



## The World Ahead

The World Ahead 2022

# What next? 22 emerging technologies to watch in 2022

New ideas can emerge seemingly overnight



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BY THE SCIENCE AND TECHNOLOGY CORRESPONDENTS OF THE ECONOMIST



**T**HE ASTONISHINGLY rapid development and rollout of coronavirus vaccines has been a reminder of the power of science and technology to change the world. Although vaccines based on new mRNA technology seemed to have been created almost instantly, they actually drew upon decades of research going back to the 1970s. As the saying goes in the technology industry, it takes years to create an overnight success. So what else might be about to burst into prominence? Here are 22 emerging technologies worth watching in 2022

### **Solar geoengineering**

It sounds childishly simple. If the world is getting too hot, why not offer it some shade? The dust and ash released into the upper atmosphere by volcanoes is known to have a cooling effect: Mount Pinatubo's eruption in 1991 cooled the Earth by as much as 0.5°C for four years. Solar geoengineering, also known as solar radiation management, would do the same thing deliberately.

This is hugely controversial. Would it work? How would rainfall and weather patterns be affected? And wouldn't it undermine efforts to curb greenhouse-gas emissions? Efforts to test the idea face fierce opposition from politicians and activists. In 2022, however, a group at Harvard University hopes to conduct a much-delayed experiment called SCOPEX. It involves launching a balloon into the stratosphere, with the aim of releasing 2kg of material (probably calcium carbonate), and then measuring how it dissipates, reacts and scatters solar energy.

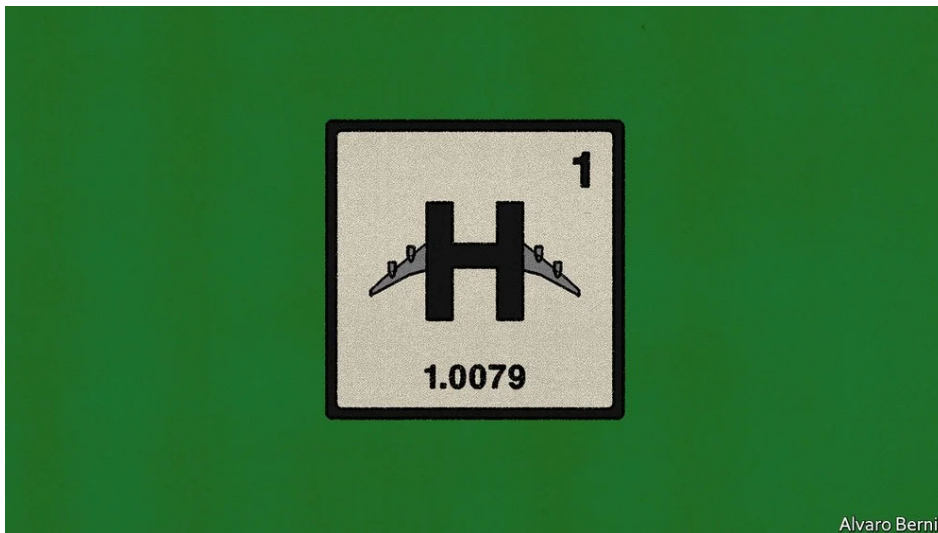
Proponents argue that it is important to understand the technique, in case it is needed to buy the world more time to cut emissions. The Harvard group has established an independent advisory panel to consider the moral and political ramifications. Whether the test goes ahead or not, expect controversy.

### **Heat pumps**

Keeping buildings warm in winter accounts for about a quarter of global energy consumption. Most heating relies on burning coal, gas or oil. If the world is to meet its climate-change targets, that will have to change. The most promising alternative is to use heat pumps—essentially, refrigerators that run in reverse.

Instead of pumping heat out of a space to cool it down, a heat pump forces heat in from the outside, warming it up. Because they merely move existing heat around, they can be highly efficient: for every kilowatt of electricity consumed, heat pumps can deliver 3kw of heat, making them cheaper to run than electric radiators. And running a heat pump backwards cools a home rather than heating it.

