DAVID PARKINS

How neuroscience is breaking out of the lab

Nervous-system scientists share how they're working in a variety of settings.

BY NIC FLEMING

Concerns that neuroscience's rise in popularity as a PhD subject has not been matched by a proportional growth in academic positions, coupled with a recent scaling back of brain-science research by many pharmaceutical companies, has led to worries that researchers will be forced to leave the field.

But neuroscience is opening doors in a broad range of alternative settings. *Nature* spoke to five neuroscientists putting their discipline to work to find satisfaction and impact in their careers.

KRIS DE MEYER
The film-maker

Postdoctoral research associate, King's College London.

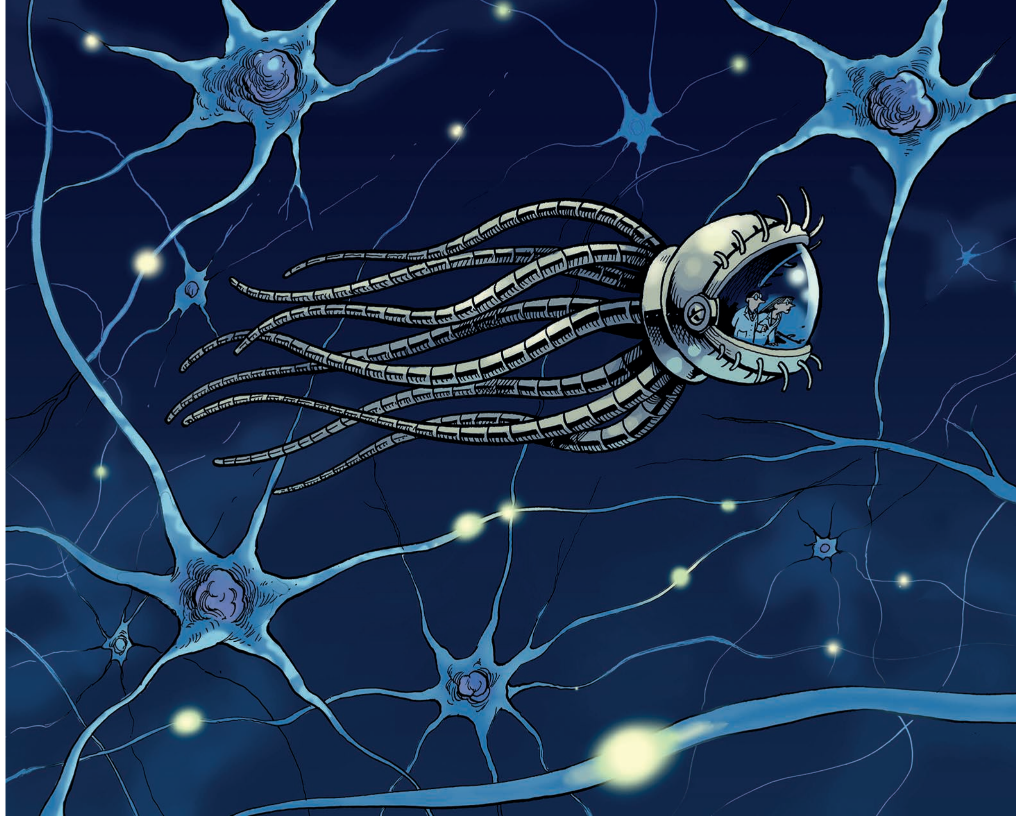
The world did not end on 21 October 2011. It carried on spinning despite US Christian radio host Harold Camping persuading large numbers of people that once God had finished gathering his chosen few into heaven, everyone else would be destroyed in a fury of earthquakes, tsunamis and fire.

