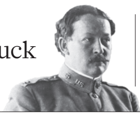
COMMENT

MEDICINE When bubonic plague struck San Francisco **p.454**



BIOTECHNOLOGY The rise and fall of medical-testing firm Theranos **p.455**

EXHIBITION Artist Katie Paterson takes the long view as she envisages deep time **p.457**

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IAN TEH/PANOS

High-rise buildings cast shade for much of the day on public spaces in Hong Kong, one of the most densely populated cities on Earth.

Protect our right to light

Skyscrapers in cities rob people of sunlight and put human health, well-being and sustainability at risk, warn **Karolina M. Zielinska-Dabkowska** and **Kyra Xavia**.

"The struggle for light" is how the Swiss architect Le Corbusier described the history of architecture in 1935. Today, with the skies crowded out by buildings in modern cities, those words should ring in the ears of policymakers and planners.

Skyscraper construction is booming. China is the leader, last year completing 88 of the 143 buildings around the world that are taller than 200 metres (see 'Vertical growth'). As the nation's urban populations swell, by 2025 it will need to build 10 cities the size of New York, or 5 million buildings, to house people migrating from the countryside[1]. Most of the buildings will be tightly packed towers of flats. These 'vertical cities' will look a lot like Hong Kong, one of the world's densest urban areas, which has 26,000 people packed into each square kilometre.

Beyond Asia, even historic European cities such as Frankfurt, Amsterdam and London are now embracing skyscrapers. London's skyline is set to be transformed by 510 tall structures over the next decade. Middle Eastern cities such as Dubai and Doha are competing to erect ever more showy palaces in the air.

But dense, vertical development comes at a huge price. Placing tall buildings close together slashes levels of natural light in and around them. In Asia and Australia, solar ultraviolet radiation can be reduced by ▶

up to 90% in shaded 'urban canyons'[2]. Evidence is emerging of the widespread health effects of chronic low exposure to natural light, from vitamin D deficiency[3] to short-sightedness. And dense, dark cities will be energy-hungry and unsustainable.

The problem of stolen light is not new. The United Kingdom and Japan have long had planning laws that enshrine the right to light. In the United States, San Francisco in California protects the illumination of its parks and plazas with a Sunlight Ordinance; in Switzerland, Zurich restricts the length of time a high-rise addition to residential areas can cast shadows on a surface, limiting it to less than 2 hours a day during winter. Last month, Germany became the first country to adopt the new European Standard on daylight in buildings (EN 17037).

Elsewhere, protective measures are missing. Many towers are constructed without planning restrictions or height limits. And the scale of development demands a rethink before unhealthy conditions are cemented in.

Surprisingly, access to natural light is not mentioned in the World Health Organization (WHO) Healthy Cities concept[4], nor in any of the 17 United Nations Sustainable Development Goals. Light accessibility needs to be part of global discussions about sustainable living, health and well-being.

Research gaps need to be filled, including the impacts of urban light loss on people, animals and plants, and on sustainability and energy. Standards for natural lighting are essential to guide architects and city planners.

LIVING IN SHADOW

Daylight is vital for our physical health and mental well-being. Natural light drives basic biological processes, from circadian rhythms to sleep and mood. Most artificial lighting disturbs those processes, and the blue-rich white light from LEDs might even be harmful (especially at night)[5].

Before the Industrial Revolution in the eighteenth century, the majority of city dwellers spent most of their day in the open air, although residential buildings generally had small windows to conserve heat and because glass tended to be inordinately expensive and impractical.

Later on, the design of industrial buildings shifted to include larger windows and skylights to give people enough daylight to go about their business. After incandescent lamps became commercially available, artificial illumination extended the day into the evening. Modern society is now so dependent on electric lights that we seem to have forgotten that access to natural light is crucial.

The results are plain to see. Europeans and North Americans now spend 90% of their time indoors, on average. People sit in offices under artificial lighting from early in the morning until late at night. Children spend more time indoors, too, and when they do go out, the courtyards, playgrounds and parks they play in are often overshadowed by buildings.