Gradient, based in San Francisco, is one of several companies offering a heat pump that can provide both heating and cooling. Its low-profile, saddle-bag shaped products can be mounted in windows, like existing air conditioners, and will go on sale in 2022.



### Hydrogen-powered planes

Electrifying road transport is one thing. Aircraft are another matter. Batteries can only power small aircraft for short flights. But might electricity from hydrogen fuel cells, which excrete only water, do the trick? Passenger planes due to be test-flown with hydrogen fuel cells in 2022 include a two-seater being built at Delft University of Technology in the Netherlands. ZeroAvia, based in California, plans to complete trials of a 20-seat aircraft, and aims to have its hydrogen-propulsion system ready for certification by the end of the year. Universal Hydrogen, also of California, hopes its 40-seat plane will take off in September 2022.



### **Direct air capture**

Carbon dioxide in the atmosphere causes global warming. So why not suck it out using machines? Several startups are pursuing direct air capture (DAC), a technology that does just that. In 2022 Carbon Engineering, a Canadian firm, will start building the world's biggest DAC facility in Texas, capable of capturing 1m tonnes of CO<sub>2</sub> per year. ClimeWorks, a Swiss firm, opened a DAC plant in Iceland in 2021, which buries captured CO<sub>2</sub> in mineral form at a rate of 4,000 tonnes a year. Global Thermostat, an American firm, has two pilot plants. DAC could be vital in the fight against climate change. The race is on to get costs down and scale the technology up.

### **Vertical farming**

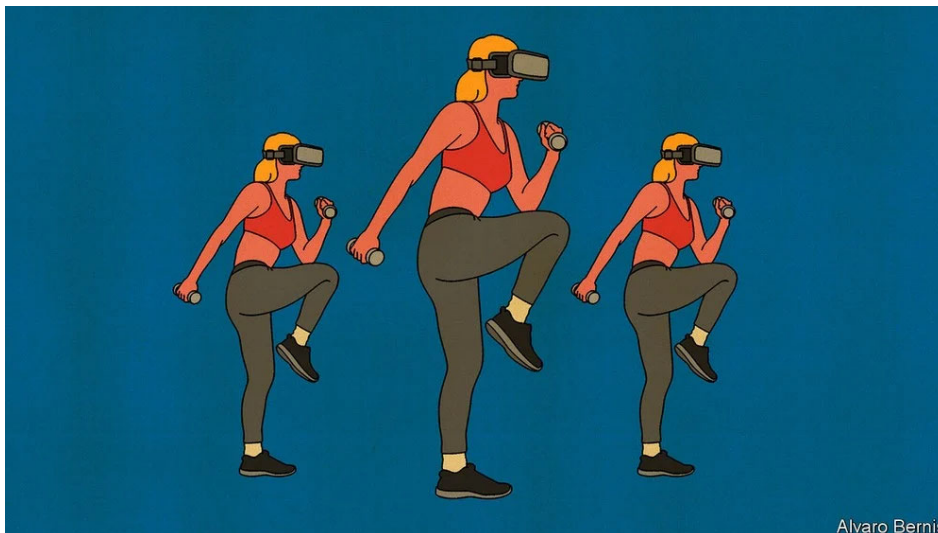
A new type of agriculture is growing. Vertical farms grow plants on trays stacked in a closed, controlled environment. Efficient LED lighting has made the process cheaper, though energy costs remain a burden. Vertical farms can be located close to customers, reducing transport costs and emissions. Water use is minimised and bugs are kept out, so no pesticides are needed.

In Britain, the Jones Food Company will open the world's largest vertical farm, covering 13,750 square metres, in 2022. AeroFarms, an American firm, will open its largest vertical farm, in Danville, Virginia. Other firms will be expanding, too. Nordic Harvest will enlarge its facility just outside Copenhagen and construct a new one in Stockholm. Plenty, based in California, will open a new indoor farm near Los Angeles. Vertical farms mostly grow high-value leafy greens and herbs, but some are venturing into tomatoes, peppers and berries. The challenge now is to make the economics stack up, too.

