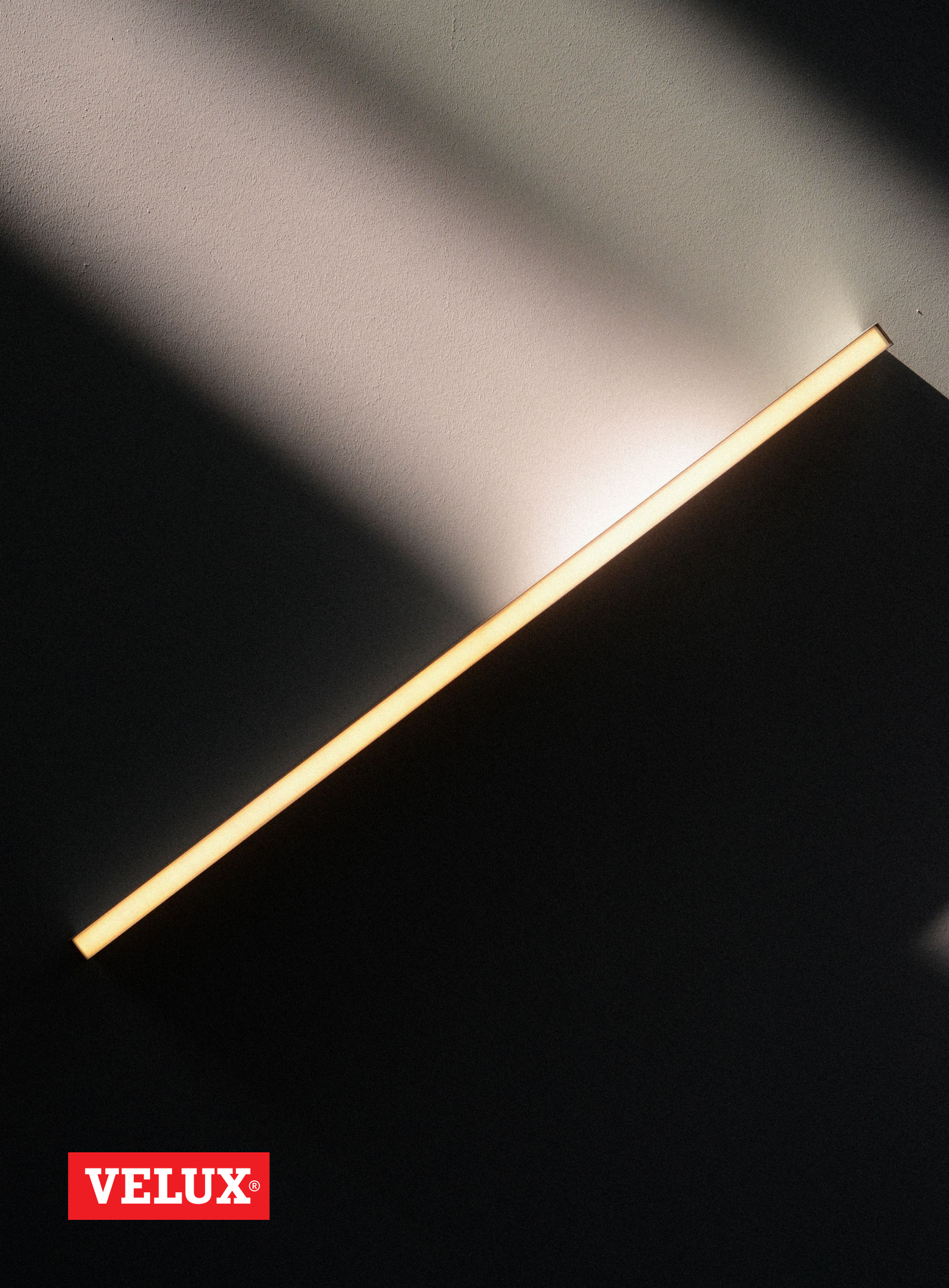
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