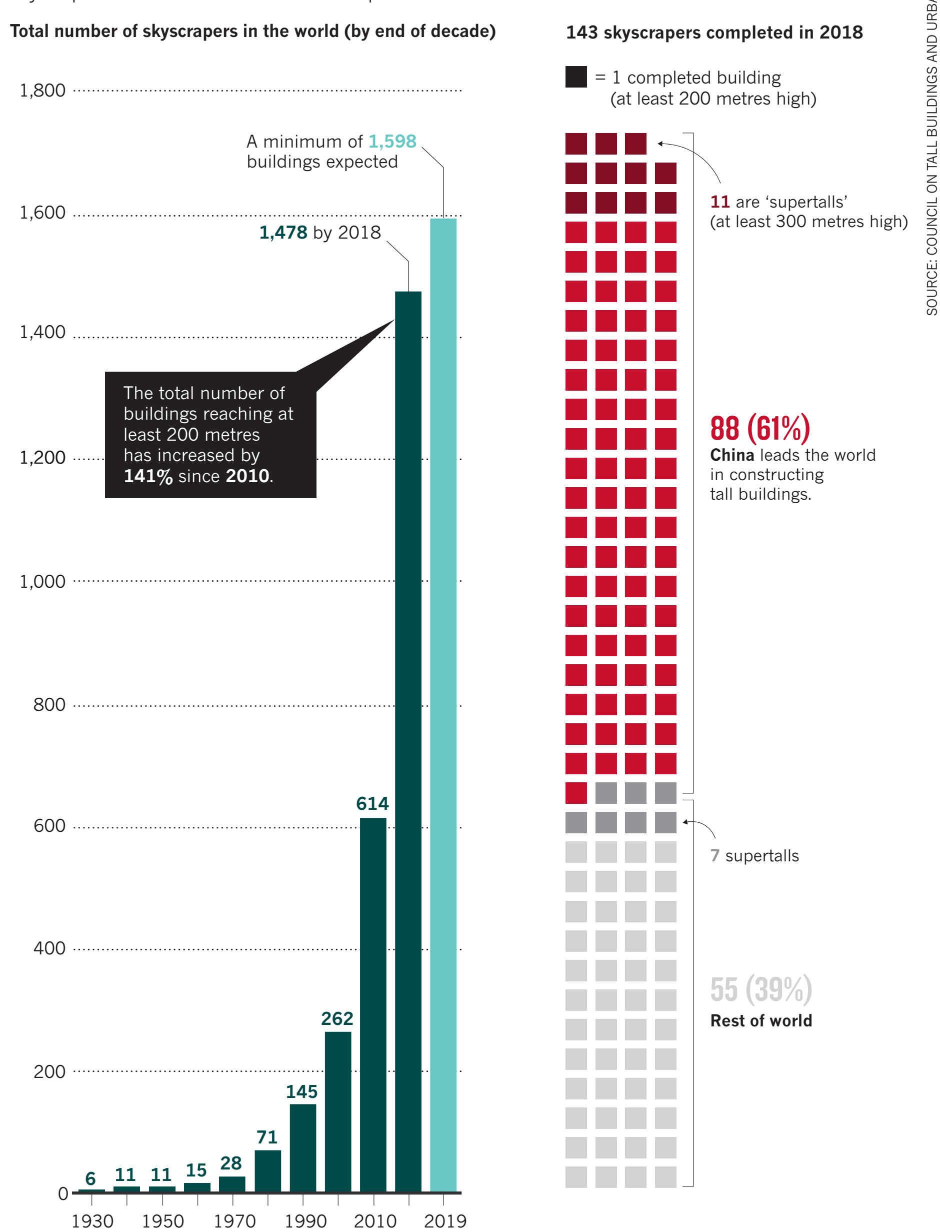
Alarming health consequences are emerging. For example, a global rise in short-sightedness (myopia) since the 1960s has been linked to low exposure to daylight[6]. Today, around 70–80% of young adults living in Taiwan, Japan, Hong Kong, Singapore and other parts of eastern Asia are short-sighted[7]; by contrast, in 1950s China, only 10–20% of the population was affected. By 2050, half of the world's population could be myopic. Yet myopia might be prevented by spending just 2 hours a day outdoors in bright sunlight[8]. Researchers are trying to pin down the particular biological mechanisms involved.

Similarly, around one billion people globally are deficient in or have insufficient levels of vitamin D[9]. Some health professionals have noted an increase in conditions related to this insufficiency that weakens bones, such as rickets and solar osteomalacia. Most of the vitamin D in our bodies comes from exposing the skin to UVB radiation: 80–100%, according to the WHO. The sunlight-derived form of this vitamin is stored in the body for twice as long as that absorbed through supplements, and it has no risk of toxicity.

A lack of outdoor natural light during winter has been linked to seasonal affective disorder (SAD) and depression. Up to 10% of the world's population is thought to have SAD. Exposure to outdoor daylight can reduce symptoms.

VERTICAL GROWTH

Skyscraper construction has boomed in the past decade.



Time spent in sunlight might also improve other conditions. For example, about 1.7 billion people, or 23% of the world's population, are thought to have a latent tuberculosis infection. Again, vitamin D has been linked to its prevention. Even in high-income countries such as the United Kingdom, winter dips in sunshine correlate with peaks in the incidence of tuberculosis six months later. The burden on hospitals and health-care systems could also be reduced, because research suggests that patients experience less stress, require less medication and recover faster in sunny rooms[10].

Studies in the field of photobiology and the effects of ultraviolet, visible and infrared radiation on living organisms should be re-examined. Health fears about sun exposure — mainly concerns over skin cancer and premature ageing — might need to be reconsidered. For decades, people have been encouraged to shy away from direct sun and to cover up to avoid damaging the skin and eyes. Researchers need to develop balanced recommendations for sun exposure that promote vitamin D while avoiding burning, and should examine the impacts of sunscreens.