### **Container ships with sails**

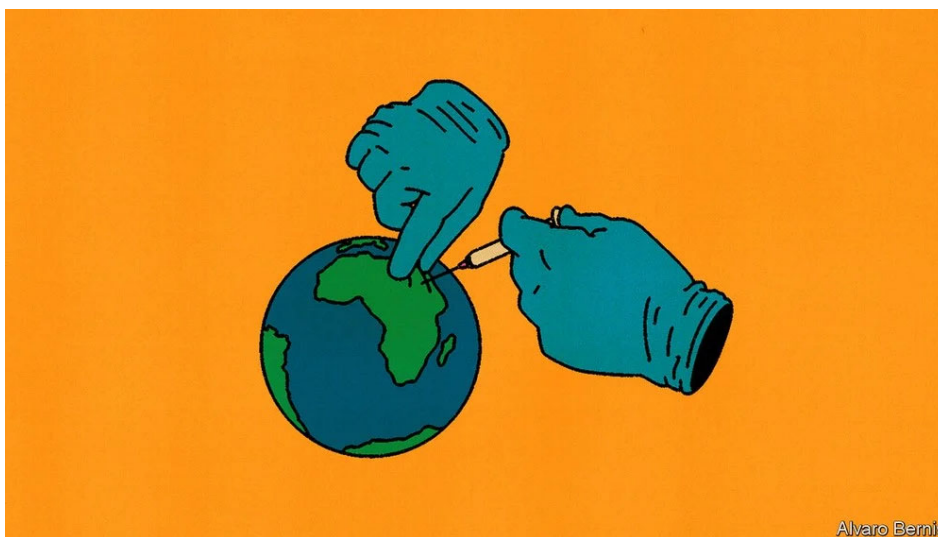
Ships produce 3% of greenhouse-gas emissions. Burning maritime bunker fuel, a dirty diesel sludge, also contributes to acid rain. None of this was a problem in the age of sail—which is why sails are making a comeback, in high-tech form, to cut costs and emissions.

In 2022 Michelin of France will equip a freighter with an inflatable sail that is expected to reduce fuel consumption by 20%. MOL, a Japanese shipping firm, plans to put a telescoping rigid sail on a ship in August 2022. Naos Design of Italy expects to equip eight ships with its pivoting and foldable hard "wing sails". Other approaches include kites, "suction wings" that house fans, and giant, spinning cylinders called Flettner rotors. By the end of 2022 the number of big cargo ships with sails of some kind will have quadrupled to 40, according to the International Windship Association. If the European Union brings shipping into its carbon-trading scheme in 2022, as planned, that will give these unusual technologies a further push.



### **VR workouts**

Most people do not do enough exercise. Many would like to, but lack motivation. Virtual reality (VR) headsets let people play games and burn calories in the process, as they punch or slice oncoming shapes, or squat and shimmy to dodge obstacles. VR workouts became more popular during the pandemic as lockdowns closed gyms and a powerful, low-cost headset, the Oculus Quest 2, was released. An improved model and new fitness features are coming in 2022. And Supernatural, a highly regarded VR workout app available only in North America, may be released in Europe. Could the killer app for virtual reality be physical fitness?



### **Vaccines for HIV and malaria**

The impressive success of coronavirus vaccines based on messenger RNA (mRNA) heralds a golden era of vaccine development. Moderna is developing an HIV vaccine based on the same mRNA technology used in its highly effective coronavirus vaccine. It entered early-stage clinical trials in 2021 and preliminary results are expected in 2022. BioNTech, joint-developer of the Pfizer-BioNTech coronavirus vaccine, is working on an mRNA vaccine for malaria, with clinical trials expected to start in 2022. Non-mRNA vaccines for HIV and malaria, developed at the University of Oxford, are also showing promise.

