disproportionating the S^0 into sulphide and sulphate, where the latter can be recycled by the archaea. While these two parts of the process can be teased apart in the lab, the coordinated growth rates of bacteria and archaea in natural settings suggests that they work closely together, with S^0 being the chemical species linking the reactions. Luzan likens the bacteria to scavengers in the animal kingdom: “According to this new paper, the relationship between the sulphate-reducing bacterium and archaeon is more like that between lion and hyena — like the hyena, the bacterium takes the leftovers.”

While Milucka and colleagues base their current analysis on just one location, they believe that the mechanisms may be widespread, as similar sediments occur in many parts of the sea floor. “Our cultures originate from sediments of a marine mud volcano, which represents a typical habitat in which AOM is regularly found,” says Milucka. “Interestingly, our observations, such as production and accumulation of elemental sulphur, have also been reported from so-called sulphate–methane transition zones, which represent another common habitat of AOM.”

Globally, this biological degradation of methane is an extremely important factor for climate stability. “Under the environmental conditions prevalent in anoxic marine sediments methane is very stable and unreactive,” Milucka explains. “Therefore, microbial activity is necessary for its breakdown. Microbially-mediated anaerobic methane oxidation is a key process regulating the flux of methane into the water column. It is estimated that AOM consumes up to 90% of the methane diffusing from marine sediments, which equals ca. 300 Tg per year. However, it is the interplay between both the aerobic and anaerobic oxidation of methane in the water column and the sediment, respectively, that protects our atmosphere from the effects of this greenhouse gas.”

Three dimensions of diversity

Apart from these surprising new reactions and processes that need to be explored in more depth, a lot of the more mundane work of mapping habitats and linking species to geological context remains to be done, as highlighted by recent papers covering what would be basic knowledge on dry land, but is still a frontier on the sea floor.

Frank Scheckenbach and colleagues at the University of Cologne, Germany, have described the diversity of single-cell eukaryotes on the deep sea floor at 5,000 metres depth for three abyssal plains in the southeastern Atlantic (Proc. Natl. Acad. Sci. USA (2010), *107*, 115–120). They found great phylogenetic diversity, providing just a glimpse of the wealth of biology we’re still missing out on in these depths.

In an attempt to map diversity vertically rather than horizontally, the groups of Steffen Leth Jørgensen from the Centre for Geobiology at the University of Bergen, Norway, and Christa Schleper from the University of Vienna, Austria, have profiled microbial communities in correlation to their geological context (Proc. Natl. Acad. Sci. USA (2012) *109*, E2846–E2855).

The authors analysed two drill cores, each three metres long, from the Arctic mid-ocean ridge system that runs parallel to the east coast of Greenland. They obtained both cores at a distance of 15 km from an active hydrothermal vent field. In these locations, the alternating depositions of sediments carried by a river on Bear Island and hydrothermal vent output leads to strongly pronounced geological layer structures within a modest depth range.

Studying 15 separate sediment horizons and analysing the sequences of around 60,000 microbial 16S rRNA genes, Jørgensen and colleagues could associate microbial communities with specific types of sediments. They come to the conclusion “that organic carbon and mineral (iron and manganese) content are key determinants of microbial community structure. Conversely, the community structure is a likely determinant of the sulphate concentration.”

Linking geology to ecology in this way can help to form hypotheses about less accessible habitats, the authors say. Thus it may help to push back the boundaries of those vast uncharted territories remaining on our own planet. As humanity is confronted with planetary problems like climate change and ocean acidification, our lack of knowledge regarding the 72% of our planet covered by oceans is becoming downright dangerous.

