A Digital Twin Might Just Save Your Life

Digital twins offer humankind the ability to command virtual replicas of forests, oil fields, cities, supply chains — and even, maybe one day, our very bodies.

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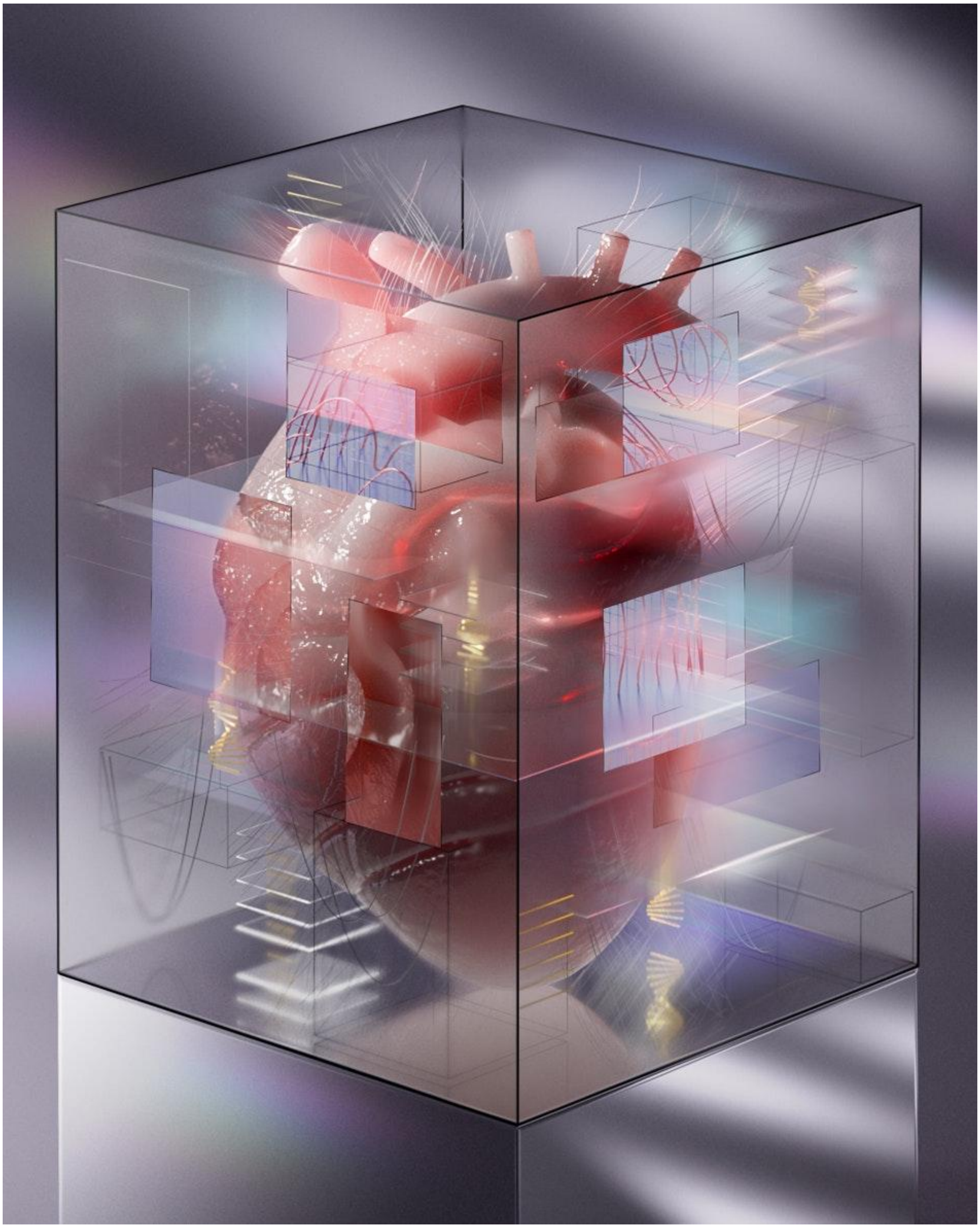


Luis López (Mallet) for Noema Magazine

On the morning of June 24, 1993, Yale University Professor David Gelernter arrived at his office on the fifth floor of the computer science department. He had just returned from vacation and was carrying a large stack of unopened mail. One book-shaped package was in a plastic ziploc — he thought it looked like a PhD dissertation. As he unzipped it, pungent white smoke poured out, followed by what he later described as a "terrific flash." He never heard the bang. Shrapnel shot into his eyes, hands and torso, as well as the steel file cabinets around him. A fire ignited and triggered the sprinklers in the ceiling, which began to soak his books and papers.