### **3D-printed bone implants**

For years, researchers have been developing techniques to create artificial organs using 3D printing of biological materials. The ultimate goal is to take a few cells from a patient and create fully functional organs for transplantation, thus doing away with long waiting-lists, testing for matches and the risk of rejection.

That goal is still some way off for fleshy organs. But bones are less tricky. Two startups, Particle3D and ADAM, hope to have 3D-printed bones available for human implantation in 2022. Both firms use calcium-based minerals to print their bones, which are made to measure based on patients' CT scans. Particle3D's trials in pigs and mice found that bone marrow and blood vessels grew into its implants within eight weeks. ADAM says its 3D-printed implants stimulate natural bone growth and gradually biodegrade, eventually being replaced by the patient's bone tissue. If all goes well, researchers say 3D-printed blood vessels and heart valves are next.



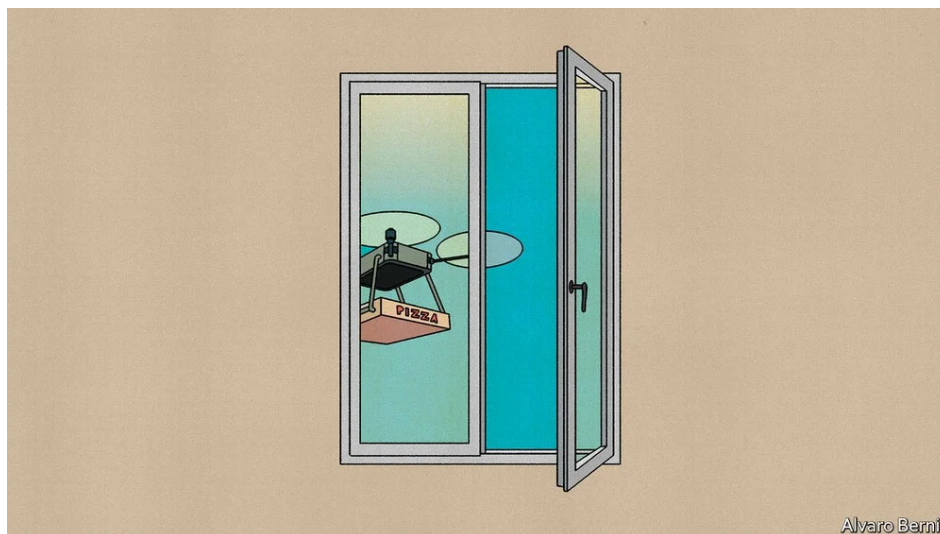
### **Flying electric taxis**

Long seen as something of a fantasy, flying taxis, or electric vertical take-off and landing (eVTOL) aircraft, as the fledgling industry calls them, are getting serious. Several firms around the world will step up test flights in 2022 with the aim of getting their aircraft certified for commercial use in the following year or two. Joby Aviation, based in California, plans to build more than a dozen of its five-seater vehicles, which have a 150-mile range. Volocopter of Germany aims to provide an air-taxi service at the 2024 Paris Olympics. Other contenders include eHang, Lilium and Vertical Aerospace. Keep an eye on the skies.

### **Space tourism**

After a stand-out year for space tourism in 2021, as a succession of billionaire-backed efforts shot civilians into the skies, hopes are high for 2022. Sir Richard Branson's Virgin Galactic just beat Jeff Bezos's Blue Origin to the edge of space in July, with both billionaires riding in their own spacecraft on suborbital trips. In September Elon Musk's company, SpaceX, sent four passengers on a multi-day orbital cruise around the Earth.

All three firms hope to fly more tourists in 2022, which promises to be the first year in which more people go to space as paying passengers than as government employees. But Virgin Galactic is modifying its vehicle to make it stronger and safer, and it is not expected to fly again until the second half of 2022, with commercial service starting in the fourth quarter. Blue Origin plans more flights but has not said when or how many. For its part, SpaceX has done a deal to send tourists to the International Space Station. Next up? The Moon.



