

► afflicts 700 million people. *Factfulness* is not, however, comprehensive. I have wondered whether Rosling would have been his usual cheery self when confronted with the challenges of antimicrobial resistance (AMR), and the needed solutions. I had the chance to discuss this issue with him only briefly. Its absence from the book is disappointing, but then, I'm biased. I led a global review on AMR for the UK government under then-prime minister David Cameron, during which I departed from my own generally cheery take on the state of the world.

I came to Rosling's work in the past decade, when someone at Goldman Sachs Asset Management (which I chaired) suggested that I should follow one of Rosling's online presentations about the state of the world, its evolution and probable future. It was wise advice. Although I initially

sulked because of the inference that Rosling discussed such information better than me, I soon realized that he took aspects of what I had become

“I loved Rosling’s positive approach to life’s challenges; it did, and does, inspire me.”

known for to a completely new level. His knowledge of issues around health, disease control and many aspects of development was obviously deep and broad. A few years later, I shared a platform with him. I loved his positive approach to life's challenges; it did, and does, inspire me.

Long before US President Donald Trump and fake news, I warned audiences about slavishly believing what they read. As Rosling spells out, our awareness of facts has never been that strong, and many journalists are not motivated to tell us that the world is getting better. (No news is sometimes the only good news.) It is up to individuals to ensure that we foster the disciplined habits of mind that Rosling eloquently and clearly sets out.

This magnificent book ends with a plea for a factual world view. Rosling was optimistic that this outlook will spread, because it is a useful navigational tool in a complex world, and a genuine antidote to negativity and hopelessness. A just tribute to this book and the man would be a global day of celebration for facts about our world. Perhaps Trump should lead the charge on that. ■

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NEUROSCIENCE

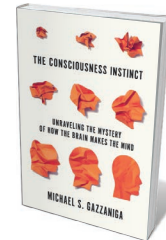
From meat to mind

Douwe Draaisma enjoys Michael Gazzaniga's exploration of the biological basis of consciousness.

In April 1648, a young admirer of René Descartes visited the French philosopher at his estate on the Dutch coast. Aiming to discuss the cardinal points of Cartesian philosophy, Frans Burman had marked more than 70 passages in Descartes's works. How, he asked, can soul and body affect each other, given their fundamental difference? Descartes conceded that the question was thorny, but pointed to the evidence that they do — for instance, in emotion. The mystery lies in the mechanism, and this, Descartes confided, was perhaps best left to theologians.

Neuroscientist Michael Gazzaniga tackles this abiding mind-body problem anew in *The Consciousness Instinct. Unraveling the Mystery of How the Brain Makes the Mind*, rephrases Descartes's conundrum into a bold promise. But then, Gazzaniga is a bold scientist. He made his name in the 1960s through pioneering work on severing the connection between the brain's left and right hemispheres ('split brains'), as his autobiography vividly details (D. Draaisma *Nature* 518, 298–299; 2015).

His latest book is certainly evidence that scholars advancing in age (Gazzaniga is now 78) often trust themselves with ever broader scientific and philosophical questions. Thus he guides readers through neurology, biology and psychology, discussing the origin and neural underpinnings of language or the mechanism of facial recognition.



The Consciousness Instinct: Unraveling the Mystery of How the Brain Makes the Mind

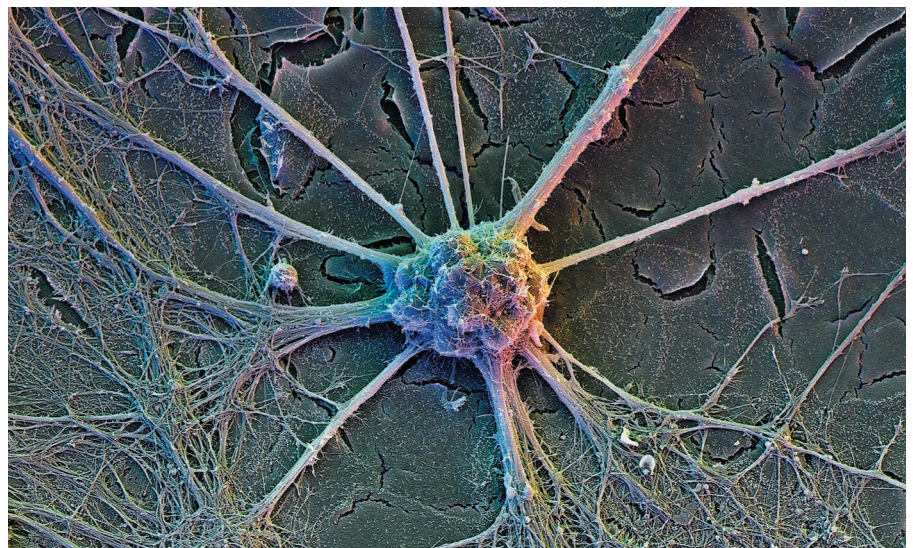
MICHAEL S. GAZZANIGA
Farrar, Straus and Giroux: 2018.

