

Beam Me Up

Light can cure depression, keep the aged younger and make us happy and hard-working. Now science is discovering why

Rosie Blau

Every summer when he was a boy, Satchin Panda would stay on his grandparent's 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 eight-hectare plot. He produced almost everything his wife and eight children needed. They cooked what he grew; they bought salt and sold a little rice.

"He did that for his entire life," says Panda. "He travelled more than 100 kilometres from his home perhaps eight or nine times."

Panda's home now is thousands of kilometres 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 gets 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. 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.

For most of human history we have marked time by the solar cycle. We evolved to spend hours outside every day; bedtime came soon after sunset and the night was black. Now most of us pass our waking hours inside offices, factories, schools, shops, hospitals and nurseries, in cosy but often dim rooms with sealed windows and little natural light. Then, as day starts to fade, we flick a switch and bring it back. Compared with the past, our working hours are gloomy and our nights dazzling.

We have been slow to recognise the positive link between light and health. Over the past 40 years, the sun has been the enemy: the medical establishment has warned us off the ultraviolet rays that contribute to skin cancer. But now scientists have a new worry – that getting too little daylight may also do long-term damage to our health.

Satchin Panda is one of these scientists. A professor of molecular biology, he works at the Salk Institute for Biological Studies in La Jolla, California, where he does research on the body clock that every living being has inside them.

“My grandpa was almost religious about taking an hour’s nap by day,” Panda says “He slept nine to ten hours a night.”

Such habits would be inconceivable for Panda himself. But he is far from complacent about the contrast between their lives: he fears that when we override the light-dark cycle of the natural world, we are disrupting the internal workings of the human body. By robbing ourselves of daylight, we may be losing something more fundamental.

Moving off the land and lighting up the night have been integral to the narrative of human progress. When people first domesticated fire, their lives changed forever: day didn’t end at sundown. They enlivened dark caves and later lit 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 burnt reliably even when the fickle sun did not. Less than a century and a half on from Thomas 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.

One consequence is that we sleep less and less. A few hundred years ago, we probably conked out for up to 10 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 at about 8.5 hours, older people a little lower. Americans sleep about 20 per cent less than a century ago, according to the United States National Sleep Foundation and a third have six hours or fewer. In Australia, the National Sleep research Project found we average eight hours 1 minute over 24 hours.

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 small hours 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 overeat 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. But whereas tired adults are sluggish and lethargic, kids become hyperactive and distracted – which may be one reason that more than one in 10 children in the US are now diagnosed with attention deficit hyperactivity disorder (ADHD), the symptoms of which are remarkably similar to sleep deprivation.

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 day and asked why they occur.

Some consequences are predictable: in brighter environments we are more alert, complete visual task 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 to 12 percent faster than those without.

Other responses are most surprising. In 1999, consultants studied an unidentified retail chain with 108 similarly laid out stores in a single region and found that people spent 40 per cent 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 or SAD – which can be reversed if the sufferer sits by a large light-box every morning.

But light eases other forms of depression, too; an Italian study found that bipolar patients in east-facing hospital rooms stayed almost four days fewer than those in west-facing ones.

Even physical conditions respond to doses of daylight: people recuperating 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 recovered faster if they were exposed to plenty 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,” Satchin Panda tells me, sitting beneath cluttered bookshelves in his lab office. Crazy for a man who works on such things, his laboratory is two storeys below street level. But this is California and, on bright days, rays pour through a light well which can easily hold a table tennis table.

Light is such a new field of study that its medical contribution is still very much in question. But Panda is convinced.

“It affects so much of our psychology, physiology and mood. But we take it for granted,” he says, dark eyes gleaming behind heavy glasses as he explains how the science of light applies to all of our lives.

We need light, he argues, because it affects our body clock. Animals kept in the dark all day, humans included, will 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, 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. “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, however, 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 the 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 day even when it isn't. Just 10 minutes of regular electric light can make some changes to our internal clock.

"We evolved to be blue-sensitive, we need it," Panda says.

But many of us get a tonne of it, particularly in the evening: when we get home we spotlight the kitchen so we can make the dinner, then plug into our laptops 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 function. All of which makes us more prone to insomnia.