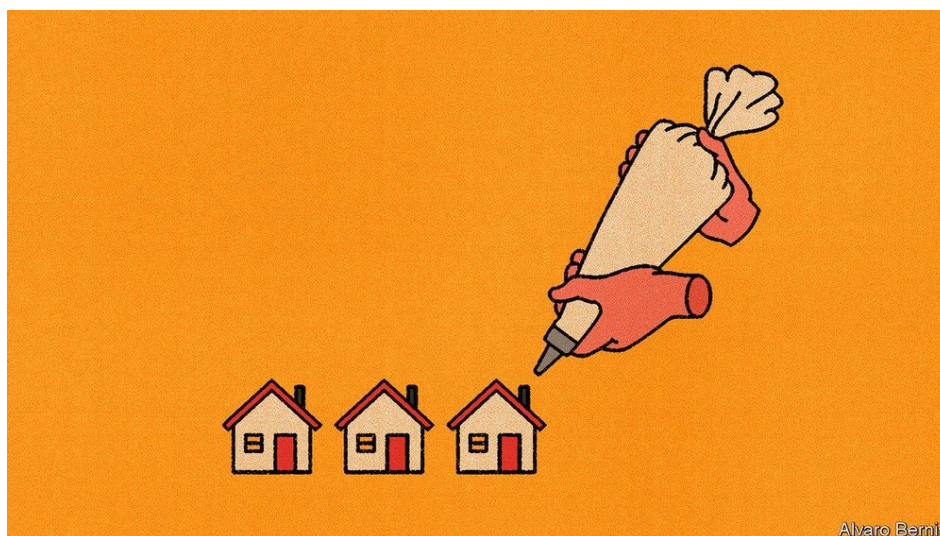
### Delivery drones

They are taking longer than expected to get off the ground. But new rules, which came into effect in 2021, will help drone deliveries gain altitude in 2022. Manna, an Irish startup which has been delivering books, meals and medicine in County Galway, plans to expand its service in Ireland and into Britain. Wing, a sister company of Google, has been doing test deliveries in America, Australia and Finland and will expand its mall-to-home delivery service, launched in late 2021. Dronamics, a Bulgarian startup, will start using winged drones to shuttle cargo between 39 European airports. The question is: will the pace of drone deliveries pick up—or drop off?

### Quieter supersonic aircraft

For half a century, scientists have wondered whether changes to the shape of a supersonic aircraft could reduce the intensity of its sonic boom. Only recently have computers become powerful enough to run the simulations needed to turn those noise-reduction theories into practice.

In 2022 NASA's X-59 Quesst (short for "Quiet Supersonic Technology") will make its first test flight. Crucially, that test will take place over land—specifically, Edwards Air Force Base in California. Concorde, the world's first and only commercial supersonic airliner, was not allowed to travel faster than sound when flying over land. The X-59's sonic boom is expected to be just one-eighth as loud as Concorde's. At 75 perceived decibels, it will be equivalent to a distant thunderstorm—more of a sonic "thump". If it works, NASA hopes that regulators could lift the ban on supersonic flights over land, ushering in a new era for commercial flight.