Some of Camping's followers prepared for the end by leaving their jobs and selling their homes. A handful of them feature in the 2016 documentary *Right Between Your Ears*, co-produced by neuroscientist Kris De Meyer, based at King's College London. The film highlights neuroscience research into how we form opinions and change or refuse to change our minds. ▶

Why a film? “Had we done a purely scientific study, it would have been published in a specialist journal with limited readership,” says De Meyer. “As a story and film that brings out the science, it has brought useful scientific insights to hundreds of thousands of people to date.”

Since 2013, De Meyer has been helping scientists, especially those concerned with climate change and the environment, to use insights from the brain sciences to improve the way that they communicate. “If you understand better why part of your audience rejects what you are saying, you might be able to compensate for that and find more constructive ways of getting your message across,” he says.

De Meyer has also been working on projects that build neuroscience and psychology into immersive theatre. He is especially excited about the Justice Syndicate, in which audience members play the parts of jurors. The play helps the audience to gain insight into how people presented with the same evidence reach different conclusions.



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TARA SWART
The leadership coach

Public speaker, lecturer and author based in London.

Tara Swart couldn’t disagree more with those who are pessimistic about the prospects of early-career neuroscientists. Swart, a leadership coach, public speaker, lecturer and author, thinks that brain science offers important insights into how people can develop the mental resilience needed to thrive in our rapidly-changing world. As a result, she says, there is great demand for those with expertise in the field in a wide range of business settings. “Doing a neuroscience PhD can set you up to do pretty much anything you want these days,” says Swart, who is based in London. “It’s hot property.”

Swart originally studied medicine, before completing a PhD in neuropharmacology and working as a psychiatrist for seven years. She moved into leadership coaching a decade ago, after she noticed a “demand for rigorous but applicable neuroscience in the business and leadership context”.

Neuroscience’s not-so-secret weapon, according to Swart, is neuroplasticity — the ability of the brain to form or reorganize networks of connections between brain cells. The disrupted, information-rich, 24-hour environment in which many businesses operate can put its leaders under immense stress. Swart provides executives and managers with neuroscience-based insights, which she says can improve their ability to adapt to change and motivate their staff, for example. “Building mental resilience is probably the biggest part of my work,” she says. “That’s where neuroplasticity really comes in, because to build emotional intelligence or mental resilience you have to change pathways in your brain.”

Swart uses a range of neuroscience research in her talks and coaching sessions. When discussing nutrition, she describes a study (M. E. Raichle & D. A. Gusnard *Proc. Natl Acad. Sci. USA* **99**, 10237–10239; 2002) showing that the brain uses 20% of calories consumed, and another that found that judges who have recently eaten are significantly more likely to rule in favour of prisoners in parole hearings than those who haven’t (S. Danziger *et al. Proc. Natl Acad. Sci. USA* **108**, 6889–6892; 2011).

Swart also highlights research that describes how US marines doing stressful combat training showed fewer physiological markers of stress if they had previously attended mindfulness classes (D. C. Johnson *et al. Am. J. Psychiatry* **171**, 844–853; 2014). She tells her audiences to find forms of exercise that they enjoy, saying research shows that rats that voluntarily use a treadmill produce more of a protein that helps support brain-cell growth and survival, called brain-derived neurotrophic factor, than animals forced to do so. “I see myself as a translator of academic neuroscience to business,” she says.

ORI AMIR
The comedian

Visiting assistant professor, Pomona College, Claremont, California.

If you ever go to an improvised comedy class, you may well be told to ‘get out of your head’. This is not an invitation to take recreational drugs. Rather, it’s the idea that setting aside your ego-driven concerns and tuning into your emotions might make you funnier.

