The difference between 67.8 and 74 might seem small, but it has become statistically significant as both techniques have improved. So, theorists have started to wonder whether the reason for the discrepancy lies in the standard theory of cosmology, called ΛCDM, which assumes the presence of invisible particles of dark matter as well as a mysterious repulsive force called dark energy. But they have struggled to find a tweak to the theory that could solve the problem and still be consistent with everything that is known about the Universe. "It's hard to look at ΛCDM and see where the loose threads are, that if you pull them, they will unravel it," says Rocky Kolb, a cosmologist at the University of Chicago.

Freedman's red-giant technique updates a key element of the established Hubble measurement method — and produces a value of 69.8.

The hard part of measuring the Hubble constant is to gauge galaxies' distances reliably. Hubble's first estimate depended on measuring the distances of nearby galaxies by observing individual, bright stars called Cepheids. Astronomer Henrietta Swan Leavitt had discovered in the early twentieth century that these stars' actual brightness was predictable. So, by measuring how bright they appeared on photographic plates, she could calculate how far away the stars were. Astronomers call such signposts standard candles.

But researchers have been trying to find better standard candles than Cepheids, which tend to exist in crowded, dust-filled regions that can distort estimates of their brightness. "The only way we have to get to the bottom of this is to have independent methods, and up to this point we've had no checks on the Cepheids," says Freedman, who has spent much of her career improving the precision and accuracy of Cepheid measurements. Kolb says, "She knows where all the bodies are buried."

Freedman and her colleagues sidestepped Cepheids altogether, and instead used as their standard candles red giants — old stars that have become puffed out — together with supernovae explosions, which serve as signposts for galaxies farther away.

GIANT CALCULATION

Red giants are more common than Cepheids, and are easy to spot in the peripheral regions of galaxies, where stars are well separated from one another and dust is not an issue. Their brightness varies widely — but, taken as a whole, a galaxy's red-giant population has a handy feature. The stars' brightness increases over millions of years until it reaches a maximum, and then it suddenly drops. When astronomers plot a large group of stars by colour and brightness, the red giants look like a cloud of dots with a sharp edge. The stars at that edge can then serve as standard candles.

Freedman's team used the technique to calculate the distances to 18 galaxies, and obtained an estimate of the Hubble constant that for the first time has an accuracy comparable to that of the Cepheid-based studies.

Riess says that the red-giant study still relies on assumptions about the amount of dust in galaxies — particularly in the Large Magellanic Cloud, which the study used as an anchor point. "Dust is very tricky to estimate, and I am sure there will be lots of discussion" about why the authors' approach leads to a lower estimate of the Hubble constant, he says.

The result is statistically compatible with the Planck prediction and with Riess's Cepheid calculation — meaning that the error bars of the calculations overlap — and the technique's precision will improve as data on red giants accumulate. They could beat Cepheids in the near future, Kolb says.

The needle could shift towards one of the other values. Or it could stay put, and the other techniques might eventually converge to it. For now, cosmologists have plenty to puzzle over. ■

OPTOGENETICS

Light makes mice hallucinate in tests

Behavioural evidence suggests that targeting just 20 neurons makes animals 'see' an image.

BY SARA REARDON

Scientists have induced visual hallucinations in mice by using light to stimulate a handful of cells in the animals' brains. The feat could improve researchers' understanding of how the brain interprets and acts on what the eyes see — and could even lead to the development of devices that would help visually-impaired people to see.

The authors of the study, published in *Science* on 18 July, used a technology known as optogenetics that controls individual brain cells with pulses of light (J. H. Marshel *et al. Science* http://doi.org/c8jm; 2019). The technique works with mice that have been modified so that their neurons produce a protein that causes the cells to fire when exposed to light.

In this case, a team led by neuroscientist Karl Deisseroth of Stanford University in California attempted to implant images into the brain's visual cortex. This region knits pictures together from data produced by the retinas.

Deisseroth's team showed mice images of either horizontal or vertical bars, and trained the animals to lick from a tube of water whenever they saw the vertical bars. The scientists monitored the animals' brains and recorded which neurons fired when the mice saw the vertical bars. They eventually identified about 20 cells per animal that seemed to be consistently associated with the vertical image.

"We're just scratching the surface here."

To create the hallucinations, the researchers shone light on only these neurons — stimulating them to fire. This caused the mice to lick the tube of water as if they were seeing vertical bars, even though the animals were sitting in darkness. The mice didn't lick the tube when the scientists stimulated neurons linked to the image of horizontal bars.