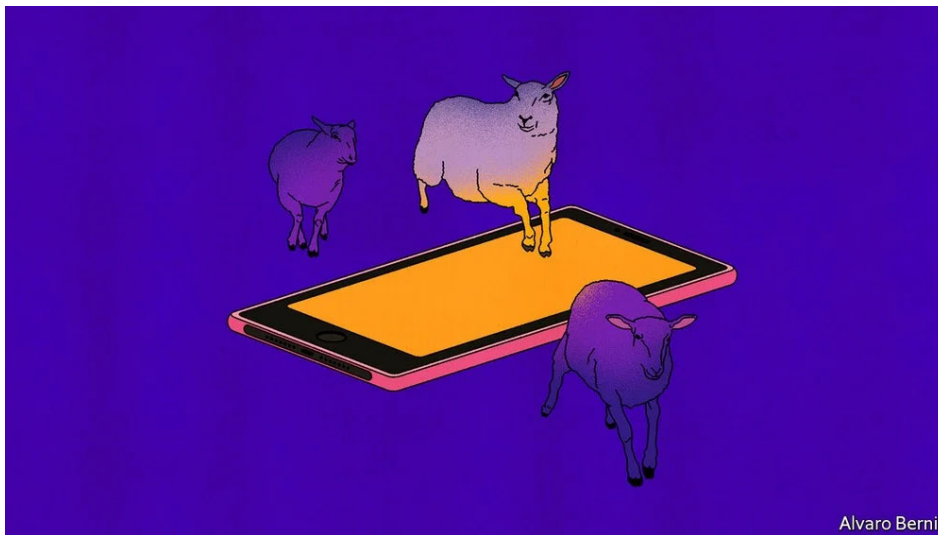


### 3D-printed houses

Architects often use 3D printing to create scale models of buildings. But the technology can be scaled up and used to build the real thing. Materials are squirted



out of a nozzle as a foam that then hardens. Layer by layer, a house is printed—either on site, or as several pieces in a factory that are transported and assembled. In 2022 Mighty Buildings, based in California, will complete a development of 15 eco-friendly 3D-printed homes at Rancho Mirage. And ICON, based in Texas, plans to start building a community of 100 3D-printed homes near Austin, which would be the largest development of its kind.

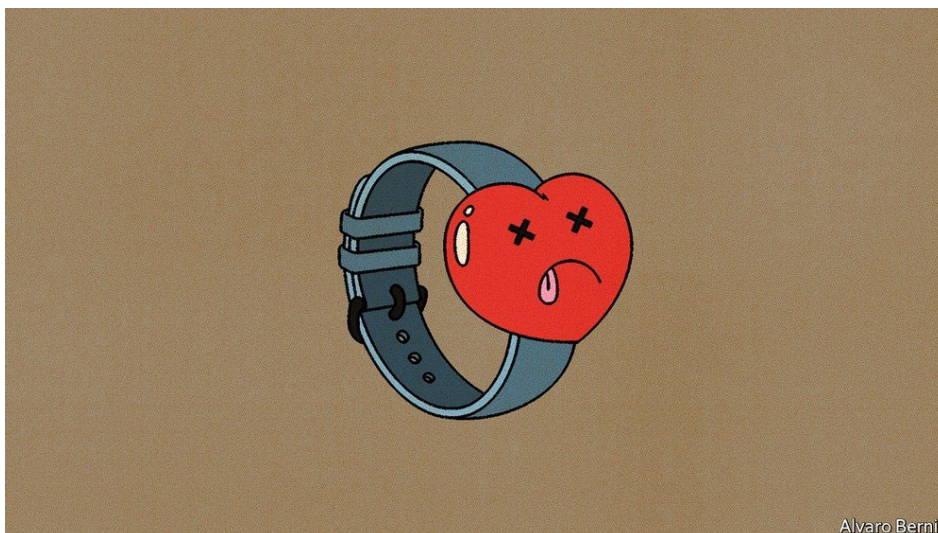


### **Sleep tech**

It's become a craze in Silicon Valley. Not content with maximising their productivity and performance during their waking hours, geeks are now optimising their sleep, too, using an array of technologies. These include rings and headbands that record and track sleep quality, soothing sound machines, devices to heat and cool mattresses, and smart alarm clocks to wake you at the perfect moment. Google launched a sleep-tracking nightstand tablet in 2021, and Amazon is expected to follow suit in 2022. It sounds crazy. But poor sleep is linked with maladies from heart disease to obesity. And what Silicon Valley does today, everyone else often ends up doing tomorrow.