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Q & A

Eleanor A. Maguire

Eleanor Maguire is Professor of Cognitive Neuroscience and a Wellcome Trust Senior Research Fellow at the Wellcome Trust Centre for Neuroimaging, University College London, where she is also Deputy Director. Her undergraduate degree in psychology at University College Dublin was followed by an MSc in neuropsychology at Swansea University, UK, and then a PhD back in Dublin which was completed while working as a neuropsychologist in Ireland’s then largest neurological and neurosurgical hospital. In 1995 she joined University College London, UK, as a postdoc at the new Functional Imaging Laboratory (FIL) where, after a number of years, she set up her own lab combining neuropsychology and neuroimaging to study how spatial and episodic memories are formed, represented and recollected by the human brain. Eleanor is a Fellow of the Academy of Medical Sciences and has won numerous prizes for outstanding contributions to science including the Royal Society Rosalind Franklin Award, and also the Ig Nobel Prize for Medicine which celebrated her work on plasticity in the brains of London taxi drivers.

What turned you on to biology, and neuroscience in particular? From an early age I had an insatiable thirst for facts which was most acute in three domains — archaeology, astronomy and biology. When it came to making choices for university, my parents ruled out archaeology as they felt I couldn’t make a decent living from it! In Dublin in the late 1980s, studying astronomy seemed like pie in the sky. So I quite happily plumped for a career in biology. Visits to the local university arranged by my biology teacher quickly confirmed that a wet lab was not for me, and consequently I fell into psychology. To be honest, I didn’t really enjoy it at first, but then the neuropsychology module started, and I was hooked; the brain — here was something tractable that challenged and completely absorbed.

Who are your scientific heroes? I should probably say something lofty here, but as a young child in the late 1970s I was obsessed with Star Trek, and so my first scientific hero was fictional — Spock, science officer on the starship Enterprise. He embodied so much of what attracted me to science; he was inquisitive, logical, honest, meticulous, calm, fearless in facing the unknown, innovative and unafraid of taking risks; science was exciting on board the Enterprise, their cutting-edge technology to be envied. And of course, they adhered to 'the prime directive' which dictates that there can be no interference with the internal development of alien civilizations. My research, while obviously not concerned with aliens, has been influenced by this. My desire to study a cognitive phenomenon or behaviour such that the examination of it does not divert it from its natural course or how it would occur in the real world, owes much to Starfleet's General Order #1.

Consequently, my interest in trying to understand how the brain allows us to navigate in the world and to remember what happens to us along the way is underpinned in part by paradigms that study these behaviours directly. This is challenging, particularly in the context of neuroimaging, where people cannot move their head while being scanned, and yet we want them to navigate through the streets and through their life's experiences. It requires inventive approaches such as the use of virtual reality environments, of multi-voxel pattern analysis of functional magnetic resonance imaging (fMRI) data to detect neural signatures of specific autobiographical memories, and careful control conditions to deal with the complexity of the cognition under scrutiny. Nevertheless, the judicious use of naturalistic protocols, where key neuroscience questions cannot be addressed effectively in other ways, is a rewarding and effective pursuit.

My second hero is Wilhelm Wundt, often regarded as the 'father of modern psychology'. Wundt was the first to adopt introspection, the self-examination of one's conscious thoughts and feelings, as a legitimate tool for research. Of course much is hidden from our awareness, but what is not shouldn't be ignored. Introspecting has helped me to decompose complex thoughts and behaviours to make them amenable to investigation. In addition, debriefing subjects following an experiment, having them introspect on how they performed a task, can provide valuable insights into their priorities and strategies. Some people frown upon introspection and regard this information as unreliable, while I on the other hand am disappointed when experimenters don't include it.

Overall, these 'heroes' represent for me the importance of not being afraid to address your research question directly, of availing of information at multiple levels, combining the quantitative and the qualitative, the creative with the assiduously controlled.

Do you have a favourite paper? If I had to pick one, it would be O'Keefe and Nadel's 1979 Behavioral and Brain Sciences paper 'Précis of O'Keefe & Nadel's *The Hippocampus as a Cognitive Map*', which is a summary of their 1978 book, accompanied by commentaries from other neuroscientists. In the early 1990s I was working as a neuropsychologist with patients who were undergoing temporal lobectomy for the relief of intractable epilepsy. I was about to start a PhD studying this cohort, but was unsure what to focus on. I read this paper and it cemented everything. First, it contacted with something personal, my complete inability to find my way around, something that plagues me to this day. Second, navigation problems were prevalent among these patients in their everyday lives, thus affording the opportunity to study something meaningful. And third, it opened up the wondrous world of the hippocampus, with its exquisite anatomy and physiology, its clear importance for navigation but also for episodic memory and, as we now know, for imagining fictitious and future experiences. How it manages to achieve all of this remains the central question of my research programme. John O'Keefe was subsequently the examiner of my PhD, and when I moved to UCL we had the chance to collaborate. I've benefitted a lot from his advice (and wonderful anecdotes!), in particular his encouraging me to consider the physiological grounding of the higher cognitive functions that I investigate.

