THE LIGHT THERAPEUTIC

If you go to the doctor or psychiatrist, they probably won't ask you how much light you are getting. But scientists working in this area, from California to Japan, are convinced that where there is light - the right type, at the right time of day - there is health. Rosie Blau reports
EVERY SUMMER WHEN HE WAS A BOY, Satchin Panda would stay on his grandparents’ farm near Chandipur on the east coast of India. He lazed in a hammock, caught fish in the lake and climbed trees to pick mangoes. His grandfather spent most of his 91 years there, working on his 20-acre plot. He produced almost everything his wife and eight children needed. They cooked whatever he grew; they bought salt and sold a little rice. “He did that for his entire life,” says Panda. “He travelled more than 10km from his home perhaps eight or nine times.”

Panda’s home now is thousands of miles away – a four-bedroom house on the edge of a canyon near San Diego, California. He lives off his mind rather than his muscles and regularly jets around the world for work. “If I’m within a five-hour flight of India,” he says, “I go and see my Mum and my sister.” But the shift is more profound than one of geography. Panda commutes by car, works in a basement and spends most of his leisure time between four walls too. Within two generations, he and his family have moved inside out of the daylight, from rising with the sun to being woken by an alarm, from ending their day near dusk to choosing how late – and how bright – to make their night.

MOVING OFF THE LAND and lighting up the night have been integral to the narrative of human progress. When people first domesticated fire they changed their lives for ever: day did not end at sundown. They enlivened dark caves, and later their homes with candles and oil lamps. After the incandescent bulb was commercialised in the 1880s, some feared electricity as a silent, god-like force that might bend the laws of nature. Others clamoured for the bright, white, steady filaments that burned reliably even when the fickle sun did not. Less than a century and a half on from Edison’s eureka moment, we live in a 24-hour society unimaginable without such brilliance.

The illumination of the world has brightened our lives in more ways than the simply physical. Now we can watch the news, work on our laptops, make a Facebook friend, play video games, eat pancakes, buy shoes or download a novel at any hour of the day or night. We are undaunted by the rising or setting of the sun. Now we are all masters of the light.

One consequence is that we sleep less and less. A few hundred years ago, we probably clocked out for up to ten hours a night, depending on the season. When researchers give people the opportunity to rest as much as they want over a few months, most young adults eventually stabilise around 8.5 hours, older people a little lower. On average, Americans sleep about 20% less than a century ago, according to the National Sleep Foundation, and a third have six hours or fewer. These trends are repeated across the developed world.

This matters. If we don’t sleep, we die. Literally. Rats kept from sleeping drop dead within weeks. Being tired makes us less productive, more forgetful and apt to make mistakes – human error in the wee smalls contributed to the Exxon Valdez oil spill, and the Chernobyl and Three Mile Island nuclear accidents. Sleep affects the body’s internal workings too. It enhances our immune system, so that when deprived of it, we are not only liable to catch a cold, but also more susceptible to some types of cancer – and if we already
have cancer it will probably grow faster. We are more likely to have heart attacks or become depressed. We over-eat when tired, and because our metabolism alters too, we are far more prone to obesity and diabetes.

We also inflict these ills on our children: worldwide they sleep for an estimated hour and 15 minutes less each school night than a century ago; in America only a third of high-school students get at least eight hours on a week-night. But whereas tired adults are sluggish and lethargic, kids become hyperactive and distractible — which may be one reason that more than one in ten children in America are now diagnosed with attention deficit hyperactivity disorder, the symptoms of which are remarkably similar to sleep deprivation. What would be the effect if, rather than popping pills, we sent them outside to play each morning and put them to bed earlier?

The medical benefits of sleep are well established but the science of light is much newer. We have only recently started to notice the benefits of boosting our light exposure by recovered faster if they were exposed to lots of natural light. Mortality in both sexes is consistently higher in dull rooms. But why is it a matter of light or death?

"YOU DON'T HEAR A PSYCHIATRIST ASKING HOW MUCH LIGHT YOU GET... IT AFFECTS SO MUCH OF OUR PSYCHOLOGY, PHYSIOLOGY AND MOOD. BUT WE TAKE IT FOR GRANTED"

SATCHIN PANDA

day and asked why they occur. Some consequences are fairly predictable: in brighter environments we are more alert, complete visual tasks better and make fewer mistakes — a study of call-centre workers in Sacramento found that those with a good window view from their workstation processed calls 6-12% faster than those without. Other responses are more surprising. In 1999 consultants studied an unidentified retail chain in America with 208 similarly laid out stores in a single region and found that people spent 40% more in the shops with skylights than in those lit only by electricity.