### **Personalised nutrition**

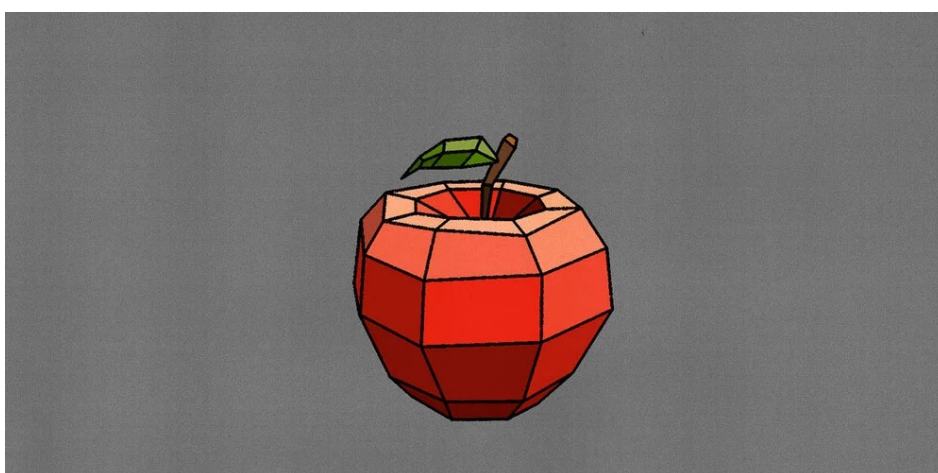
Diets don't work. Evidence is growing that each person's metabolism is unique, and food choices should be, too. Enter personalised nutrition: apps that tell you what to eat and when, using machine-learning algorithms, tests of your blood and gut microbiome, data on lifestyle factors such as exercise, and real-time tracking of blood-sugar levels using coin-sized devices attached to the skin. After successful launches in America, personalised-nutrition firms are eyeing other markets in 2022. Some will also seek regulatory approval as treatments for conditions such as diabetes and migraine.



### **Wearable health trackers**

Remote medical consultations have become commonplace. That could transform the prospects for wearable health trackers such as the Fitbit or Apple Watch. They are currently used primarily as fitness trackers, measuring steps taken, running and swimming speeds, heart rates during workouts, and so forth. But the line between consumer and medical uses of such devices is now blurring, say analysts at Gartner, a consultancy.

Smart watches can already measure blood oxygenation, perform ECGs and detect atrial fibrillation. The next version of the Apple Watch, expected in 2022, may include new sensors capable of measuring levels of glucose and alcohol in the blood, along with blood pressure and body temperature. Rockley Photonics, the company supplying the sensor technology, calls its system a “clinic on the wrist”. Regulatory approval for such functions may take a while, but in the meantime doctors, not just users, will be paying more attention to data from wearables.