12 tips to 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 lights dimmed – every night;
- don't use your computer or tablet for two hours before bedtime;
- install f.lux software on your computer. It's a free program that cuts blue glare later in the day;
- turn off the light half an hour earlier. It could save your life.

Panda has assembled these ideas into strict rules. He rarely watches television and never checks his email 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 to science 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 1923 when US geneticist Clyde Keeler noticed that even the pupils of blind mice contract in response to light. They couldn’t see it, but it had a non-visual effect.

Scientists had since identified seven or eight receptors that might respond 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.

He 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. “It was the middle of the night and we had our experiment. And there it was: mouse number 1626 did not entrain (modify its circadian rhythms) to light.”

The other blind mice changed their waking times when exposed to different light-dark cycle, but Panda’s melanopsin-free mouse did not. “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. 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 of mystery.”

Last summer, an international group of scientists (including Panda), doctors, ophthalmologists, architects and engineers gathered in Tokyo, all animated by the same questions: how does light affect health?

That first meeting of the Blue Light Society was concerned by Kazuo Tsubota, professor of ophthalmology at Japan's Keio University school of medicine. 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 with 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 eye sight fades with age – what he calls the eye as a camera – but "the eye as a clock" does too. As we get older our lenses yellow, 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. Says Tsubota, "At 58 my lens is a third as good at receiving blue light as the 20 year old lens. In order to have a proper amount of light, I have to play outside three times as much as a 20 year old." He laughs, "That gives me a good excuse to ski, go swimming, jogging."

Tsubota says he is motivated by *gokigen*, meaning of life filled with happiness. Happiness is one of three things that help to stave off the depredations 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's sleep 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 believes many of the other benefits of the operation flow from this. "The surgery replaces the opaque lens and suddenly 90 percent of the blue light is received; you are like a five-year old. So [removing the] cataract is a treatment for the clock as well as the camera.

While lack of light can be a problem for some, for others the headache is that we get too much by night, particularly blue light, Tsubota says. This is particularly so for those of us interminably glued to radiant, luminous screens only a foot or so from our eyes.

For tech junkies – which most of us are these days – Tsubota has helped to develop “PC glasses” that cut 30 to 50 per cent of the blue light reaching the wearer’s eyes.

“The idea is that we can wear these for protection, not just for myopia – just as we wear shoes to protect our feet.” The glasses are slimline, slight on the nose and come in 15 frames and 16 colours with faint yellow tinge to the lens. They are marketed as cool accessories: one ad for them features manga characters wearing the shades.

Since 2011, Jins, a regular spectacle maker, has sold more than 3 million pairs at \$42 to \$62 each. Tsubota’s team is working on the next creation: light protecting contact lenses.

Teenagers 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 2012 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 backlit devices ruins our sleep. But Figueiro draws another inference too. Because they blast us with blue light, these same backlit items could act as light therapy by day to 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.

Born in Belo Horizonte, one of Brazil’s largest cities, Figueiro trained as an architect 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 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 recalls, “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, grey day. “But we think a television is a log 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 percent 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. Figueiro reckons more exposure to bright light by day could help keep the doctor away.

She has created a lighting system specially for aged 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 light-box.

Blue light might be used to help drivers and pilots stay awake at the wheel. Figueiro says. And as for the backlit gadgets that wreak havoc with our sleep, she argues there 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. There are plenty of technical answers. But her best advice for a good day's light – and a good night's sleep – involves no machines. "Wake up and go for a walk every morning."

In the US, 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 wellbeing. This

question is becoming urgent, Mark tell me. 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 for privacy or to avoid glare.

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 “electromic glazing” – which can be transparent or translucent depending on the brightness of the sun. It has been used to save on air-conditioning and deflect blinding rays, he says, but you could equally apply large plates of it for more natural light.

Artificial lighting can also be manipulated. The lights we dazzle ourselves with by night have got brighter in the past 10 years, as we replace incandescent bulbs with more intense light-emitting diodes (LEDs).

At the moment thee 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 from your phone. Why not your lights?

In addition to light and dark, the body clock also responds to the direction of the rays and movement in a scene (which is shy glittering, windowless casinos are so disorientating). Within 20 years, architect 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.

Work-hard, play-hard cultures 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 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 not solution, he says. “But what if you can change a light bulb and change your life?” Light up your life.