What is most startling is the way our bodies respond to light. Gloomy winter days are known to trigger a form of depression — seasonal affective disorder — which can be reversed if the sufferer sits by a large lightbox every morning. But light eases other forms of depression too: an Italian study found that bipolar patients in east-facing hospital rooms stayed nearly four days fewer than those in west-facing ones. Even physical conditions respond to doses of daylight: people recovering from spinal and cervical surgery in bright rooms took fewer painkillers every hour; in sunny Alberta in Canada female heart-attack patients treated in an intensive-care unit

wake and sleep at precise intervals over a 24-hour period. This indicates that an internal clock controls the sleep-wake cycle. (That's why we get jetlag — the body remembers the time.) Crucially, though, this circadian pacemaker also responds to the environment, especially light and dark.

Panda laughs at me as I fire off queries: how much light do we need; does it matter if it is natural or electric; does getting lots of light on one day compensate for less on another; what could be the long-term effects of spending our days in drab rooms? "These are very interesting questions," he says, shifting about on his chair. But we simply do not know the exact answer to most of them. "It's an area of research that falls between the cracks."

Partly thanks to Panda, though, we at least know quite a lot about how light affects our body clock. When it comes to the internal clock, some types of light are more equal than others. The eye perceives three main colours in light: red, green and blue, each vibrating at a different wavelength. In the morning, high concentrations of blue occur naturally; by dusk we are left mostly with green and red. The blue light has the greatest impact on our circadian system, telling the brain
that it’s morning and time to be alert, and setting our clock for the day. That is important because we sleep soundly, and our brain and body function better, when the internal signals of the body clock are in sync with external cues of day and night.

The problem is that artificial light does not replicate the colours of the natural world. Much electric light has high intensities of blue, so it deceives our brains into thinking that it’s daytime even when it isn’t. Just ten minutes of regular electric light can make some changes to our internal clock. "We evolved to be blue-sensitive, we need it," says Panda. But many of us get an awful lot of it, particularly in the evening: when we get home we spotlight the kitchen so we can make the dinner, and then plug into our laptops, tablets or smartphones, which beam blue light into our eyes at close range. So we bombard our internal clock with mixed messages: our gloomy morning sends a weak signal to be alert; our overbright evening shouts at our brain to rise and shine. We also lessen the contrast between light and dark that our circadian system relies on to work well. All of which makes us more prone to insomnia or disturbed sleep in some way.

Panda has assembled these ideas into strict rules for himself. He rarely watches television and never checks his e-mail after 9pm (“It’s always bad news and deadlines”); he eats three small meals a day, and takes a photo of everything he consumes (food helps synchronise our clock too); the layout of his home is “close to ideal for circadian health”. He knows this because he monitors his surroundings all the time – he points to a small black disc on his wrist that at first glance looks like a plastic watch: it is a sensor, which has been recording how much light he gets every 30 seconds for the past 18 months. He wears it day and night, except in the shower: “It says it’s waterproof, but I don’t trust it,” he says, laughing.

His biggest contribution as a scientist has been to discover that a particular receptor senses blue light and tells our brain when to nod off and when to sharpen up. The likelihood of such a photoreceptor was suggested in 1932, when an American geneticist, Clyde Keeler, noticed that even the pupils of blind mice contract in response to light. They could not see it, but it had some kind of non-visual effect. Scientists had since identified seven or eight different receptors that might be responding to light in some way, but no one had pinpointed the exact one.

It took Panda a year to construct an artificial segment of DNA with the embryonic stem cells that blocked one of these receptors, melanopsin. Ic. I handed it over to a lab technician just before he returned to India to get married in 2001. It took another year to breed a single blind mouse that lacked the specific receptor, and then he really got going. "It was the middle of the night and we had our experiment. And there it was: mouse number 1626 did not entrain (respond) to light." All the other blind mice changed their waking times when exposed to a different light-dark cycle, but Panda’s single melanopsin-free mouse did not. His voice lifts. "I knew that this was going to change something," he says. "I had this cocky feeling that I am the only one in the world that knows this. If you get that kick three or four times in your life, that’s enough."

He later repeated the experiment with more mice. He even left the bedside of his wife and sleeping newborn daughter when she was hours old, because he had “messed up” the timing and needed to switch on the lab lights over the mice. (“I didn’t tell my wife about that for some years.”) And he was right about the receptor: every animal has melanopsin – “even the blind catfish” – which registers blue light and helps to reset and synchronise the biological clock on a daily basis. “We closed a 75-year-old mystery.”