ENERGY BOOST

By ignoring the benefits of sunlight, cities will also miss goals for sustainability, including reducing carbon emissions and energy use. Sunshine is free, and a building designed to capitalize on that can have 20–60% lower energy costs for lighting[11] and heating. High-rise office buildings are often more energy hungry than are low-rises. Offices that are higher than 20 storeys use nearly 2.5 times as much electricity per square metre of floor area as do those with fewer than 7 storeys. More research is needed to understand why, but greater exposure to wind and direct sun on high floors might increase the need for heating and cooling.

Yet architects continue to prioritize form over function. Overshadowing by tall buildings reduces the amount of solar radiation falling on photovoltaic solar panels on roofs by 30–40%, limiting the amount of clean electricity that can be generated. The orientations of buildings relative to the path of the Sun are often not considered; north-facing flats are now common in northern Europe. Legislation on window size (in the United Kingdom, Germany, Japan, Australia and the United States, for example) is of little use if an adjacent building blocks light.

Sunshine also promotes the growth of urban trees and vegetation that absorb carbon dioxide and air pollution, thus cleaning the air and lowering greenhouse-gas emissions. Without enough light to photosynthesize, trees suffer stress and grow poorly[12]. The benefits of planting trees in cities to reduce heat-island effects fall as urban density increases. More research is needed into urban planting and lighting to understand the details.

LIGHT ON LAWS

Inadequate legislation has a lot to answer for. In many countries, a land owner has exclusive rights to develop the spaces above and below their plot. The owner of an old 3-storey building, for example, can profit by allowing a 35-storey skyscraper to be built in its place. In New York City, rights to build in the air can be traded, allowing the upper floors of a high-rise to extend over the footprints of lower adjacent buildings and land.

This laxity is accelerating dense growth, threatening treasured public spaces. For instance, 7 towers are planned or being built on the south side of Central Park in New York City, with the tallest projected to cast a shadow as long as 1.6 kilometres — equivalent to almost 6 Manhattan-standard blocks. The public is often not consulted, and there is no legal requirement in the United States to share information on the scale of a building or its shadow. Public uproar about access to light is growing (see, for example, go.nature.com/2gkoyqg).

> ***"We seem to have forgotten that access to natural light is crucial."***

The United Kingdom, by contrast, has some of the firmest laws on the right to light. The Prescription Act of 1832 states that if a building has enjoyed continuous sunlight through its windows for 20 years, the owner has the right to such undisturbed sunshine forever. Surveyors and the justice system uphold people's right to light, although developers still try to flout it, for example by paying residents compensation that seems generous but is a fraction of the profit they stand to make over decades. Legal guidance informing city residents of their rights should become standard in all cities.

BRIGHTER FUTURE

Direction is needed on a global level. Targets and actions for protecting access to daylight and sunshine should be included in the UN 2030 Agenda for Sustainable Development and the WHO's 'health for all' policy (HEALTH21). National and regional governments should pass comprehensive legislation on the right to light.

On a local level, city authorities, urban planners and policymakers must prioritize good 'daylighting' — sufficient access to natural light to improve public health and quality of life. Access to natural light must be integrated into the early stages of urban planning. All applications should supply a thorough analysis of the shadows that will be cast by proposed buildings. Moreover, businesses and schools could encourage employees and children to take longer lunch breaks outside.

More research is needed to understand the relationships between natural light and circadian rhythms, and their effects on health and well-being. Many societies are ageing, so the links between a lack of sunlight, dementia and Alzheimer's disease should be explored. Another potential research question is whether there is any relation between daylight exposure and increased chronic inflammatory and autoimmune diseases. Impacts on the environment need to be better understood; there have been few studies on shadowing and vegetation in cities, for example, or on the development of moulds inside buildings, which might affect health.

Cities should establish interdisciplinary technical committees to provide advice, with leading experts and professionals from fields such as daylighting and urban planning, sustainability, architecture, engineering, medicine, neuroscience and chronobiology.

Architects should integrate courtyards, internal gardens and skylights to let in as much daylight as possible. Codes and standards for natural lighting must be updated. Better access to outdoor spaces should be provided for children, elderly people, nursing-home residents and people with disabilities. More research is needed to develop alternative models for urban expansion that don't diminish the many benefits of natural light.

The public should be consulted on all planning applications and be made aware of legal pathways to defend their right to daylight. The upholding of recent lawsuits against developers to maintain these rights in the United Kingdom and China, and rejections of tall buildings by planning authorities in the United States, lights the way. ■

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CORRECTION

The Comment 'Protect our right to light' (*Nature* **568**, 451-453; 2019) failed to accurately describe Taiwan and Hong Kong.