virologists and researchers with expertise in public health, animal health and food safety will lead the WHO's COVID-19 investigation. The agency has not released their names.

The team held its first virtual meeting, including researchers in China, on 30 October, and is reviewing the preliminary evidence and developing study protocols, says the WHO. The initial phase of investigations in Wuhan will probably be conducted by researchers who are already in China, and international researchers will travel to the country after reviewing those results, the agency says.

In Wuhan, researchers will take a closer look at the Huanan meat and animal market, which many of the earliest people diagnosed with COVID-19 had visited. What part the market played in the virus's spread remains a mystery. Early investigations sampled frozen animal carcasses at the market, but none found evidence of SARS-CoV-2, according to a 5 November report on the WHO mission's terms of reference (see go.nature.com/2uiz8ik). However, environmental samples, taken mostly from drains and sewage, did test positive for the virus. "Preliminary studies have not generated credible leads to narrow the area of research," the report states.

The WHO mission will investigate the wild and farmed animals sold at the market, including foxes, raccoons (*Procyon lotor*) and sika deer (*Cervus nippon*). They will also investigate other markets in Wuhan, and trace the animals' journeys through China and across borders. The investigators will prioritize animals that are known to be susceptible to the virus, such as cats and mink.

The team will also look at Wuhan's hospital records, to find out whether the virus was spreading before December 2019. The researchers will interview the first people identified to have had COVID-19, to find out where they might have been exposed, and will test blood samples collected from medical staff, laboratory technicians and farm workers in the weeks and months before December, looking for antibodies against SARS-CoV-2. The report acknowledges that some of this work might already be under way in China.

Longer-term plans

The initial investigation in Wuhan will inform longer-term studies into the pandemic's origins, which could take investigators outside China. "Where an epidemic is first detected does not necessarily reflect where it started," the WHO report states, noting preliminary reports of viral RNA detected in sewage samples before the first cases had been identified.

This statement could refer to a study, posted on the preprint server medRxiv without peer review (G. Chavarria-Miró *et al.* Preprint at medRxiv https://doi.org/fhw5; 2020), which retrospectively tested Spanish sewage samples from March 2019 and found SARS-CoV-2 fragments, says Raina MacIntyre, an epidemiologist at the University of New South Wales in Sydney, Australia. "If this study was correct, we have to ask how the virus was in Spain in March last year," she says.

Plans to look beyond China are sensible, given that extensive surveillance in bats in China since the 2002 SARS outbreak has identified only a distant relative of SARS-CoV-2, says Wang. A growing number of experts think that the immediate or close ancestors of SARS-CoV-2 are more likely to exist in bats outside China, says Wang. He says the WHO team should survey bats and other wildlife across southeast Asia for SARS-CoV-2 antibodies.

The investigation should also prioritize carnivorous mammals farmed for fur, such as raccoon dogs and civets, which had a role in the SARS outbreak, says Martin Beer, a virologist at the Federal Research Institute for Animal Health in Riems, Germany. "It is surprising that there is no mention of these animals in the report, and we have no information from China about whether these animals have been tested," says Beer.

A spokesperson for the WHO says the mission will be guided by science, and "will be open-minded, iterative, not excluding any hypothesis that could contribute to generating evidence and narrowing the focus of research".

UNDERDOG TECH MAKES GAINS IN QUANTUM COMPUTER RACE

Trapped-ion technologies are gaining momentum in the quest to make a commercial quantum computer.

By Elizabeth Gibney

A technology for building quantum computers that has long been sidelined by commercial developers is gaining momentum. As quantum computing has transformed from academic exercise to big business over the past decade, the spotlight has mostly been on one approach — the tiny superconducting loops embraced by technology giants such as IBM and Intel. Superconductors last year enabled Google to claim it had achieved 'quantum advantage' with a machine that for the first time performed a particular calculation that is beyond the practical capabilities of the best classical computer. But a separate approach, using ions trapped in electric fields, is gaining traction in the quest to make a commercial quantum computer.