Gelernter, as he later wrote in his memoir, had been "blown up." He was the 14th person attacked by a serial killer who was still then at large and known only as the "Unabomber." From 1978 to 1995, Theodore John Kaczynski, fueled by an ideology that sought to bring about the destruction of modern technological life and a return to primitive ways, murdered three people and injured 23 in a brutal mail-bombing campaign. Gelernter's lungs and other internal organs were damaged, he lost the vision in his right eye and most of his right hand was destroyed. But he survived.

Around two years later, another letter from Kaczynski arrived at the computer sciences department for Gelernter. No bomb this time — just a typewritten message in which Kaczynski explained the attack was provoked by Gelernter's most recent book: a speculative work of nonfiction titled "Mirror Worlds."

Back in 1991 when the book was first published, just over 1% of Americans were using the internet. But Gelernter claimed computing was about to revolutionize life on Earth. "This book describes an event that will happen someday soon," he wrote in the opening line. "You will look into a computer screen and see reality. Some part of your world — the town you live in, the company you work for, your school system, the city hospital — will hang there in a sharp color image, abstract but recognizable, moving subtly in a thousand places."

In essence, Gelernter believed that every aspect of life could soon be modeled in a parallel digital simulation. Everything happening in our lived reality would be tracked and monitored and fed into software "by a steady rush of new data pouring in through cables" to create a high-fidelity real-time digital representation of the world and all of its pulsing, swarming and sensuous qualities. This would be like Mark Zuckerberg's metaverse on steroids: our exact world, our very lives, all digital. And you could view, manipulate, experience and interact with this mirror world, like a child with a dollhouse. A dashboard for reality.

These "high-tech voodoo dolls," as Gelernter described them, "will mark a new era in mankind's relationship to the man-made world. They change that relationship; for *good*." It would be possible, he believed, to not just monitor what *was* happening around the world, but also to predict what *could* happen — endless simulations of possible future events would be running inside the mirror world. We could prepare ourselves for any outcome — any future — in the physical world because we would know what was coming.

In 2007, Technology Review called "Mirror Worlds" "one of the most influential books in computer science" and Jaron Lanier, a founding father of virtual reality, once hailed Gelernter as "a treasure in the world of computer science." Reviewing the book in The New York Times the year it was published, Christopher Lehmann-Haupt wrote that it “tells you how Hamlet’s dream may be fulfilled: ‘I could be bounded in a nutshell, and count myself a king of infinite space.’ ”

Gelernter believed mirror worlds might spring to life in the decade after his book was published, but nothing close came to pass. The dream was beyond the available technology. The buzz subsided.

There’s a phrase in the science fiction community known as “steam-engine time”: when lots of people have the same idea independently at the same time. It can be traced back to a line in Charles Fort’s 1931 novel “Lo!”: “A tree cannot find out, as it were, how to blossom, until comes blossom-time. A social growth cannot find out the use of steam engines, until comes steam-engine time.”

In the mid-2000s, a manufacturing expert named Michael Grieves started to spitball ways to make factories more efficient. Instead of a manager peering down on the factory floor from above, trying to sense how things were going, Grieves thought there should be an exact virtual replica of every physical nook, cranny, machine, forklift and worker that the manager could analyze on a computer screen. Create an endless stream of data from a network of sensors and cameras that flowed from the real factory to the virtual one, and you’d get an ever-changing real-time representation of its brick-and-mortar counterpart. Anything that changed in the factory would change in the model, instantly: the physical and the virtual locked together in what the French philosopher Jean Baudrillard might have called an “ecstasy of communication.”

What power this would give a factory manager! Perhaps they wanted to see how a change to one of the production lines would impact the entire operation. Run a simulation to see how it might play out. Should anything go wrong, rewind it back, find out what the hell happened. Heck, the manager wouldn’t even need to be anywhere near the physical factory — they could be off in a beach house on some idyllic island.

Grieves, along with a NASA researcher named John Vickers who had been mulling over a very similar idea, called this a “digital twin.” “Not only the factory manager, but everyone associated with factory production could have that same virtual window to not only a single factory, but to all the factories across the globe,” he wrote in 2014. Here at last was Hamlet’s king of infinite space.

In the last decade, thanks to advances in AI, the internet of things, machine learning and sensor technologies, the fantasy of digital twins has taken off. BMW has created a digital twin of a production plant in Bavaria. Boeing is using digital twins to design airplanes. The World Economic Forum hailed digital twins as a key technology in the “fourth industrial revolution.” Tech giants like IBM, Nvidia, Amazon and Microsoft are just a few of the big players now providing digital twin capabilities to automotive, energy and infrastructure firms.

The inefficiencies of the physical world, so the sales pitch goes, can be ironed out in a virtual one and then reflected back onto reality. Test virtual planes in virtual wind tunnels, virtual tires on virtual roads. “Risk is removed” reads a recent Microsoft advertorial in Wired, and “problems can be solved before they happen.”