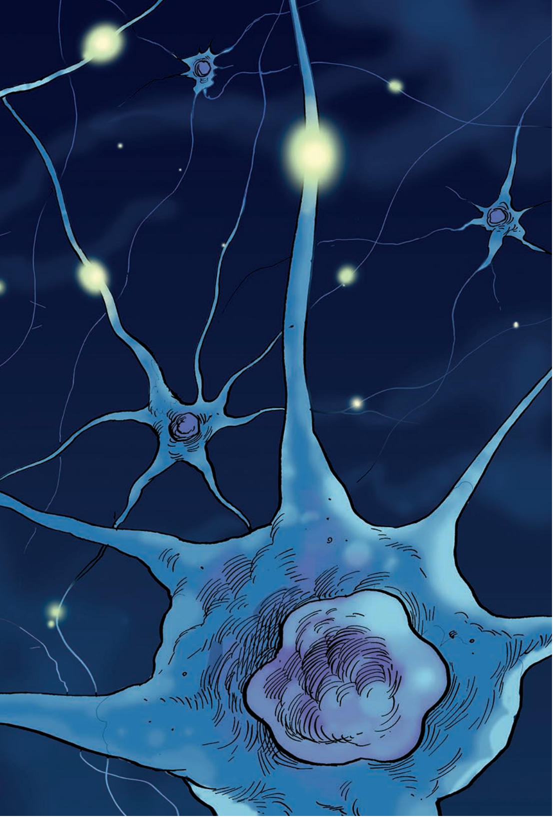
Ori Amir, a neuroscientist and amateur stand-up comedian, has shown that this advice has at least some basis in science. He asked 13 professional comedians, 9 amateurs and 18 non-comedians to come up with both funny and non-funny captions for cartoons while undergoing brain scans in a functional magnetic resonance imaging machine.

“Generating funny ideas involves pretty much everything the brain can do.”

Amir’s study (O. Amir & I. Biederman *Front. Hum. Neurosci.* **10**, 597; 2016), which was part of his PhD on perceptual pleasure, was the first to explore brain activity during real-time humour creation. Amir showed that while trying to be funny, volunteers had increased activity in the medial pre-frontal cortex (mPFC) and some high-level semantic regions in the temporal lobes, where information converges from lower-level brain regions.

Amir concluded that the temporal regions are the origin of funny ideas because activation there was greater for more-experienced comedians and during the generation of funnier jokes — as rated by a separate group of volunteers. “It looks like ‘getting out of your head’ when doing improv works,” he says. “The neuroscience translation is ‘try to reduce the top-down control of the mPFC and trust that the stream of associations in the temporal regions will lead to funny ideas.’” Other research has shown this can be done through meditation.

Amir is now investigating the use of artificial intelligence (AI) to model comedy generation. He is not worried that his efforts to make computers funny will put his comedian friends out of work. “I think comedy generation is



an AI-complete problem," he says. "In other words, generating funny ideas involves pretty much everything the brain can do. So comedians are unlikely to be replaced by AI, at least until almost every other profession has been replaced by it."

RITA BALICE-GORDON
The pharmacist

Global head, neuroscience, Sanofi, Boston, Massachusetts.

Drugs giant Pfizer's announcement in January that it was pulling out of neuroscience research and development (R&D) was just the latest instalment in a string of similar bad news for brain scientists hoping to work in the pharmaceutical industry. GSK, AstraZeneca, Novartis and Merck have all either closed neuroscience divisions or scaled back their brain-science research since 2010. Many saw these moves as adding to the sense that the field had over-promised and under-delivered when it came to real-world impact and application.

Yet, Rita Balice-Gordon, head of neuroscience at French pharmaceutical company Sanofi, says that such reports present only a partial picture. "Big pharma might not be all in when it comes to neuroscience, but when looked at in terms of the broader biopharma ecosystem, the field has never been more vibrant," she says. "We have a number of promising internal programmes, and, like other companies, we also have a number of exciting partnerships with biotech companies and start-ups, which together give me tremendous hope for the future."