Earlier this year, technology and manufacturing company Honeywell launched its first quantum computer that uses trapped ions as the basis of its quantum bits, or 'qubits', which it had been working on quietly for more than a decade. Honeywell, headquartered in Charlotte, North Carolina, is the first established company to take this route, and it has a 130-strong team working on the project. In October, seven months after the launch, the firm unveiled an upgraded machine; it already has plans to scale this up.

And Honeywell is not the only company planning to make trapped-ion systems at scale. Last month, University of Maryland spin-off firm IonQ in College Park announced a trapped-ion machine that could prove to be competitive with those of IBM or Google, although the company has yet to publish details of its performance. Smaller spin-off firms — such as Universal Quantum in Brighton, UK, and Alpine Quantum Technology in Innsbruck, Austria — are also attracting investment for trapped-ion projects.

Trapped-ion quantum computers, which store information in the energy levels of individual charged atoms held in an electric field, are far from new: they were the basis of the qubits in the first basic quantum circuit in 1995, long before anyone used superconducting loops (C. Monroe *et al. Phys. Rev. Lett.* **75**, 4714; 1995). But efforts to put all the building blocks together to build viable commercial systems are "sort of bursting on the scene now", says Daniel Slichter, a quantum physicist at the US National Institute of Standards and Technology in Boulder, Colorado.

Rising challenger

"I think nowadays people say 'superconductors' and 'trapped ions' in the same breath, and they weren't saying that even five years ago," says Chris Monroe, a physicist at the University of Maryland who worked on the 1995 experiment and is a co-founder of IonQ. Quantum computing is still in its infancy, and although various companies are jockeying to claim that their quantum computer is the most advanced, it is too early to say which types of hardware – if any – will prevail. As companies embrace a range of technologies, the field is wider than ever.

Classical computers store their information as 1s and 0s, but qubits exist in a delicate superposition of 1 and 0. Through the quantum phenomenon of entanglement, qubits' states can become intertwined, and interference of their wavelike quantum states should allow a quantum computer to carry out certain massive calculations exponentially faster than the best classical machines can. This includes finding the factors of prime numbers.

Pros and cons

Any system with two possible quantum mechanical states – such as the oscillations in a superconducting loop or energy levels of an ion – could form a qubit, but all hardware types have pros and cons, and each faces substantial hurdles to forming a full-blown quantum computer. A machine capable of living up to the original promise of quantum computing by, for example, cracking conventional encryption, would require millions of individually controllable qubits. But size is not the only issue: the quality of the qubits and how well they connect to each other are just as important.

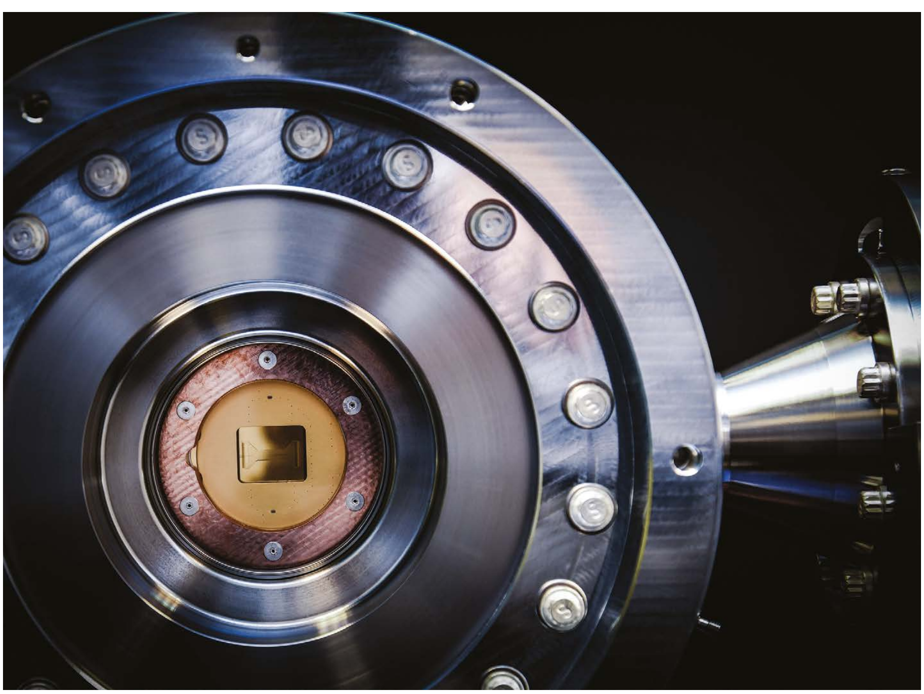
The frequency of errors in qubits and their operations, caused by noise, tends to increase as more are connected. To operate at scale, each qubit needs to work with error rates that are low enough to allow mistakes to be detected and fixed in a process known as error correction, although physicists also hope that smaller, noisier systems will prove useful in the short term.