All of a sudden, Dirk Helbing and Javier Argota Sánchez-Vaquerizo wrote in a 2022 paper, “it has become an attractive idea to create digital twins of everything.” Cars, trains, ships, buildings, airports, farms, power plants, oil fields and entire supply chains are all being cloned into high-fidelity mirror images made of bits and bytes. Attempts are being undertaken to twin beaches, forests, apple orchards, tomato plants, weapons and war zones. As beaches erode, forests grow and bombs explode, so too will their twins, watched closely by technicians for signals to improve outcomes in the real world.

The first city to begin the process of digitally twinning itself was Singapore, which deployed fleets of aircraft, drones and cars armed with lasers to scan the entire city-state from above and on the ground and then combine as much weather, demographic and movement data as possible. That twin will be used by the government to simulate construction projects, the effects of flooding and extreme heat, large-scale emergencies and more. The city is expanding the digital twin’s scope underground too, mapping a vast network of subsurface infrastructure. Tuvalu, a nation of low-lying islands and atolls in the Pacific, has also begun to digitally twin itself in the hope of preserving, at least in virtual reality, what may soon disappear entirely under the rising seas of physical reality.

Digital twin projects are probably going on in your city or state too. Search YouTube and you’ll find countless experts in sharp attire giving giddy presentations, their slides filled with illustrations of physical objects reduced to luminescent geometric grids reminiscent of the original “Tron.” TED Talks abound — “How ‘Digital Twins’ Could Help Us Predict the Future,” “Digital Twin: Towards Next Generation Virtual World.”

A skeptic might catch the faint rumble of a hype train and wince as a new multibillion-dollar industry intent on making spectral replicas of things that already exist comes to life. One has to wonder: How accurate can these things truly be? Whom do they serve? What damage to the environment will the necessarily massive amounts of computation do? Are we really interested in having yet more of our lives and shared public goods uploaded into digital realms and controlled by a tiny group of techno-capitalists?

Digital twin technology is still in its infancy, and many of these projects are in varying degrees of incompleteness. But there is a sense that this is all now a matter of time. Reflections of ourselves and our worlds are enticing, beckoning us. Digital twins are already changing how people think across many academic disciplines and professional fields. You see, they aren’t just being made of objects, places and processes — they are being applied to living entities and organisms. And this is where things get a bit weird, because these twins might just save your life. In fact, some of the most scientifically advanced and potentially life-changing projects are coming from the world of healthcare, where there is an ongoing quest to make a digital twin of you.

On the western outskirts of Barcelona, next to a park filled with orange and cypress trees and a pond populated by ducks and geese, sits a Catholic chapel built of pink sandstone in the 1940s. It fell out of use in the 1970s and was eventually deconsecrated and donated to the city. In the early 2000s, the Barcelona Supercomputing Center

(BSC) chose it as the unlikely location for the construction of one of the world's most powerful supercomputers.

The first iteration of the supercomputer, MareNostrum ("our sea" in Latin), was switched on in 2004 and could do over 42 trillion calculations per second. Every few years, it undergoes an upgrade. At its peak, the current one, MareNostrum 4, crunches numbers at around 11 quadrillion calculations per second. It has been used to do the complex math behind exploding stars, map ocean currents and develop potential AIDS vaccines; it provides complex climate forecasts and predicts the flow of lung-damaging dust through the atmosphere. Its nickname is "Spain's brain."

The computer is outgrowing the chapel like a plant pressing against the panes of a greenhouse: MareNostrum 5 is next door. In the final stages of testing, it will be able to compute in one hour what takes the current machine a whole year.

