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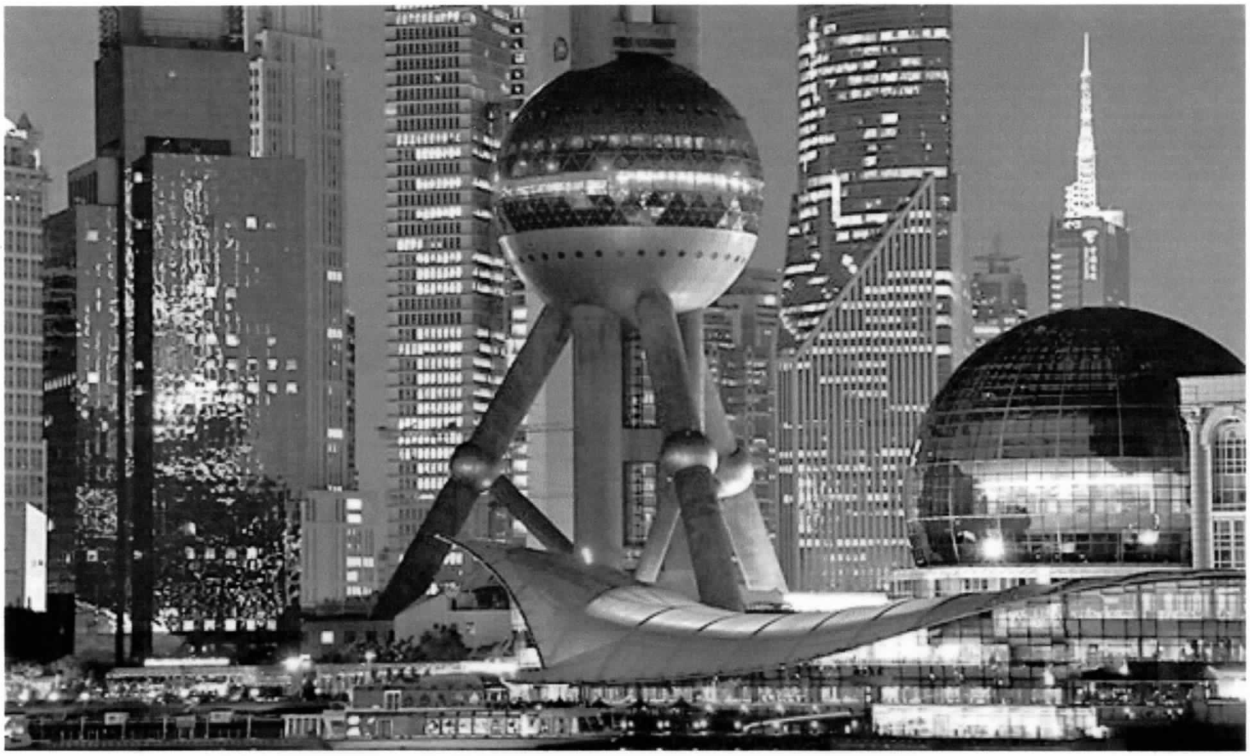
Living in the city

Buildings that eat carbon dioxide? Fish bacteria that light the streets? Meet the architects rebuilding our future



(Tom Bonaventure/Getty Images)

Close up of Pudong with Oriental Pearl Tower

Hannah Devlin

From Eureka, our new science and environment magazine

As temperatures rise and ice melts, it has become clear that Man's attempt to impose his will on Nature has gone awry. A new breed of scientists is beginning to approach our myriad problems from a new, humbler perspective; how, they ask, can we learn from Nature and borrow some of its extraordinary inventiveness in the fight against climate change.

The deep ocean is an unlikely source of inspiration for one project, which aims to make our cities alive and glowing. The plan sounds almost biblical; the lighting of the world from a multitude of fish.

Dr Rachel Armstrong, an architectural researcher from University College London, wants to transform buildings from being sterile, inert objects into entities that interact and evolve with the natural environment. She sees this as the fulfilment of what architects have always seen as the purpose of their work. "We've likened the city to an organism, but so far it has been a symbolic description. In the future, architecture will be literally alive," she said.

Imagine the cityscape of the future. Forget skyscrapers studded with undimmed lights. Instead, think of crystal whites and luminous blues forging the city's silhouette. Picture a city that sucks in carbon and uses bacteria harvested from dead fish to light the darkness. The city as a living character will no longer be a literary conceit, but a reality. From metaphor to concrete in one generation.

One of her projects starts with a simple premise. Leave a fish rotting in a bowl of water for long enough and it will begin to glow. The light comes from bacteria in the fish. In certain species, such as the flashlight fish and the anglerfish, a symbiotic relationship with this bacteria, Vibrio phosphoreum, allows the fish to glow and flicker in the deep ocean. The flashlight fish carries the bacteria in pouches beneath its eyes, which it opens to show off the glimmering organisms or closes to hide them, depending on whether it wishes to lure in prey or evade predators. But how have scientists leapt from flashes of light in the sea to a new vision for our cities? Welcome to the world of nanoarchitecture.

With her colleagues at the Bartlett School of Architecture, Armstrong is focusing on "grunge" solutions to global warming: technologies that are cheap and relatively simple. We've already seen a sliver of this idea. Steven Chu, the United States Secretary of Energy, is an advocate of the use of whitewash on our houses. "If you take all the buildings in the world and make their roofs white and you do this uniformly?.?.?.?it's the equivalent of reducing the carbon emissions due to all the cars on the road for 11 years," he told a meeting in London earlier this year.