In the past few years, rapid progress in superconducting loops risked leaving trapped ions in the dust. Google, IBM and others have developed machines with around 50 or more high-quality qubits. IBM aims to have a 1,000-qubit machine by 2023. John Martinis, a quantum physicist at the University of California, Santa Barbara – and, until April, head of quantum hardware at Google in Mountain View, California – thinks that Google will use the same basic architecture it used to achieve quantum advantage to achieve error correction, the next big milestone.

Superconducting qubits have so far benefited from feeling familiar to many companies, as their basic components are compatible with classical chip technology.

"I want to help someone to build the first quantum computer. It doesn't have to be me."

But trapped-ion qubits have many inherent advantages, says Sabrina Maniscalco, a quantum physicist at the University of Helsinki. Their operations are much less prone to errors and the delicate quantum states of individual ions last longer than those in superconducting qubits, which, although small, are still made of a very large number of atoms. Moreover, superconducting qubits tend to interact only with their nearest neighbours, whereas trapped ions can interact with many others, which makes it easier to run some complex calculations, she says.



HONEYWELL QUANTUM SOLUTIONS

An ion trap from Honeywell's quantum computer inside a vacuum chamber.

But trapped ions have drawbacks: they are slower at interacting than superconducting qubits, which will be important when it comes to accounting for real-time errors coming out of the system, says Michele Reilly, founder of quantum software company Turing in New York City. And there are limits to how many ions can fit in a single trap and be made to interact. IonQ's latest model contains 32 trapped ions sitting in a chain; plucking any 2 using lasers causes them to interact. To scale up to hundreds of qubits, the company is working on ways to link up multiple chains of qubits using photons. The firm aims to double its number of qubits each year.

Meanwhile, Honeywell plans to interconnect all the ions by physically shuttling them around a giant chip (J. M. Pino *et al.* Preprint at https://arxiv.org/abs/2003.01293; 2020). The latest system by the firm's Honeywell Quantum Solutions (HQS) division, called H1, consists of just ten qubits, but its chief scientist, Patty Lee, says that the firm is already working on its next iteration. In the next 5 years, the team plans to connect around 20 qubits, which should allow the machine to carry out problems that are otherwise impractical on classical machines, says Tony Uttley, president of HQS.

The challenge is to keep the quality and precision of qubits, while controlling dozens, or even hundreds, at once – which neither Honeywell nor IonQ has yet shown it can do. Although many of the necessary components have been mastered individually, "what is needed is a system-level integrative approach putting it all together, testing it, solving its problems", says Barbara Terhal, a theoretical physicist at Delft University of Technology in the Netherlands.

No clear victor

Trapped-ion hardware isn't the only technology attracting substantial investment. The success of superconducting qubits has opened doors for various technologies, says Slichter, including silicon-based spin qubits, which store quantum information in the nuclear spin states of an atom embedded in a silicon crystal. In a coup for this technology, Martinis joined Silicon Quantum Computing in Sydney, Australia, on a six-month sabbatical in September – his first move away from superconducting systems in almost two decades. Martinis doesn't mind which design ends up winning. "I want to help someone to build the first quantum computer. It doesn't have to be me [or] whatever I'm working with," he says.

The race is also far from being called, says Maniscalco, and a winner might never emerge. "It may be that there isn't one winning platform, but we have a hybrid or different platforms being useful for different tasks."