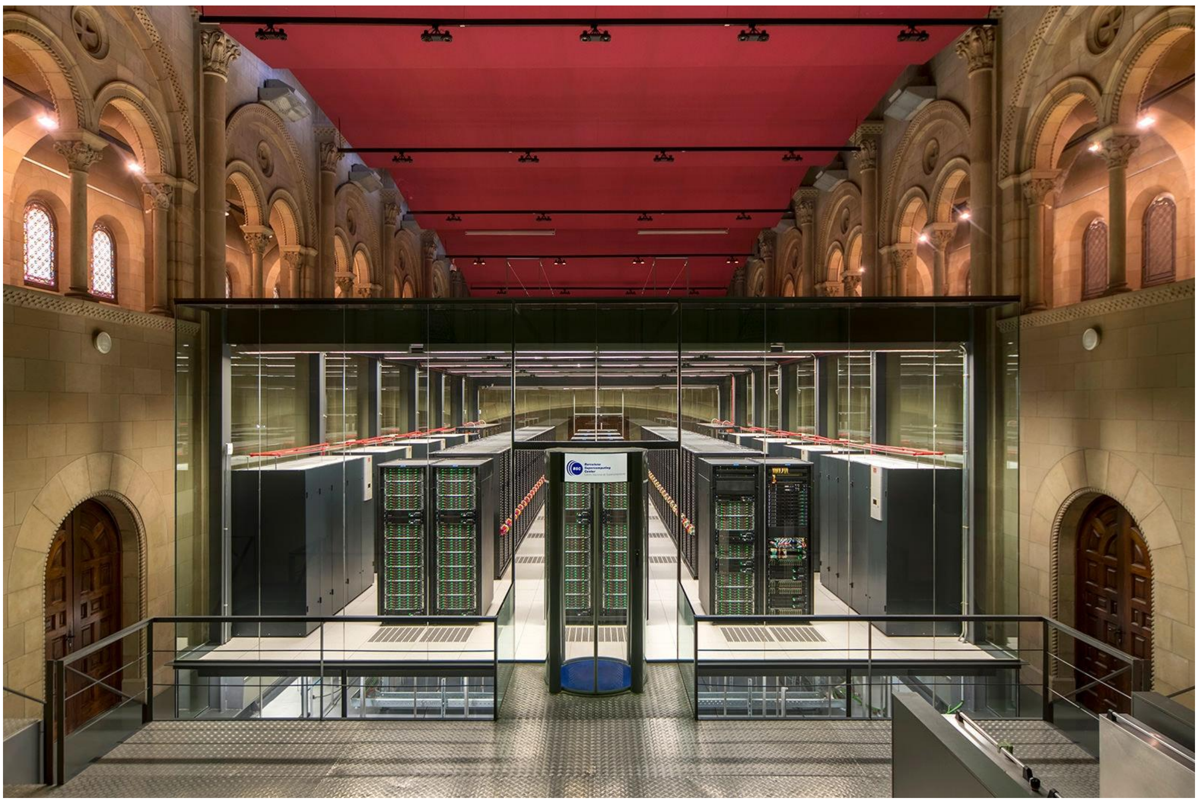
Recently, some of MareNostrum's precious time has been devoted to the creation of digital twins. In 2018, a group of scientists from BSC started a spinoff company called ELEM Biotech. The company's tagline is "the virtual humans factory," and its ultimate mission is to create highly advanced digital humans that can be used for medical experiments. The digital humans are mathematical models, Mariano Vázquez, a computational scientist and co-founder of ELEM, told me. It's all computer code.

"I read in a very good book a phrase that I like a lot: 'We are looking for the mathematical roots of reality,'" Vázquez said. "We do it with the weather, we do it with supernovas and galaxy formation, we do it with volcanoes. Why not do it with a human being?"

It was January and I had come by train to visit Vázquez at his office in the BSC building, a modern construction that looks like a gigantic internet router and is joined by an elevated walkway to the chapel next door. The walkway had been designed as a subtle optical illusion, getting gradually narrower and smaller as you traversed it. At its end, through a thick security door, we entered the chapel. Its stone vaults and stained glass windows of glowing angels reading from scrolls were a different world entirely from BSC's white walls, white ceilings, white strip lights and concrete pillars.

From the choir on its upper floor, we gazed down into the nave at MareNostrum. It sat within a square chamber made of glass and steel around half the size of a basketball court, glowing with white light. Inside the chamber were rows and rows of immaculate monolithic black blocks. Green lights blinked and flickered all across it, giving it a sense of aliveness. Thick braids of cables — yellow, red, green, blue and aqua, more than 4,000 of them — ran between racks and down into the floor. "Everything is clean and perfect; everything is well ordered," said Vázquez. "Neatness is a very important thing."

In his late 50s, Vázquez wore a blue hoodie and tan trousers and carried under his arm a laptop with a sticker of a cartoon cat on it. He spoke fluent English with speedy enthusiasm, even when showing me a simulation of his own heart's possible future — 25 or 30 years from now — riddled with the diseases of aging. "I hope not," he said with a smile.



MareNostrum 4 (Barcelona Supercomputing Center)

Born and raised in Buenos Aires, Vázquez cut his engineering teeth in aeronautics and has published research on topics ranging from supersonic aircraft to cloud formation to the flow of water around whales. In the mid-2000s, he began to focus increasingly on biomedicine. “Equations are just a way of describing nature,” he said. “Air is a fluid and blood is a fluid, so the same equations that model the air around an aircraft are the ones used to model the blood inside your body.”

We sat down on red-cushioned seats in the choir, and the dull thrum of the supercomputer’s cooling system reverberated off the stone walls around us as if we were in a cave listening to a waterfall. Vázquez told me the story of ELEM. In the beginning, they wanted to create a highly complex and hyperrealistic computer simulation of the average human heart. That involved doing a lot of physics, from the electromechanics that determine a heartbeat to the fluid dynamics that determine blood flow. After that, they collaborated with a local hospital to gather as much cardiac data as possible, and they took heart scans of everyone who worked at the company. Eventually, they had a highly realistic average model that could be tweaked and adjusted based on personal data to create a whole range of virtual hearts that mirrored the diversity of sizes, shapes, ages and health levels that one might find in a random group of real people.

