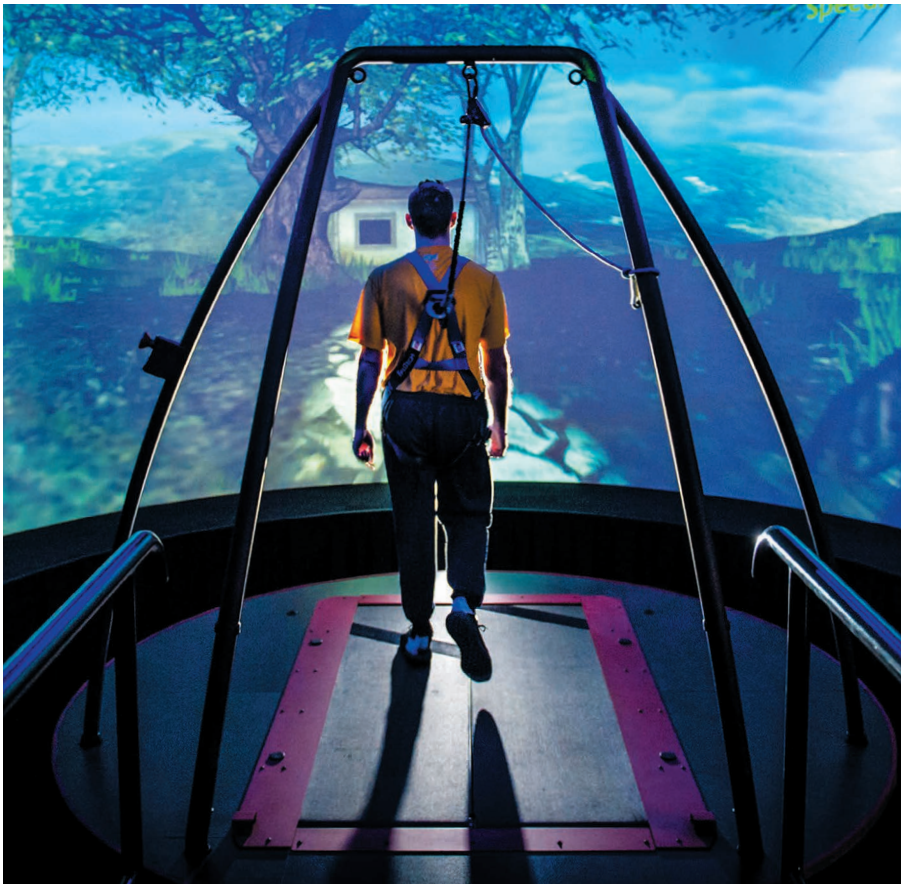


J. M. EDDINS JR/US AIR FORCE

Virtual reality in use as part of physical therapy after a traumatic brain injury.

TECHNOLOGY

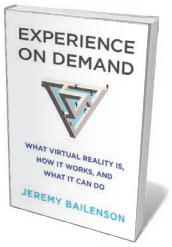
Virtual reality comes of age

Ramin Skibba weighs up a hymn to the technology's applications, from school to sports.

You strap on the head-mounted display, slip on the gloves, tune your ears to the surround sound — and suddenly you are facing a plank jutting out over an abyss. The depths here are virtual, but not everyone can force themselves to jump.

This is just one program developed by psychologist Jeremy Bailenson to demonstrate the capabilities of virtual reality (VR). As a leading researcher in the field, Bailenson crafts new worlds that feel real, to explore their beneficial uses. In *Experience On Demand*, he tours the myriad applications that he and others are developing. After a great deal of hype by science-fiction film writers and video-game designers in the 1990s, the technology now finally seems poised for widespread use. Eventually, as Bailenson details, it could transform work, schools, hospitals and more.

Fast, high-resolution VR systems such as Bailenson's excel as training tools because they so effectively recreate interaction with a particular environment: a user's motor and perceptual systems interact with the surroundings more or less as they would with the real thing. Psychologists refer to this as "presence"; it is, as Bailenson notes, "the fundamental characteristic of VR". The system tracks your every move, providing a realistically shifting sensory perspective. Small things loom as you move towards them; the view turns as you rotate your head. Props or a shaking floor can make an experience feel very real indeed.



Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do
JEREMY BAILENSON
W. W. Norton: 2018.

The applications, as Bailenson details, are legion. VR is an efficient way to train workers in dangerous or challenging jobs. For example, quarterbacks in American football need daily strategy practice alongside their cardio and weights, to prepare for every possible defence. Bailenson developed a training program for the team at Stanford University in California; he has now expanded it into STRIVR, a company offering immersive training. The firm provides tools that claim to improve performance and boost productivity in a range of companies and sports teams.

VR also lends itself to social, ethical and environmental education. Bailenson discusses examples of how it could be used to tackle ageism and reduce waste. The idea is that it can give users any kind of body. In one of Bailenson's studies, for instance, participants who were given an 'elder' avatar and saw themselves in a virtual mirror showed a 20% improvement against ageist stereotypes in one measure of bias. This was a word-association task posing questions such as "When you think of somebody old, what are the first five words that come to mind?"; people who had experienced the elder avatar used more positive words. However, the tactic backfired with respect to race. White people who tried on a black avatar subsequently scored worse in a test of implicit bias. In this case, rather than boosting empathy, the virtual experience primed racist stereotypes.

Programs can also be used for physical and psychological therapy. People with burn injuries experienced up to 44% less pain when using VR because the immersive environment was such an efficient distraction, according to a study by psychologist Hunter Hoffman at the University of Washington in Seattle and his colleagues (Y. S. Schmitt *et al. Burns* **37,** 61–68; 2011). VR has also been used to help people with post-traumatic stress disorder to gradually come to terms with their traumatic experience.

There are inevitable risks and drawbacks. Mayank Mehta, a neurophysicist at the University of California, Los Angeles, investigated the effects of the technology on the brains of laboratory rats. His team found that rats respond to the sight of a virtual dispenser of sugar water as if it is the real thing, running faster towards it and even salivating and licking as they (virtually) approach

it — a sign of addiction (Z. M. Aghajan *Nature Neurosci.* **18,** 121–128; 2015). In a 2014 study by Frank Steinicke and Gerd Bruder at the University of Hamburg in Germany, a participant started blurring the distinctions between real and virtual objects after immersion in a virtual environment many times in a single day (F. Steinicke and G. Bruder *Proc. 2nd ACM Symp. on Spatial User Interaction* 66–69; 2014).

Bailenson mentions escapist, excessive use of VR as a major risk. Because of "simulator sickness" and eye strain, which can develop after just 20 minutes, this has not yet been studied in humans. It is as yet a speculative concern, explored more in film and fiction. In addition, there are concerns that violent programs, such as VR versions of first-person-shooter video games, might encourage antisocial or aggressive behaviour in the real world. But Bailenson gives such concerns short shrift. Nor does he call for transparency or oversight of VR companies, or for regulations to ensure consumers' safety. He seems confident that developers and users will know how to use the technology responsibly.

Indeed, Bailenson is, by his own admission, "bullish" about VR; he recognizes that he might have "drunk the Silicon Valley Kool-Aid". That relentless positivity means that the book can lack nuance, as if VR can solve the world's problems. Bailenson, for instance, wants to combat climate change by using the technology to encourage people to change their behaviour, for example by taking shorter showers and making fewer long-distance flights. He also wants to see it used in schools for virtual field trips — although the cost of the equipment would make access unequal.

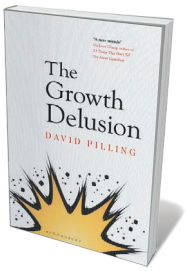
"Virtual reality lends itself to social, ethical and environmental education."

Social-media trolls pose another problem. Platforms such as Facebook — which acquired the VR company Oculus in 2014 — could one day incorporate virtual interactions, raising the chilling spectre of increasingly realistic goading and abuse.