Last summer an international group of scientists (including Panda), doctors, ophthalmologists, architects and engineers gathered in Tokyo, all animated by the same question: how light affects health. That first meeting of the Blue Light Society was convened by Kazuo Tsubota, professor of ophthalmology at Keio University School of Medicine in Japan. After years of research, he had concluded that only if different disciplines collaborate can we adjust the way we live to the needs of the circadian system.

“Some people don’t like this idea. It is like big tobacco,” Tsubota tells me. “They ask you to prove that there is a health hazard. The tobacco industry has been fighting that proof for years, and I can see the same with this.” We have to learn how to live with blue light, for good and for ill, he says. In contrast to cigarettes, “blue light is not the bad guy. But you shouldn’t have it all the time.”

Tsubota’s ambition as an ophthalmologist is “to protect the eye for this long-lived society”. We all know that our eyesight fades with age – what he calls “the eye as a camera” – but “the eye as a clock” does too. As we get older, our lens yellows, so less light reaches the receptor at the back of the eye to tell our brains what time it is – and we need more daytime rays to reset our body clock. “At 50 years, my lens is a third as good at receiving blue light as the 20-year-old lens,” says Tsubota, who talks with a wide smile and waving hands. “In order to have a proper amount of light, I have to play outside three times as much as a 20-year-old boy,” he says and laughs. “That gives me a good excuse to ski, go swimming, jogging.”

Tsubota says he is motivated by gozigen, meaning a life filled with happiness. This is not idle chat, he insists. Happiness is one of three things that help to stave off the deprivations of age, along with diet and exercise. His remedy is not to sing and laugh, or even to get rich or get married, but to sleep: “It has almost the same beneficial effect on health as smoking has a bad one.” And getting a good night depends on having the right amount of light at the right time of day.

Much of his research focuses on his own cataract patients. After a cataract operation, people usually have fewer falls, their mood lifts and they think more sharply. Tsubota also found that his patients’ sleep “dramatically improved”. He >
characters wearing the shades, another shows a young courting couple. Since 2011, Jins, a regular spectacle-maker, has sold more than 2m pairs of them at $59.99-9.99 (£23-35) a piece. Tsubota’s team is now working on the next creation: light-protecting contact lenses.

TENAGERS IS THE WORLD over should be cheering on the work of Mariana Figueiro, an expert on light and health at Rensselaer Polytechnic Institute in upstate New York. In 2002 she found that when a group of young adults used an iPad for two hours before bedtime, they suppressed their production of melatonin, a sleep-promoting hormone. The media focused on the obvious conclusion: that using such backlight devices ruins our sleep. But Figueiro draws another inference too. Because they blast us with blue light, these same backlight items could act as light therapy by day to help invigorate us and reset our clock. She may be the first person to prescribe an hour playing “Angry Birds” each morning as a solution to our ills.

Figueiro is an unlikely hero for the American teen. Born in Belo Horizonte, one of Brazil’s largest cities, she trained as an archetect – “I thought it seemed charming” – and in 1996 moved to Troy, New York, because her husband wanted to do an MBA. To fill her time she embarked on a master’s at Rensselaer; for her thesis her supervisor suggested she look at how shift workers in the local neo-natal unit functioned in different light levels. It was a serendipitous choice. “It got me busy, and it got me started,” she tells me. “And I became infatuated with research.” At the end of the year Figueiro’s husband returned to Brazil. She stayed in Troy.

We are bad at judging how much light we get, says Figueiro, relaxing as she moves from talking about herself back to her research. “Our visual system fools us a lot.” There is plenty of daylight even on an overcast, greay day. “But we think a television is a lot of light because it is from a single source – and we often work in offices that seem bright but give us too little light.”

We need more light to synchronise the circadian system than we do to see. The upside of this is that you can turn on a lamp to go to the bathroom at night and not immediately crash your biological clock. The downside is that most of us have no idea how our light exposure varies between home and outdoors. A study of a group of Colorado campers found that they got four times as much light on a summer holiday in a mountainous desert as they did at home, and their melatonin levels rose two hours earlier.

Daylight is not intrinsically better for us than electric light, Figueiro says. It’s just that getting artificial light to do the same job is more expensive, uses more energy and is more difficult to get right”. But getting it right is exactly what she’s aiming to do. Sleep disturbances magnify as we age: anything from 40% to 70% of people over 65 have serious problems dropping off, wake up often at night or struggle to keep their eyes open by day. Disrupted sleep often accompanies a general decline in our physical condition and immunity, as well as depression and other ills. Most of us assume this is just part of getting old. Not Figueiro. She reckons more exposure to bright light by day could help keep the doctor away.