Using these disembodied virtual hearts, ELEM has been able to run virtual clinical trials (known as in silico trials) inside the supercomputer that might have traditionally been performed on animals or humans (in vivo).

“There are plenty of pharmaceutical products that are tested on, say, a mouse, then a dog, and then swine, and in that move from dog to swine you suddenly realize it won’t work, and you’ve already wasted millions,” Vázquez said. “And that’s aside from all the ethical problems of animal tests.” He wasn’t exaggerating: It takes around 12-15 years and approximately $2.5 billion to get a single drug to market; 90% of clinical drug trials fail. Every year, researchers at Cruelty Free International estimate that more than 100 million animals — mice, frogs, dogs, rabbits, monkeys, fish, birds — are killed in laboratories around the world in search of solutions to human medical problems. When it comes to medicine, research and development and testing are slow, expensive and leave a long trail of blood. “We developed a computational tool for pharmacy companies to test the cardiac safety of their products in human beings — *virtual* human beings,” he emphasized. “But they *are* human beings.”

In the virtual world, the ethical and physical restrictions of science are nonexistent, for now at least. As Vázquez said: “There are some experiments you cannot do: You can’t go and measure the pressure around a supernova, and you can’t do certain experiments on people. It’s very difficult to run clinical trials on children, for instance. But virtual children? That’s just a mathematical model.”

“I always knew cardiology was my thing,” said Jazmín Aguado-Sierra. “I remember playing with my friend when I was 5 or 6 years old, and there were these little apple-like fruits from a tree. I would dissect them and transplant the seeds from one fruit to another. Why? I have no idea whatsoever. But it always attracted my attention, this little thing that was in the middle of everything.”

Aguado-Sierra is a biomedical engineer at ELEM. When I met her, she was wearing oval glasses and enjoying a lollipop. Continuing a long tradition of scientists experimenting on themselves — a tradition littered with both success and horror — she had twinned her own heart.

ELEM’s new ambition, now that the company has provided medical and drug companies a way to run tests on humans without the financial, time and ethical considerations of traditional trials, is to create precise digital twins of specific people’s hearts right down to the cellular level. Accomplishing this would mean opening up the possibility of a virtual heart accompanying you throughout your life, getting continually updated with whatever personal medical data is available from your doctors and from wearable devices and implants. Any medicines or therapies or devices (like a pacemaker) that you need to receive could be designed around your unique anatomy and then tested in your twin heart to gauge effectiveness and possible side effects. Surgeons, should you need them, could rehearse an operation in this risk-free zone.

Aguado-Sierra’s digital heart is one of the closest attempts we have toward this ambition. Last year, she went in for MRI scans and an electrocardiogram (ECG) and gathered a trove of blood pressure data from her smartwatch. Then she blended all that with the complex physics ELEM had developed on heart functions. After a month of sorting and testing, she translated everything into a series of equations and then translated that into lines of code she fed to MareNostrum. The supercomputer needed nine hours to do the calculations. The virtual heart the machine produced beat three times.

“What was that like, watching your digital heart beat?”

“I was like: Oh my god, it’s really cool,” she said. “It had a good amount of torsion — the heart doesn’t just beat, it also twists.” She locked her closed fists together and turned them in the air. “It was twisting exactly as it should be. I could see that, anatomically, my heart was good. The other thing I’ve learned, and I’m still learning, is the arrhythmic risk of my heart. It appears that my heart is a bit sensitive to drugs.”

“What kind of drugs?”

“Any drug you take can produce a little prolongation; your ECG expands a little bit. Drugs like antibiotics and antihistamines can have a very strong prolongation that produces arrhythmias. You see, I’m currently pregnant, and I’ve been taking antihistamines that are good for the nausea, but I’ve now observed that they actually produce supraventricular tachycardia in my heart. It’s mostly noticeable at rest or at night. You wake up to your heart racing and going crazy for no reason — that’s drug-induced arrhythmia. How much of that risk is actually dangerous? That’s something we can test and simulate with my digital twin.”

Images from the digital twin of Jazmín Aguado-Sierra's heart from the "Virtual Heart" display in the Engineers Gallery at the Science Museum, London. (Science Museum Group)

The risk of a drug-induced arrhythmia is relatively low but differs from person to person, depending on the specifics of their body. But most of the medical treatment you will receive throughout your life won't be based on you or your actual, unique body. Modern medicine tends to rely on a one-size-fits-all approach in which treatment is based on historical data of people who might be a bit like you, but might not be, and might have been in the same situation as you, but also might not have. The mesmerizing variety of human body types, characteristics and abilities are simplified into models of averages. And the data for those averages is gleaned from clinical trials that consist largely of white males. For everyone else, it's a bit murky. That's why treatments, diagnoses and medicines that work for other people won't necessarily work for you. The majority of common medications have small to medium effects, leaving many people untouched but exposing a select few to harmful side effects. Each year, around 1.3 million Americans visit the emergency room due to adverse drug events.