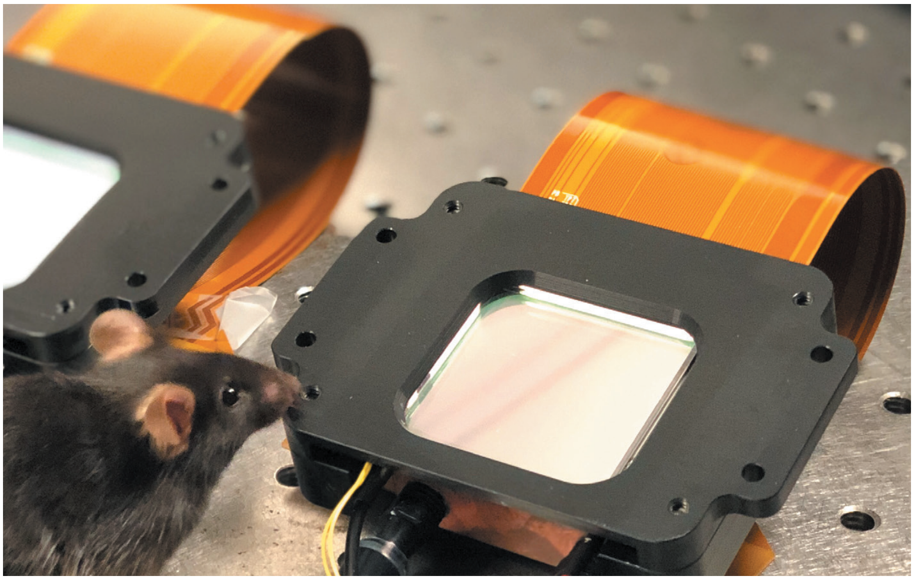
Christof Koch, president of the Allen Institute for Brain Science in Seattle, Washington, says that the paper is a technical tour de force. "It's playing the piano of the mind," he says.

Anil Seth, a neuroscientist at the University of Sussex in Brighton, UK, says it is not clear whether the mice in the study 'saw' vertical bars consciously, and finding this out might require a different behavioural test. But he is enthusiastic about the potential applications of the approach. "These optogenetic techniques really are game-changing," he says, because they allow scientists to manipulate the brain rather than just observing it. That could lead to the development of prostheses that input sensory information directly into the brain.

For his part, Deisseroth was surprised that stimulating only 20 neurons seemed to make the mice hallucinate. Given the chance that this number of neurons could randomly fire, he wonders why mice are not constantly hallucinating.

But Koch says that cells in the visual cortex are only part of what the brain uses to perceive and interpret an image — the first master switch in a cascade of neurons. Other regions of the brain connected to the visual cortex assess the meaning of an image by putting it into context. In some cases, such as in dreams, the brain can generate images without any input from the eyes.

And master-switch neurons in the visual cortex can be very specific. In 2005, Koch's group published a study showing that a single



SEAN QUIRIN, JAMES MARSHEL, CEPHRA RAJA & KARL DEISSEROTH, STANFORD UNIV.

A mouse sits next to a sensor that generates the images used in the study.

neuron fired whenever a person saw an image of actress Jennifer Aniston (R. Quian Quiroga *et al. Nature* **435**, 1102–1107; 2005). It's unclear whether mice can recognize faces in this way, he says, but vision is less important to mice than it is to primates.

The next challenge for the Stanford team will be to determine how neurons that sense specific images connect to regions of the brain that interpret the meaning of visual information. "We're just scratching the surface here," Deisseroth says.

The technique that the researchers devised relies on a set of proteins that are sensitive to dim, red pulses of light, to reduce the risk of overheating the brain. The scientists hope that the proteins will enable them and others to explore the function of neurons associated with the perception of other visual factors such as colour and shape, and other types of sensory input — including sound and touch.

For now, optogenetics is far from ready for use in people. But research is under way into other methods to supplement the senses by stimulating the human brain. In June, a company called Second Sight in Los Angeles, California, revealed early clinical results from a device that uses electrodes implanted in the visual cortex to restore some vision to people who are blind. The electrodes stimulate the brain in response to information gleaned from a camera worn near a person's eye.

The system improved the vision of six people to the point that they could see a white square on a black screen. The company hopes that the device will one day restore sight by sending more complex visual information directly into the brain. ■

CLARIFICATION

The News Feature 'The plan to mine the world's research papers' (*Nature* **571**, 316–318; 2019) used the term 'fair use' inappropriately — the term isn't relevant under Indian law.