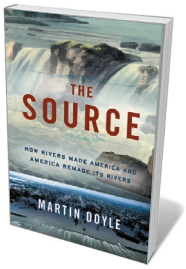
Bailenson often writes like a scientist. His prose can be verbose, peppered with jargon such as "boundary conditions". He verges on the grandiose, calling VR a "movement" or a "revolution". Nevertheless, his enthusiasm is contagious, and he explains complex issues to an audience broader than fellow scientists, providing a real vision of our possibly VR-infused future. ■

Ramin Skibba *is an astrophysicist turned science writer based in San Diego, California.*
e-mail: raminskibba@gmail.com

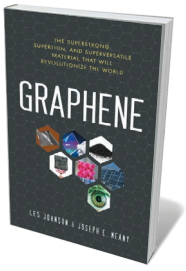
Books in brief



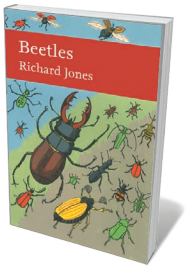
The Growth Delusion
David Pilling BLOOMSBURY *(2018)*
"Only in economics is endless expansion seen as a virtue. In biology it is called cancer." Rarely does a study of gross domestic product (GDP) and growth sizzle with such wit and acuity, but *Financial Times* editor David Pilling manages the feat. He skewers the linked concepts as a statistical neverland that factors in crime and ignores housework. He pulls out absurdities such as the stratospheric US health-care costs that prop up the nation's economic well-being, yet destroy uninsured families. And he presents a cogent argument for the multi-index 'dashboard' superseding mere GDP. Masterful.



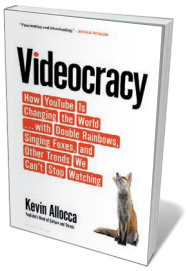
The Source
Martin Doyle W. W. NORTON *(2018)*
Rivers have shaped the United States geologically, economically and demographically — there are, after all, 250,000 in the country. This history by water-policy expert Martin Doyle nimbly explores that process in tandem with the heroic era of US construction that saw the rise of projects such as the Grand Coulee Dam. In his telling, rivers become a lens on federalism, energy and conservation — a rolling narrative taking us from George Washington's quest to find a passage from the Atlantic Ocean to the Ohio River, through decades of levee-building, flood control, water wars and much more.



Graphene
Les Johnson and Joseph E. Meany PROMETHEUS *(2018)*
How can a material one atom thick conduct electricity or filter filthy water? Physicist Les Johnson and chemist Joseph Meany tell all about graphene, that wispy "tessellation of carbon atoms" finally coming into its own. Their primer is fittingly slim, but covers an impressive swathe of the science and its applications. Along with a lucid history of earlier carbon "miracle materials", they follow the path from lab to production. The potential is vast, from making the material using waste carbon dioxide harvested from astronauts' breath, to creating graphene-based transistors that detect harmful genes.



Beetles
Richard Jones WILLIAM COLLINS *(2018)*
It's no surprise that Alfred Russel Wallace and Charles Darwin were both avid fans of the beetle. The nearly half a million described species of Coleoptera are like animated jewels, from their gaudy wing-casings to their shiny, secateur-like mandibles. Entomologist Richard Jones's illustrated tome (part of the Collins New Naturalist Library) ranges over their anatomy, natural history and behaviour. Things get really wild with the defensive 'chemical cannon' of the bombardier beetle, and the biscuit beetle's reduction of noodles to "ticker tape and dust". Watch out — there are wonders underfoot.



Videocracy
Kevin Allocca BLOOMSBURY *(2018)*
YouTube can seem like a parallel universe — a trove of cultural data so huge it would take years to watch the content posted in a day. This 'biography' of the web-video behemoth by its trends director, Kevin Allocca, tours the technology and the clips that have trended or gone viral, from astronaut Chris Hadfield singing David Bowie's 'Space Oddity' on board the International Space Station, to Egyptian protests during the Arab Spring. Allocca examines, too, the darker side of mass cultural participation, such as the raising of troll armies. **Barbara Kiser**