The case of women and heart disease provides a powerful example, but similar stories can be told around age and ethnicity. Around 44% of women in the U.S. are living with some form of heart disease — it is the number-one cause of female deaths, more than all cancers combined. But women's hearts remain something of a blindspot for modern medicine. For much of the 20th century, heart disease was viewed as a predominantly male affliction. The American Heart Association hosted a conference in the 1960s titled "How Can I Help My Husband Cope with Heart Disease?" The Multiple Risk Factor Intervention Trial — published in 1982, one of the first studies to identify a link between cholesterol and heart disease — consisted of 12,866 men and no women. The Physicians Health Study, completed in 1995, which identified the benefits of aspirin in reducing the risk of a heart attack, consisted of 22,071 men and no women.

Modern trials and public campaigns have aimed to rectify this and the knowledge gap has narrowed, but the historical bias still haunts women who are experiencing heart disease. Today, women are 50% more likely than a man to experience a wrong diagnosis for a heart attack. They have worse outcomes than men in heart operations and surgical treatments. And there's been a long-held assumption in medicine that females are essentially just "smaller versions" of males, and therefore the drugs that work for men will work for women, just in smaller doses. But when it comes to prescription drugs, women are 50-75% more likely to experience an adverse reaction than men.

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"As a pregnant woman, when I go to the doctors with nausea, they say: Just take these pills, two every eight hours," Aguado-Sierra said. "But if I take two every eight hours I will die, because it's producing this effect on me. I'd rather take candy." She pointed at the lollipop: mango and chili. "That's why we need personalized medicine. I think it's so important to actually make doctors and everyone realize that we need to be more aware of the personal, because we all respond completely differently."

The dream of a digital twin is to bypass the averages and biases and develop a personalized and predictive form of healthcare that is built around a person's specific physiology and pathology rather than vaguely representative historical data. "The idea [of the virtual human] starts from the premise that modern medicine isn't really that modern in scientific terms," Peter Coveney, a computer scientist and coauthor of "Virtual You" (2023), told me over Zoom. Coveney worked on a project to digitally twin the entire 60,000-mile-long circulatory system of a deceased South Korean woman named Yoon-Sun who had donated her body to science. Cross-sections were taken from her frozen cadaver to help trace the network of vessels, arteries, veins and capillaries. Once mapped, they created a digital simulation of how her blood flowed by feeding 200,000 lines of code into a supercomputer.

"It's still debatable in some sense how far it's a science," Coveney went on. "A lot of decisions that are taken on how to treat people are based on the past: You look like someone we've dealt with in the past or have a similar condition to someone we've dealt with in the past, and this is how we treated that patient, so we are going to give you the same thing. That's better than nothing. But ultimately it falls short of what we need, which is individuals being treated for what they are. We are using your data, not other people's data, to tell you how you should be treated. That's quite a compelling vision."

According to Coveney and his coauthor, Roger Highfield, your digital doppelganger, should one ever become available, wouldn't just spring into action when you're ill, with data and diagnoses about what's wrong and how to fix it. It would also assist in keeping you healthy, predicting the effects of diet and lifestyle the same way meteorologists predict when hurricanes will make land.

Their book attempted to capture in a single volume the global enterprise to build virtual humans, detailing the attempts to digitally twin livers, lungs, bones, guts, brains and more. In the final chapter, Coveney and Highfield envision "a lifelong, personalized clone that ages just like you, as it is constantly updated with each measurement, scan or medical examination that you have at the doctor's, along with behavioral, environmental, genetic and a plethora of other data."

"The rise of the digital twin could and should give many people pause for thought about where this technology is taking us," they conclude. "Some may welcome how digital twins allow them to take more responsibility for their destiny, others may condemn this as unnatural. We should not let the downsides deter us, however. The Janus-like nature of technology has been apparent for more than a million years: ever since we harnessed fire, we knew we could use it to stay warm and cook but also to burn down our neighbors' houses and fields."

Models have always been vital tools when it comes to creating representations of physical objects, phenomena, processes and systems to gain a deeper understanding of the world around us. Science is essentially the practice of model-making, and history is filled with replicas and representations, miniatures and prototypes. But all models are simulacra: simplified representations of the real thing. The trick is to make a model close enough to reality to be useful but not so close as to become as complex as the thing you are trying to understand. "What is simple is always false," wrote the poet Paul Valéry in his 1942 book, "Bad Thoughts and Others." "What is not is unusable."