And he evokes Isaac Newton's laws of motion, the special and general theories of relativity and quantum physics — surprisingly, for a man with a self-confessed blind spot for mathematical abstraction.

The tour yields a couple of useful lessons. With theoretical biologist Howard Pattee, Gazzaniga emphasizes that we should resist the lure of the “single-explanation fallacy” — the idea that one theory can cover

everything, from our introspective sense of awareness down to the subatomic particles of brain tissue. Explanations, he asserts, should be thought of as context-dependent, just as light in quantum physics sometimes behaves like waves and sometimes like particles.

Gazzaniga defines consciousness as “the subjective feeling of a number of instincts and/or memories playing out in time in an organism”. He points out that clinical cases — he spent a few years working on neurological wards — add complexities. For instance, people who are completely unable to move can still be conscious, a frightening condition



A nerve cell in the human brain, seen in a false colour under a scanning electron microscope.

DAVID SCHARF/SPL

called locked-in syndrome. Consciousness might be absent in sleepwalking. Thus, coupling it to behaviour is misleading.

Nor is it straightforward to link consciousness to parts of the brain. One of Gazzaniga's earliest findings was that disconnecting the left and right hemispheres produced two separate conscious systems; only one, usually supported by the left brain, was able to express itself in language. It had been assumed that consciousness co-evolved with the cerebral cortex, supporting 'higher' functions such as language and reasoning. But referring to the work of neuroscientist Björn Merker, Gazzaniga makes the case that consciousness might not be necessarily — or exclusively — locked into cortical and linguistic processes. In some children born with a seriously compromised forebrain, the damaged tissue gets replaced by fluid (hydranencephaly). They grow up lacking language, but still express feelings and have subjective experiences. According to Gazzaniga, consciousness might actually originate in the evolutionarily older midbrain, with the cortex providing "a collection of extensions (apps!) to enhance conscious experiences".

In an engaging discussion of the brain's architecture, he offers a mundane simile for consciousness. The brain should be thought of as a multitude of modules, each specialized for a single task, such as recognizing patterns or monitoring rhythm in music. The end products of these modules rise to the surface and burst like "bubbles in a boiling pot of water", each a fleeting part of our awareness. Our subjective sense of continuity, described by pioneering psychologist William James as "stream of consciousness", might be illusion: we merely experience the rapid succession of elements as a smooth movement, like the frames of a film. The metaphor of the bubbles seems first and foremost an invitation to generate a testable theory, and Gazzaniga's observations will almost certainly provide much of the test material.

Gazzaniga ends by reflecting that the ultimate explanation for how mind emerges from meat might not prove "warm and cuddly". Instead, it might vie with quantum mechanics for sheer counter-intuitive weirdness, hovering "way beyond our intuitions and imaginations". Once again we seem to hear what Burman heard, 370 years ago: a sigh of resignation, as Descartes indicated that it might all be better left to the theologians. ■

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Tom Lehrer performing in San Francisco, California, in 1965.

MATHEMATICS

Tom Lehrer at 90

Andrew Robinson looks back at the scientific high notes in the mathematician and satirist's inimitable oeuvre.

In 1959, the mathematician and satirist Tom Lehrer — who turns 90 this month — performed what he characteristically called a "completely pointless" scientific song at Harvard University in Cambridge, Massachusetts. (He was a PhD student there at the time.) 'The Elements', now one of his most cherished works, sets the names of all the chemical

elements then known to the tune of the 'Major-General's Song' from *The Pirates of Penzance*, the comic opera by W. S. Gilbert and Arthur Sullivan. Lehrer's heroically precise, rapid-fire enunciation of 102 elements (reordered to allow flawless end-rhymes), ends with the much-quoted crack, "These are the only ones of which the news has come to Harvard/And ▶