The Theory of Everything is, like *The Imitation Game*, about a scientist. There the similarities end. The film tells us that Hawking has refused a knighthood, but it thoroughly canonizes him. There have been other depictions of Hawking's life, including *Hawking* (2013), a documentary by Stephen Finnigan, and *Hawking* (2004, a BBC television film starring Cumberbatch). This turn, with Eddie Redmayne in the lead role and directed by James Marsh, is loosely organized around Hawking's relationship with his first wife, Jane Wilde, and based on her memoir *Travelling to Infinity* (Alma, 2008). Despite Redmayne's fine performance, it unfolds with such plodding, reverential linearity, and with so much melodrama and uplift, that it is the least compelling of the treatments.

The story begins in Cambridge, UK, in 1963. Stephen and Jane flirt. He is diagnosed with motor neuron disease and told that he has two years to live. She remains selflessly devoted and they marry. Stephen works despite his disability. "He has done it!" we are told at one point, but we haven't a clue as to what 'it' is. Caring for Stephen and their three children gives Jane moments of doubt and insecurity. The ins and outs of the couple's relationships with each other and with their eventual second spouses — choir director Jonathan Hellyer Jones and Stephen's nurse Elaine Mason — are rolled out with surprisingly little conflict. Everyone is presented as well intentioned and concerned only for Stephen's welfare.

Key moments in Hawking's life are handled simplistically. He announces, "I will write a book," and knocks off *A Brief History of Time* (Bantam, 1988) without strain or editorial conflict; it is an instant best-seller. A final scene shows Hawking, now a venerated celebrity, delivering a talk to an entranced audience. One questioner asks how it is possible for him to live without believing in God. The question seems pointless: in the world of this film, so full of saints and sacrifice, who needs God? But cloaked in the ethereal strains of his electronically synthesized voice, Hawking's response — "Where there is life, there is hope" — brings the audience cheering to its feet. The scene invites us to regard Hawking himself as a miracle.

Dramatizing the lives of scientists, so much of whose work is mentation, is demanding. These two films demonstrate the promise and the perils. ■

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WARNER BROS. ENTERTAINMENT/PARAMOUNT PICTURES

Matthew McConaughey, Anne Hathaway and David Gyasi in *Interstellar*.

Q&A Kip Thorne

Space–time visionary

Thanks to theoretical physicist Kip Thorne, real science is embedded in Christopher Nolan's film Interstellar, *in which explorers seek a new home for humankind. Thorne talks about what he learned from the film's unprecedented visualizations of black holes and wormholes, what it and his accompanying book can teach, and the likelihood of humans escaping the Solar System.*

ILLUSTRATION BY JIM SPENCER

How did *Interstellar* come about?
I have long worked on black holes and, since the 1980s, wormholes — hypothetical tunnels in space that link distant regions of the Universe. About eight years ago, I and my friend Lynda Obst, a film producer, came up with a movie set on the 'warped side of the Universe' — black holes, wormholes, higher dimensions and beyond. It interested director Steven Spielberg, who brought in Jonathan 'Jonah' Nolan to write the screenplay. Steven dropped out and later Jonah's brother Christopher Nolan took over as director and final screenwriter. Chris and Jonah changed our story almost completely, but preserved the warped space-time and splendidly fulfilled our vision of a science-fiction movie with real science woven deeply in its fabric. In it, nothing violates well-established physical laws and all the wild speculations spring from science, not just the fertile mind of a screenwriter.

How hands-on were you during development?
I met with Jonah and Chris every few weeks as they crafted the screenplay, brainstorming about the science. I worked on the visualization of black holes and wormholes with Oscar-winner Paul Franklin and his team at Double Negative Visual Effects in London.

Interstellar
DIRECTED BY CHRISTOPHER NOLAN
Warner Brothers: 2014.

The Science of Interstellar
KIP THORNE
W. W. Norton: 2014.

Black holes do not emit light, so you visualize them through gravitational lensing — how they bend light from other objects. I took equations based on Einstein's general theory of relativity and created a description of a wormhole with three parameters: diameter, interior length and the degree of flare where the wormhole joins the external Universe. Paul's team used my equations to compute what a camera would see through the wormhole; Chris, perusing the images, chose the parameter values for *Interstellar*'s wormhole.

Did you learn anything new?
With computing power beyond what is normally used by physicists, and software designed to give rapidly changing images at IMAX resolution, we were able to see something never seen before. We simulated a fast-spinning black hole and a field of stars, and what we discovered is an amazingly complex,

fingerprint-like pattern of starlight near the edge of the black hole's shadow, which comes from this gravitational lensing. There are regions where the stars look as if they are still, right next to others where the stars are swirling around. When we first saw hints of this, I thought we had done something wrong. We now think it is caused by a complex set of caustics (wrinkles) in the camera's 'past light cone' — not unlike the patterns on the bottom of a sunlit swimming pool. These wrap around the sky many times because the black hole's spin makes space whirl.