During the 20th century, models gave way to computer simulations, and the physical objects we'd relied on for centuries were usurped by superior and compelling virtual objects. "The molecular model built with balls and sticks gives way to an animated world that can be manipulated at a touch, rotated and flipped," wrote Sherry Turkle, a sociologist at the Massachusetts Institute of Technology, in the 2009 book "Simulation and Its Discontents." "The architect's cardboard model becomes a photorealistic virtual reality that you can 'fly through.'" During the creation of the thermonuclear bomb in the 1940s, there were fierce debates about whether the simulated detonations they created inside the vacuum tubes of the MANIAC were consequence-free worlds that perfectly replicated nature in all its complexity, or instead paltry simplifications that couldn't be trusted as legitimate sources of scientific truth.

Regardless, simulation has a spellbinding allure. The historian Peter Galison interviewed a physicist who worked on the first H-bomb and admitted that he couldn't bear to look at the hardware of the bomb itself or the real-life explosions it created but worked rigorously on its computer simulations. "The alternative world of simulation, even in its earliest days, held enough structure on its own to captivate its practitioners," Galison wrote in a 2011 paper.

Already, there is something of a lie in the etymology of the digital twin. The words "model" and "simulation" both contain an undisguised wink toward that which they are intended to represent. Model comes from the Latin word "modulus," meaning "measure." Simulate comes from the Latin for "simulo," meaning "imitate". But twin comes from the Anglo-Saxon for "getwinne" meaning double. It conjures centuries of cultural baggage — of twins as eerily identical, deeply connected and, on occasion, telepathic.

"While models are generally understood as an abstraction of reality, the strong focus on realism and comprehensiveness in the conceptualizations suggest that a Digital Twin aspires to move beyond being an abstraction and instead represent all functionalities of a concrete physical entity, and in some cases even suggest a kind of hyperrealism," wrote the philosopher Paulan Korenhof and her colleagues in a 2021 paper.

Korenhof has been considering how digital twins of objects, places and processes might change our relationship with physical reality. In the paper, she and her coauthors give the example of a dairy farmer who is able to monitor and control milk production via a digital twin. No longer required to maintain proximity to the dairy or its animals, the farmer's relationship with the farm is reduced to the occasional "confirmation check" to make sure the twin is functioning correctly. The human is optimized out of the picture.

Could digital twins become yet another technology that fuels the odd and vague feeling of estrangement we feel from the natural world, from others, from ourselves — from all the things that used to feel close? And what if that estrangement begins to permeate our relationship with our own bodies?

When new technologies become omnipresent in our lives, we often end up relinquishing responsibility for the problems they miraculously solve. Our intimacy with our smartphones has contributed to a sense of memory loss known as "digital amnesia." Our reliance on GPS apps like Google Maps has contributed to, among many things, a dearth in geographical knowledge. If our health were to be constantly monitored in real-time by a twin that informs us if there are any signs of forthcoming illness or injury, how could that disrupt our interoception — our internal sense of our bodily functions and well-being?

Perhaps it could have the opposite effect. The people I know who've bought smartwatches that keep a constant record of their heart rates and blood pressures haven't become disembodied by the experience. In fact, they are more obsessed with their bodies than ever before.

Other questions abound. If your digital twin communicates that you are on the brink of heart disease or at high risk of Alzheimer's, are you already ill? Will you go to work tomorrow? If the digital twin makes predictions about forthcoming ill health, and you successfully make drastic changes in your life that improve the prognosis, how would you ever know if the twin was right? How can we build faith in its predictions? Or should we be more worried about how to build up suspicion?

More generally, how accessible will this technology actually become? It's not hard to foresee a future in which personalized high-tech healthcare becomes the preserve of the rich. Billionaires could end up with their bodies digitized in supercomputers, an extra tool in the quest to prolong life, while the rest of us make do with the crumbling, overpriced healthcare system we have today.

And then there's the data. In the U.S., people generally do not own their medical records: In all 50 states, medical providers, not patients, own medical data. In the U.K., the National Health Service recently signed a £330 million (about $419 million) contract with the U.S. spy-tech firm Palantir to build a new data platform, in turn granting it access to patient data and medical records. Those records might become available to health insurance companies, raising the cost of care when you need it.

When I put some of these questions to Vázquez in the chapel, he conceded that we are at the frontier of this technology and that he didn't have the answers. "In the very near future, all these sorts of discussions must be brought to the table. We need to integrate other people into the conversations — doctors, patient associations, philosophers and sociologists — to really analyze all the changes this might bring to society. It is very dangerous to leave the fate of the world to engineers."