She has created a lighting system specially for residential homes. If elderly people get two hours of morning sun every day for two weeks, their sleep improves; some research shows benefits even sooner. Yet most people see a fraction of that; one study found that middle-aged adults get about an hour of bright light a day, older adults in assisted-living facilities
about half that, and those in nursing homes only two minutes. So Figueiro has experimented with adding bright lamps to TV screens, wheelchairs or sofas in the morning. Alzheimer’s patients can be hard to treat, she says, because they don’t reliably stay in one place – but everyone eats, so you can make a dining table a lightbox. Residents slept better when she tested this lighting scheme at an assisted-living facility in Troy. Other old-people’s homes are introducing similar ones.

Figueiro is now working with the American navy on how much light submariners need to be sharp, productive and healthy at the bottom of the sea. Blue light might be used to help drivers and pilots stay awake at the wheel, she says. And as for the backlit gadgets that wreak such havoc with our night, she argues these should be made more circadian-friendly. Like many working in this field, Figueiro says she doesn’t “do electronic devices before bed”. But such products could be programmed to our daily schedules so they radiate less blue light later in the day. “It’s possible,” she says. “Why not?”

There are plenty of technical answers. But her best advice for a good night’s light – and a good night’s sleep – involves no machines. “Wake up and go for a walk in the morning,” she says. “Every morning.”

In America, the advisory committee that sets the light standard for architects focuses on having just enough illumination to perform a task, says Frederick Marks, a Los Angeles architect: “People do not think about health.” He is a founding member of the Academy of Neuroscience for Architecture, a group of scientists and architects looking at how buildings affect our behaviour and well-being.

This question is becoming urgent, Marks tells me, speaking slowly, deliberately, as if lecturing a class of students. As urbanisation continues apace, ever more of us will live in high-rises, where “the opportunity for natural light is often not that good”. Even where light is abundant, many of us draw our blinds to stop people peeking in or to avoid glare. Thermostats are now fitted as standard in homes. A light sensor costs less than a carbon-monoxide monitor, says Marks, “but no one has them”.

Measuring light is only one part of the solution. The other is making better use of what we’ve got. Marks is keen on a new kind of glass – “electrochromic glazing” – which can be transparent or translucent depending on the brightness of the sun. So far people have used it to save on air conditioning and deflect blinding rays, he says, but you could equally apply large plates of it to enjoy more natural light.

Artificial lighting can also be manipulated. The lights we dazzle ourselves with by night have got brighter in the past ten years, as we replace incandescent bulbs with more intense light-emitting diodes (LEDs). At the moment these LEDs have all three types of light within them: red, green and blue. These can be programmed, as a visit to any nightclub will confirm. So our homes could mirror the natural world, with shining blue in the morning, and gentler reds and greens later. You can already set your sprinklers or security systems from your phone. Why not your lights?

In addition to light and dark, the body clock also responds to the direction of rays and movement in a scene (which is why glittering, windowless casinos are so disorientating). Within 20 years, Marks reckons many of us will have a digital, programmable wall in our homes or workplaces. Depending on our taste, our mood or the time of day, we might choose to project a Thai beach with towering palm trees, a vista over sunny mountain peaks or a taverna under a twinkling sky. “You interact with what you see and what you see interacts with you,” says Marks. The lighting is on the wall.

Consider the whole span of human life on Earth as a single day and the light switch was flipped on less than a second ago. Piccadilly Circus, Times Square and Shibuya have only just started to shimmer; the iPad has been glowing for well under a nanosecond.

Work-hard, play-hard cultures both prize the hours stolen from the night. The question is how we manage our health in a 24-hour society. If we know how much light we need and make sure we get it, we may live better, longer and more happily. “Getting the light wrong isn’t something that produces an acute or immediate problem,” says Satchin Panda, “It’s not like flunking an exam.” But in the long run we may gradually realise that it’s too late to correct something that has been going wrong for years. “It’s like a chronic disease.” Returning to the savannah – or even his grandfather’s farm – is no solution, he says. “But what if you can change a light bulb and change your life?”

---

**LIGHT UP YOUR LIFE**

12 tips for a better day’s light and a better night’s sleep

- Get up and go to bed at the same time every day, even at weekends
- Open your curtains each morning and embrace the day, not your privacy
- Spend time outside by day and take the whole family with you, young and old
- Don’t draw the blind – move your desk
- Try to work by a window – a room with a view isn’t just a good novel
- Play video games by day, not at night
- Buy an extra desk lamp
- Have a romantic dinner with the lights dimmed – every night
- Don’t use your computer or tablet for two hours before bedtime
- Install Lux software on your computer. It’s a free program that cuts blue glare later in the day
- Make your bedroom dark or sleep in a face mask
- Turn off the light half an hour earlier. It could save your life