What are the ingredients of a successful research career? Cooking not being my strong point, I don't have a coherent recipe to offer, but merely a few random observations from my own experiences. Knowing what research question to ask is vital. This may seem obvious, but in cognitive neuroscience sometimes people can't see the wood for the trees, and don't always ask the important, the 'big' questions. Also, as alluded to, being brave and trying to think around the question in new and interesting ways can be exciting and illuminating.

For me, and this may not be very helpful for aspiring researchers, a key element has been good luck. The start of my postdoc career coincided with the rise of functional neuroimaging, the establishing of the FIL in London, which also happened to be recruiting — right place, right time. I now had starship-like technology to work with and the chance to apply it to my research questions. This was only possible because of the Frith-factor. Chris Frith hired me as a postdoc to work on a schizophrenia project. An administrative delay in accessing patients saw me filling in time continuing my PhD work and doing a neuroimaging study of navigation. I never did study schizophrenia. Chris' generosity, the freedom he gave me to pursue my own interests, his wisdom, his diplomacy and the sense of delight and fun with which he approaches science were, and are, inspiring — he should probably be in my heroes category.

I was also fortunate in that neuropsychology has numerous female role-models, including Brenda Milner, Elizabeth Warrington and Uta Frith; all of them inspirational and who meant that, for the most part, it never occurred to me that gender would ever be a barrier to success. Finally, funding, the lifeblood of the research scientist. Funders who are willing to take risks, to provide long-term funding, with a light and facilitatory touch, who help to protect the scientist from the rising tide of bureaucracy are an invaluable ingredient — I have been very fortunate to benefit from such a funder in the Wellcome Trust.

Other than that, I have a small research group; it suits my type of work, and allows me to stay close to the data. I also put a lot of effort into preparing talks; I would say never underestimate the value of giving a good talk. This is the most direct way to communicate one's science, and be it a seminar to high-school students, a public lecture, or a presentation to experts, everyone enjoys and remembers a clear, uncluttered and coherent story. The final, rather obvious, ingredient that springs to mind is hard work. My Mother is fond of quoting Mark Twain: "*Don't go around saying the world owes you a living. The world owes you nothing. It was here first*".

Do you have any regrets or bugbears? Like many others I regret not knowing more maths. Although perhaps I should be careful what I wish for, as being more mathematically-savvy might prevent the occasional leaps of faith that make the naturalistic aspects of my research exciting.

Bugbears: there's definitely a few, but for brevity's sake I'll mention just two. Like everyone else, I find the peer-review process frustrating and imperfect, but I don't have a credible alternative to offer. Another frustration is the media. I'm fortunate that my work engages the interest of the general public and the media are a crucial conduit in this process. However, I sometimes feel a bit like an aging rock singer, I'm singing new songs, but the media only want to hear the old tunes — invariably about London taxi drivers. I get *a lot* of media inquiries and many of them are lazy, unimaginative, and looking to sensationalise. Of course this isn't true across the board and some science journalists are well-informed and ask important questions of academia, science and scientists. It is vital that science and the media engage, but both sides have some way to go in making it a more fulfilling and productive relationship.

What are the next big questions in your field? The questions haven't changed. Learning and memory are so fundamental to us, so enmeshed throughout cognition, that 'solving' memory, unpacking its neural mechanisms and being able to conceptualise it fully will, I believe, result in revelations across neuroscience. And once that's done (!), the whole point of this endeavour and the real work, to improve the lot of the memory-impaired in a rational and principled way and to inform education, can begin in earnest.