Matthias Braun, a professor of ethics and technology at the University of Bonn, who is leading a European Research Council-funded project on the ethics of digital twins, was keen to remind me that, while the potential downsides were abundant, digital twins might also contribute to human flourishing in fascinating ways. “When we talk to people with disabilities about digital twins, they say it would be so cool for them to have a kind of tool that lets them know, for example, when they might be about to experience a very severe phase. For example, dementia often develops in phases. If I could know when I have a bad phase coming, then I could plan to take my drugs then, so that I can still see my family, have a normal conversation, remember who they are — it could be life-changing. It’s like another life, another form of myself.”

But, he added: “It also confronts us with very interesting and fundamental questions about, for example, what does it mean to be human? What does it mean to have a physical body? Would a digital body part feel like a prosthesis or like an extension of the self?”

Perhaps, he said, we should find a way to limit what they can tell us. There may be things we just don’t want to know, things we can’t un-see, un-hear or vanquish from our minds. Things that change how we feel about ourselves, our time and those around us. To make accurate predictions about the future may just keep us imprisoned by what-ifs, marooned from the present that unfolds around us.

On the ground floor of the BSC building is an earth sciences department where the staff is working with the European Union and numerous other partners on a project called Destination Earth. It aims to create a digital twin of the whole world. The “full Earth replica,” reads the project’s website, will come online by 2030 and aims to produce “simulations which become indistinguishable from the reality.” As extreme weather becomes more frequent and the climate crisis more pronounced, the digital twin can “forecast these events with even greater accuracy, to predict their impact on the environment, life and property.”

“It’s a sort of crystal ball,” Francisco Doblas Reyes, the director of the department, told me. “But it’s a really expensive crystal ball, because every experiment we’ll be running will be an experiment with the most expensive climate models that can be run right now, producing huge amounts of data — petabytes of data per day, equivalent to the traffic of WhatsApp per day. ... That’s why we need the machine like the one we have downstairs. The problem is, even that machine is not big enough for the problem we are dealing with: the whole Earth at an unprecedented resolution. But that’s what society really needs these days. If you want to be better prepared for what climate change is going to throw at us, you need to have the most reliable information you can produce, and that is what we are trying to do.”

When I finally left the BSC, I strode down the wide boulevards and narrow alleys of Gràcia toward Hibernian, a secondhand English-language bookshop, because I had become haunted, after months of researching and talking about digital twins and mirror worlds, by a Jorge Luis Borges short story that I couldn’t place. Borges had a perverse fascination with the reflected image. As a child, he had nightmares about discovering that his face was actually a mask. He was so terrified of his reflection that he feared the polished mahogany of the furniture in his bedroom should he glimpse his likeness, or something much worse. "Mirrors have something monstrous about them," he wrote in 1940. This terror, as his biographer Edwin Williamson wrote, made him obsessed with "doubles, reproductions, copies, facsimiles, translations — with anything, indeed, that could undermine the uniqueness of an object or a person by dint of repeating it."

When I got to Hibernian, they had the story I wanted on a shelf near the door: "The Aleph." I bought it, sat down outside a nearby bar and started reading. In Borges' tale, an acquaintance of a man (also called Borges) discovers an orb — an "Aleph" as he calls it — in his basement, into which he can peer and see everything that exists all at once. Imagining the man to be insane, Borges follows him into the basement and finds a "small iridescent sphere of almost unbearable brilliance." Borges peers inside:

I saw the teeming sea; I saw daybreak and nightfall; I saw the multitudes of America; I saw a silvery cobweb in the center of a black pyramid; I saw a splintered labyrinth (it was London); I saw, close up, unending eyes watching themselves in me as in a mirror; I saw all the mirrors on earth and none of them reflected me; I saw in a backyard of Soler Street the same tiles that thirty years before I'd seen in the entrance of a house in Fray Bentos; I saw bunches of grapes, snow, tobacco, lodes of metal, steam; I saw convex equatorial deserts and each one of their grains of sand; I saw a woman in Inverness whom I shall never forget; I saw her tangled hair, her tall figure, I saw the cancer in her breast; I saw a ring of baked mud in a sidewalk, where before there had been a tree; ... I saw the circulation of my own dark blood; I saw the coupling of love and the modification of death; I saw the Aleph from every point and angle, and in the Aleph I saw the earth and in the earth the Aleph and in the Aleph the earth; I saw my own face and my own bowels; I saw your face; and I felt dizzy and wept, for my eyes had seen that secret and conjectured object whose name is common to all men but which no man has looked upon — the unimaginable universe.

I felt infinite wonder, infinite pity.

"Feeling pretty cockeyed, are you, after so much spying into places where you have no business?" said a hated and jovial voice. "Even if you were to rack your brains, you couldn't pay me back in a hundred years for this revelation. One hell of an observatory, eh, Borges?"

Joe Zadeh
A Digital Twin Might Just Save Your Life
Digital twins offer humankind the ability to command virtual replicas of forests, oil fields, cities, supply chains — and even, maybe one day, our very bodies.
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