Several announcements in the past few years suggest that she may be right. Many pharmaceutical companies are hedging their bets by restructuring their neuroscience research divisions rather than axing them entirely. Others, in step with a more general shift in the industry, are diversifying their risk by outsourcing R&D to academic labs and small biotech firms. In January, for instance, Takeda Pharmaceuticals agreed a deal worth up to US$1.2 billion with Denali Therapeutics, in San Francisco, to collaborate on three neurodegenerative disease programmes, and Johnson & Johnson unveiled four neuroscience collaborations with both academic and private-sector labs. In June, Pfizer revealed plans to invest $150 million in start-ups seeking new brain-disorder treatments.

Balice-Gordon discovered a passion for understanding how environmental cues shape brain circuitry, and how this affects behaviour, as an undergraduate at Northwestern University in Evanston, Illinois. She then spent almost 20 years at the University of Pennsylvania, Philadelphia, before becoming an enthusiastic convert to industry. She was recruited by Pfizer to lead its psychiatry and pain drug-development programmes in 2012. "I love working in the translational space between the lab and the clinic," she says. "I think that is where the real advances in neuroscience therapeutics are going to come from."

She has been with Sanofi since 2016. Balice-Gordon thinks many academics would be surprised at the similarities between doing research in universities and at drug companies. "There is a perception that in biopharma we don't ask a lot of science questions, but I think in early drug discovery, most academics would not find the focus very different. The key difference is that it requires a focus on the crucial questions from the point of view of patients, rather than exploring all possible questions."

To fellow neuroscientists interested in following in her footsteps, Balice-Gordon advises taking time to gain not just deep expertise but also broad knowledge, and says that the importance of networking cannot be overstated.

BENNY HOCHNER
The soft-body specialist

Professor of Neurobiology, Hebrew University of Jerusalem, Israel.

Before 1995, neuroscientist Benny Hochner was mainly interested in the mechanisms underlying learning and memory, something he studied in sea slugs with Eric Kandel, who later won a Nobel Prize in Physiology or Medicine, at Columbia University in New York. Then, Hochner was granted funding from the US Navy, which wanted to find out whether the mechanisms through which octopuses control their bodies could be replicated in soft-bodied military robots. This, it was hoped, could be useful for tasks such as surveillance, and search and rescue in complex terrains. He also received support from the US Defense Advanced Research Projects Agency.

Hochner began by trying to understand how the nervous systems of octopuses cope with the much greater flexibility their soft bodies afford them compared with animals that are constrained by skeletons. "Octopuses have an almost infinitely large degree of freedom of movement," he says. "Finding a way to efficiently control that is a huge problem, both for a nervous system and for a computer system."

"Octopuses have an almost infinitely large degree of freedom of movement."

Hochner, who is now at the Hebrew University of Jerusalem, showed that reaching movements could be triggered in severed octopus arms using electrical stimulation. He found that some often-repeated octopus movements can be independently controlled by neural circuitry in the arm, freeing the brain to focus on other tasks (G. Sumbre *et al. Science* **293**, 1845–1848; 2001).

He has also investigated how octopus brains represent and plan for almost limitless freedom of movement. By stimulating electrodes implanted into the brains of octopuses that were then filmed moving freely, Hochner's group found it was not possible to trigger movement in single arms or body parts. Unlike the brains of skeletal animals such as humans, Hochner found, the octopus brain does not contain specific parts that deal with sensory and motor information from individual body parts (L. Zullo *et al. Curr. Biol.* **19**, 1632–1636; 2009).

Hochner has described octopus movement and its evolution as examples of 'intelligent embodiment', a phrase used by roboticists to describe autonomous machines that learn behaviour through interacting with their environment.

His group has now returned to studying Hochner's original interest of memory and learning. Long-term synaptic potentiation, a process whereby synapses are strengthened through greater activity, is thought to have key roles in mammalian learning and memory. Hochner's group has shown it plays the same part in octopuses, suggesting the mechanism has evolved separately in parallel. He also found that, as in mammals, octopus brains have different systems for dealing with short- and long-term memories. ■

Nic Fleming *is a freelance science writer based in Bristol, UK.*