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Obituary

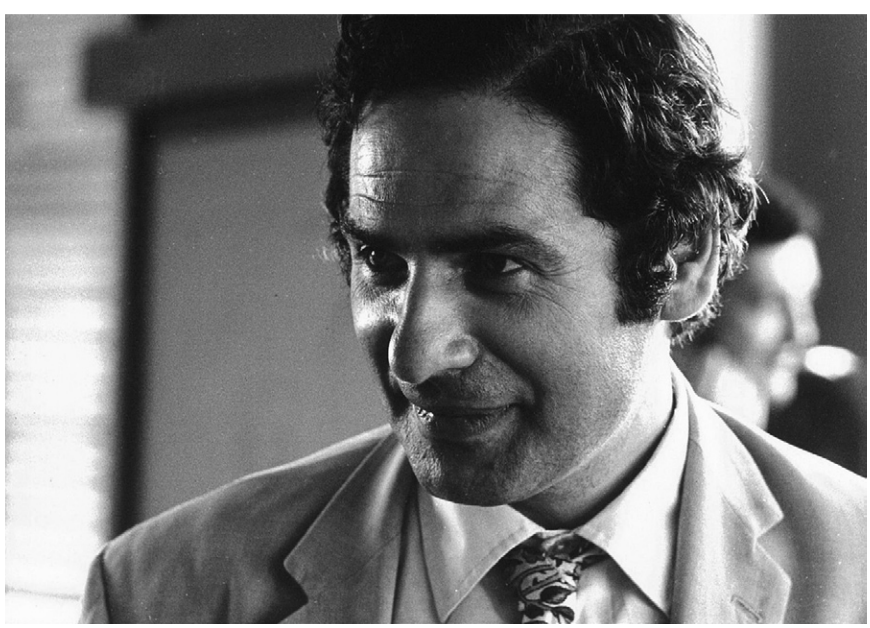
Sir Gabriel Horn (1927–2012)

Johan J. Bolhuis[1]
and Mark H. Johnson[2]

In a research career spanning well over 50 years, Sir Gabriel Horn, who died on 2nd August this year, saw the field of neuroscience grow from infancy to the mature field that we know today. In the year of his birth, 1927, neuroscience was still a young, emerging field of rather specialist interest — it was only 20 years earlier that Cajal and Golgi had shared the Nobel Prize for their work on the basic structure of the nervous system. Horn's neuroscientific contributions consistently pioneered new approaches and areas of investigation for others to follow. Indeed, his work presaged several active directions of contemporary research in cognitive and developmental neuroscience.

Gabriel Horn attended Handsworth Technical School in Birmingham, but he left at 16 to work in his parents' tailoring business. He spoke very warmly of his parents in a filmed interview conducted by Sir Patrick Bateson (see www.sms.cam.ac.uk/media/1121995). Horn continued to study at night school and, after National Service in the Royal Air Force, took a medical degree at the University of Birmingham. That this was not a foregone conclusion is illustrated by a rather stern letter from 'the Sub-Dean and Tutor' of the Medical School that Gabriel always kept above his desk in his study: "There is no possibility of you being accepted here in the near future and since you have no qualifications for the medical profession and competition is very keen, my advice to you is to abandon the project altogether for I feel it will only lead to disappointment." Thankfully, Horn persisted, and much later, in 1999, his *alma mater* redeemed itself by awarding him an honorary doctorate.

As a medical student, he already showed great interest in brain and cognition, and during a year working with Solly Zuckerman, Professor of Anatomy at the University of Birmingham, he wrote an essay on '*The Neurological Basis of Thought*' (www.zoo.cam.ac.uk/zoostaff/madingley/library/member_papers/ghorn/Horn%20Neurological%20basis%20of%20thought.pdf), published in a student journal called 'The Mermaid'. In this paper, Horn laid the foundations of much of his later work on the neural basis of attention, habituation, memory, and development, and he frequently



Gabriel Horn in India in 1976. Photo courtesy of Lady Horn.