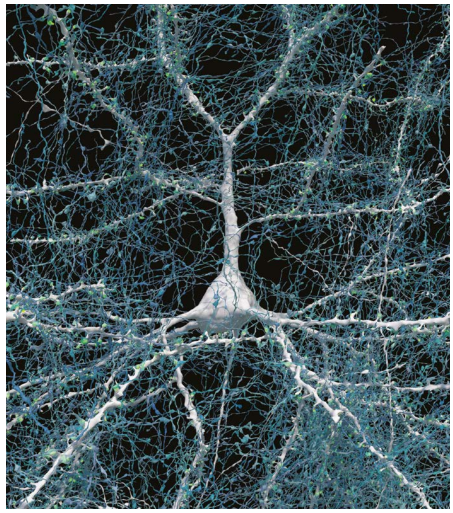
found two groups that would send their dendrites in two different directions, and sometimes there was a kind of mirror symmetry," Jain says. It is unclear what role these features have in the brain.

Proofreaders needed

The map is so large that most of it has yet to be manually checked, and it could still contain errors created by the process of stitching so many images together. "Hundreds of cells have been 'proofread', but that's obviously a few per cent of the 50,000 cells in there," says Jain. He hopes that others will help to proofread parts of the map they are interested in. The team plans to produce similar maps of brain samples from other people – but a map of the entire brain is unlikely in the next few decades, he says.

"This paper is really the tour de force creation of a human cortex data set," says Hongkui Zeng, director of the Allen Institute for Brain Science in Seattle, Washington. The vast amount of data will "allow the community to look deeper into the micro-circuitry in the human cortex", she adds.

Gaining a deeper understanding of how the cortex works could offer clues about how to treat some psychiatric and neurodegenerative diseases. "This map provides unprecedented details that can unveil new rules of neural connections and help to decipher the inner working of the human brain," says Yongsoo Kim, a neuroscientist at Pennsylvania State University in Hershey.



A single neuron and its connections.

GOOGLE RESEARCH & LICHTMAN LAB (HARVARD UNIV.)/RENDERINGS BY D. BERGER (HARVARD UNIV.)

CHINA IS FIRST IN ASIA TO BUILD NEXT-GENERATION SYNCHROTRON

The High Energy Photon Source will give China some of the world's brightest X-rays.

By Gemma Conroy in Huairou, Beijing

Some of the brightest synchrotron X-rays in the world are set to be beaming around China's new high-energy facility by the end of this year. The 4.8-billion-yuan (US$665-million) High Energy Photon Source (HEPS) will be the first of its kind in Asia, placing China among only a handful of countries in the world that have fourth-generation synchrotron light sources.

"It will certainly be a state-of-the-art installation that will cater for outstanding science," says Pedro Fernandes Tavares, a physicist who heads up the accelerator division at one of HEPS's rivals for brightness – the MAX IV Laboratory, a synchrotron radiation facility in Lund, Sweden.

In the circular HEPS building in Huairou, around 50 kilometres from Beijing's city centre, researchers are fine-tuning thousands of components that will help to produce a light source that can penetrate deep into samples to reveal their molecular and atomic structure in real time. By the end of June, the HEPS team hopes to finish installing the vacuum chamber system – an essential component for maintaining the light's brightness and stability.

Super-resolution

Inside its storage ring, which has a circumference of 1.36 kilometres, HEPS will accelerate electrons up to energies of 6 gigaelectron volts. This will produce high-energy, or 'hard', X-rays that can probe samples at nanometre scales. Its time resolution will be 10,000 times better than that achieved by third-generation synchrotrons, such as the 432-metre-circumference Shanghai Synchrotron Radiation Facility – currently China's most advanced operating synchrotron. This will allow researchers to make measurements in hundreds of nanoseconds instead of milliseconds, says Ye Tao, a beamline scientist at the Chinese Academy of Sciences Institute of High Energy Physics (IHEP) in Beijing who works on HEPS.

When HEPS opens to researchers in 2025, users will be able to select from 14 beamlines for experiments in subjects including biomedicine, materials and condensed-matter physics. Further down the track, HEPS is expected to accommodate up to 90 beamlines. The circular facility is set to "impact every scientific field, except maths", says Tao.

For instance, to discover the atomic structure of proteins, researchers need to purify and coax these molecules into orderly crystal structures that can be visualized with X-rays. Older synchrotrons require large samples that are difficult to produce, making it nearly impossible to study smaller protein crystals, says Tavares. But HEPS's hard X-rays will be powerful enough to analyse even the most minuscule samples in detail. The new synchrotron will also allow researchers to rapidly execute experiments that would take days to complete at older facilities, he adds. "It's a real game-changer," says Tavares.

Bigger and brighter

There are currently around 70 synchrotrons scattered across the world that are either operating or under construction. But only a few are part of the fourth-generation club – which produce the brightest, most focused light. These include Sweden's MAX IV Laboratory; Sirius in Campinas, Brazil; the European Synchrotron Radiation Facility's Extremely Brilliant Source in Grenoble, France; and the Advanced Photon Source in Lemont, Illinois, where an upgrade has almost been completed. HEPS was built from scratch rather than constructed from an existing facility because it requires a much larger accelerator than any already available in China to generate powerful hard X-rays, says Yuhui Li, a physicist at IHEP and deputy manager of HEPS.

Fourth-generation facilities such as HEPS rely on an array of magnets called a multi-bend achromat lattice to generate X-ray beams that are narrower – and therefore brighter – than are those produced by previous-generation facilities, says physicist Harry Westfahl Jr, director of the Brazilian Synchrotron Light Laboratory, which runs Sirius. HEPS's electron beam will be the narrowest in the world, allowing it to create particularly intense X-rays. This will enable researchers to obtain more information from their samples than they could with earlier light sources, but with the same dose of radiation. Such high-resolution imaging is set to have a big impact on scientists' understanding of the properties of matter and on the development of new materials, adds Westfahl, who is a member of the HEPS International Advisory Committee.

For now, researchers are focused on making the sure the beam is stable enough to be usable. It is a finicky process that requires step-by-step adjustments, says Li. "No beam is perfect at the beginning," he says.