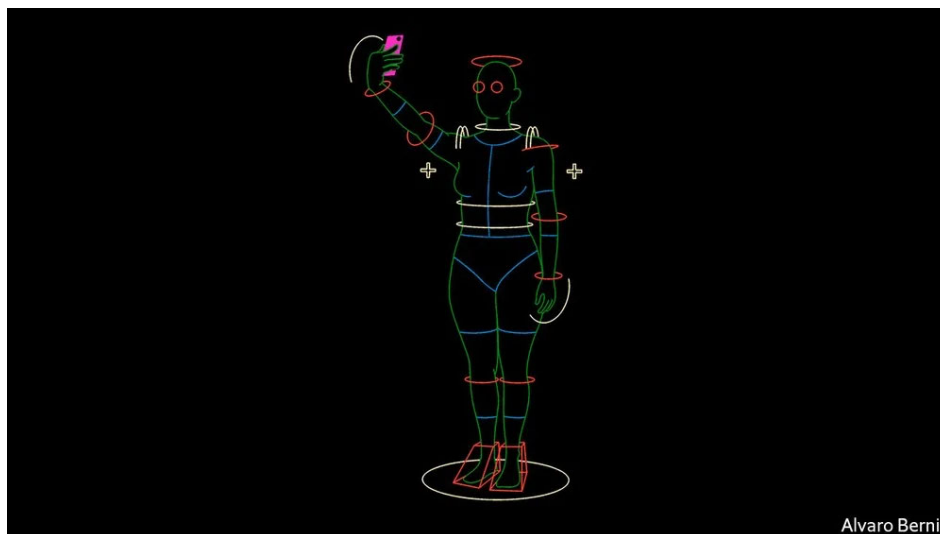
### **The metaverse**

Coined in 1992 by Neal Stephenson in his novel “Snow Crash”, the word “metaverse” referred to a persistent virtual world, accessible via special goggles, where people could meet, flirt, play games, buy and sell things, and much more besides. In 2022 it refers to the fusion of video games, social networking and entertainment to create new, immersive experiences, like swimming inside your favourite song at an online concert. Games such as Minecraft, Roblox and Fortnite are all stepping-stones to an emerging new medium. Facebook has renamed itself Meta to capitalise on the opportunity—and distract from its other woes.

### **Quantum computing**

An idea that existed only on blackboards in the 1990s has grown into a multi-billion dollar contest between governments, tech giants and startups: harnessing the counter-intuitive properties of quantum physics to build a new kind of computer. For some kinds of mathematics a quantum computer could outperform any non-quantum machine that could ever be built, making quick work of calculations used in cryptography, chemistry and finance.

But when will such machines arrive? One measure of a quantum computer’s capability is its number of qubits. A Chinese team has built a computer with 66 qubits. IBM, an American firm, hopes to hit 433 qubits in 2022 and 1,000 by 2023. But existing machines have a fatal flaw: the delicate quantum states on which they depend last for just a fraction of a second. Fixing that will take years. But if existing machines can be made useful in the meantime, quantum computing could become a commercial reality much sooner than expected.



### **Virtual influencers**

Unlike a human influencer, a virtual influencer will never be late to a photoshoot, get drunk at a party or get old. That is because virtual influencers are computer-

generated characters who plug products on Instagram, Facebook and TikTok. The best known is Miquela Sousa, or “Lil Miquela”, a fictitious Brazilian-American 19-year-old with 3m Instagram followers. With \$15bn expected to be spent on influencer marketing in 2022, virtual influencers are proliferating. Aya Stellar—an interstellar traveller crafted by Cosmiq Universe, a marketing agency—will land on Earth in February. She has already released a song on YouTube.

### **Brain interfaces**

In April 2021 the irrepressible entrepreneur Elon Musk excitedly tweeted that a macaque monkey was “literally playing a video game telepathically using a brain chip”. His company, Neuralink, had implanted two tiny sets of electrodes into the monkey’s brain. Signals from these electrodes, transmitted wirelessly and then decoded by a nearby computer, enabled the monkey to move the on-screen paddle in a game of Pong using thought alone.

In 2022 Neuralink hopes to test its device in humans, to enable people who are paralysed to operate a computer. Another firm, Synchron, has already received approval from American regulators to begin human trials of a similar device. Its “minimally invasive” neural prosthetic is inserted into the brain via blood vessels in the neck. As well as helping paralysed people, Synchron is also looking at other uses, such as diagnosing and treating nervous-system conditions including epilepsy, depression and hypertension.

### **Artificial meat and fish**

Winston Churchill once mused about “the absurdity of growing a whole chicken to eat the breast or wing”. Nearly a century later, around 70 companies are “cultivating” meats in bioreactors. Cells taken from animals, without harming them, are nourished in soups rich in proteins, sugars, fats, vitamins and minerals. In 2020 Eat Just, an artificial-meat startup based in San Francisco, became the first company certified to sell its products, in Singapore.

It is expected to be joined by a handful of other firms in 2022. In the coming year an Israeli startup, SuperMeat, expects to win approval for commercial sales of cultivated chicken burgers, grown for \$10 a pop—down from \$2,500 in 2018, the company says. Finless Foods, based in California, hopes for approval to sell cultivated bluefin tuna, grown for \$440 a kilogram—down from \$660,000 in 2017. Bacon, turkey and other cultivated meats are in the pipeline. Eco-conscious meat-lovers will soon be able to have their steak—and eat it.

*By the Science and technology correspondents of The Economist* ■

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