But Armstrong and her peers have ideas that reach far beyond whitewash. One intriguing possibility is the use of bioluminescent bacteria, organisms that give off a blue-green glow, as low-energy urban lighting. In the US, urban lighting accounts for more than 8 per cent of the country's total electricity consumption. The sides of buildings and billboards could be covered in sparkling bacteria, such as Vibrio phosphoreum — the fish bacteria. This produces light automatically when a pigment contained in the bacteria called luciferin, from the Latin meaning light bringer, reacts with oxygen in air or water. At present, the light emitted is not strong enough to illuminate a street, but scientists believe that it could be engineered to do so. Another possibility is using bacteria to metabolise carbon dioxide through photosynthesis so that the bacterial coating would effectively eat up carbon dioxide by turning sunlight into energy.

"When dealing with climate change we don't always have to invent something new, we have to think very cleverly about what we already have," Armstrong said. "It doesn't take a massive leap of imagination to envisage how much more useful the surfaces of our buildings could become if covered in bacteria that glow in the dark or remove pollutants from the atmosphere."

Choosing which bacteria to use would be the easy part, according to Armstrong, as scientists have already identified numerous common species that carry out these functions. She is now looking at the possibility of using cyanobacteria, also known as blue-green algae, to capture carbon dioxide.

What remains to be addressed, however, is how best to cultivate such organisms on the surfaces of our houses, offices and schools. Armstrong views this challenge as a form of gardening. "Bacterial gardens don't really exist and that's what we need to create," she says.

Simon Park, a microbiologist at the University of Surrey, already has some experience of bacterial gardening. He has been exploring the use of naturally bioluminescent bacteria in art, using Vibrio phosphoreum to make dazzling blue abstract displays. Park cultivates the bacteria by placing them in agar gel in petri dishes and providing them with salty water, which replicates a marine environment, and glycerol, on which they feed. Park's art installations normally last for a few days before the bacteria run out of food and gradually fade to darkness, but if fed continually the displays could be permanent, he said.

Transferring the concept to urban design would mean ingraining the necessary nutrients in the fabric of the building. Armstrong says that this could be achieved by using porous materials, such as chalk and sandstone, seeded with bacteria-friendly substances.

Again looking to nature for inspiration, scientists are trying to artificially recreate the process of limestone formation, in which atmospheric carbon dioxide is transformed into a solid carbonate form. In nature this happens over thousands of years, with atmospheric carbon dioxide first being dissolved in acidic rain water, and then combining with calcium to form calcium carbonate. Nanoarchitects are aiming to speed the process up to a matter of days. They believe it could be done simply by coating the walls of buildings with tiny droplets of engine grease. The grease would be laced with a common salt such as magnesium chloride. When the magnesium reacts with carbon dioxide in the air, a solid magnesium carbonate pearl begins to form. This serves as the seed for the growth of white, wheatsheaf-shaped carbonate crystals. The large surface area of a droplet of grease maximises the interface between the magnesium and the atmospheric carbon, speeding up the rate of the reaction. Within days, the grease would be transformed into a sparkly crystalline coating similar in appearance to heavy frost or snowfall.

What is done with the carbonate deposit would be as much an aesthetic as a scientific decision. One option would be to scrape off the carbonate and dispose of it or reuse it as a building material. Armstrong likes the idea of making a feature of it. "We could bring back the façade," she said. A green city as envisaged by Armstrong would look like Narnia under the White Witch, crystal white and beautiful. The carbon choking our planet could become a harmless decorative feature.

Having demonstrated that the technology to create carbon-eating walls works in principle, Armstrong and her colleagues are now conducting experiments to speed up crystal growth and vary the size of the crystals by changing the size of oil droplets and testing different salts. They are also calculating how much carbon can be absorbed per hour per square metre of surface covered.

Despite the research being at a relatively early stage, it has already come to the attention of commercial practitioners such as the Canadian architect Philip Beesley. He said: "Traditionally, the architecture industry is tremendously conservative but there's a hunger for this technology. We could be seeing these buildings on our streets eight years from now." Beesley is presenting a joint exhibition about the technology with Armstrong at the UN climate change conference in Copenhagen in December.

The low-tech approach has the advantage of being easy to implement and cheap. However, one potential drawback of using simple oil droplets is that once all the magnesium has been turned into carbonate and the oil has evaporated, no more carbon will be captured — at least until another oily coating is added. Armstrong believes that the solution to this problem could lie in the development of "protocells": artificial cells that, while lacking DNA, can divide and replicate in a similar manner to living cells. If scientists can create such cells, Armstrong says that they could carry out the same function as the oil droplets, but be programmed to run on salty water, making them more self-sufficient. She is in early discussions about this with synthetic biologists at the University of Southern Denmark. Professor Steen Rasmussen, the director of the university's Centre for Fundamental Living Technology, predicts that functioning protocells will be a reality within a few years. "Certainly within the next ten years someone will have done it," he said. "To be specific and say that these cells will be capable of carbon capture at this point would be speculation. But it is already clear to me that they'll have a huge impact in environmental sciences."

Oil droplets, bacteria and protocells are the cornerstone technologies of this new grunge architecture, which has the power to be the dominant aesthetic of 21st-century landscapes. As Beesley says: "Until now, the sustainability movement has been quite separate from cultural expression in architecture. Sustainable architects have tended to follow an anti-fashion trajectory closing up windows, not using glass — basically making hair-shirt buildings. The concept of living architecture combines the two."

Name/Period/Date

Living in the City

1. What is nanoarchitecture?
2. What would the effect of whitewashing all the roofs in the world be?
3. Describe the low-energy urban lighting described.
4. How can bacteria be used to combat climate change?
5. How would you feel about having "carbon-eating walls"?
6. What are protocells?
7. Would you describe this as science or science fiction? Why?