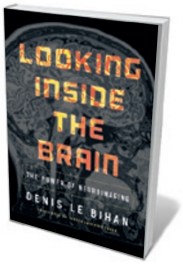
Was there any culture clash?
No, there was a full embrace of this melding of arts with science that extended to all four lead actors. Matthew McConaughey and Anne Hathaway came to me for in-depth discussions — they were trying to wrap their heads around the science. Michael Caine asked to have his photograph taken with me, and my jaw dropped. He told me his character was based on me and he wanted to talk about how a theoretical physicist thinks. Jessica Chastain asked for help with quantum equations. The nicest thing was working with artists who are brilliant, intellectually curious and from a background so different from my own.

Will interstellar travel ever be possible?
The nearest potentially habitable planet outside the Solar System is perhaps just under 12 light years (3.7 parsecs) away, orbiting the star τ Ceti. If you think of that distance as like going from New York to Perth, Australia, then the distance from Earth to the Moon would be about 7 centimetres. That gives you some sense of the challenge involved. I think humans will make that journey, but not in this century or the next, or maybe the one after that. It is too hard. For a science-fiction story, a wormhole created by an advanced civilization is the only way to do it in the next century, but it is unlikely that wormholes exist. You have to prop them open with 'negative energy' and it is unlikely that the laws of physics allow you to collect enough negative energy. But there is no proof that they can't exist.

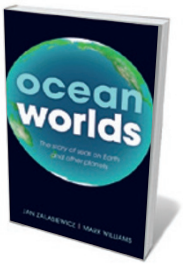
What areas of physics currently excite you?
My passion is to understand the non-linear dynamics of warped space-time, and the ideal venue for this is black-hole collisions. There is a high probability that in the next several years we will detect gravitational waves — ripples in the fabric of space-time — generated by such collisions. A combination of computer simulations and gravitational-wave observations will really open our eyes about the behaviour of warped space and warped time when they are wildly dynamical. And who knows, maybe the next movie will involve colliding black holes. We will have to see! ■

INTERVIEW BY ZEEYA MERALI

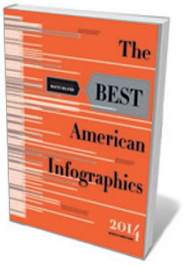
Books in brief



Looking Inside the Brain: The Power of Neuroimaging
Denis Le Bihan (Translated by Teresa Lavender Fagan) PRINCETON UNIVERSITY PRESS *(2014)*
Who better to lead us into the technological wonderland of *in vivo* brain imaging than Denis Le Bihan, pioneer of diffusion magnetic resonance imaging (dMRI)? His densely factual narrative takes us from the seminal work of French surgeon Paul Broca through evolving technologies such as X-rays and MRI. Now the story is being carried forward by Le Bihan's brainchild NeuroSpin, a French Atomic Energy Commission institute for ultra-high-field brain imaging. In 2015 it will gain an 11.7-tesla magnet and begin the search for a 'neural code'.



Ocean Worlds: The Story of Seas on Earth and Other Planets
Jan Zalasiewicz and Mark Williams OXFORD UNIVERSITY PRESS *(2014)*
For this exhilarating foray into our increasingly water-rich Universe, geologist Jan Zalasiewicz and palaeontologist Mark Williams navigate oceans earthly and elsewhere. They explore our ocean systems' formation in deep time, eons of service as life's nursery, current state of crisis and evaporation a billion years hence, under a Sun that will be 10% hotter. They then boldly go to seas actual and putative in the Solar System and beyond, such as the methane-rich Kraken Mare on Saturn's moon Titan, or oceans on exoplanet 55 Cancri e, which may host expanses of that ambiguity, pressurized 'supercritical' water.



The Best American Infographics 2014
Edited by Gareth Cook MARINER *(2014)*
The second in the US infographics series edited by Pulitzer-prizewinning journalist Gareth Cook, this is as brilliant as its predecessor. Try the 'Taste Tube Map': James Wannerton's "synaesthetic tour" ascribing mouthfeel to the name of every London Underground station: Bethnal Green is "Boiled Cabbage"; Mile End, "Fingernails". *National Geographic*'s 'In Harm's Way' is a gorgeous rendering of how tornadic thunderstorms form. And *Nature*'s own 'In the Flesh' beautifully realizes research suggesting that *Tyrannosaurus rex* may have sported fetching plumage.

Amnesia
Peter Carey FABER & FABER *(2014)*
This tale of cyber-hackery set against recent upheavals in Australian government is audacious and deliriously strange. Self-described "shit-stirrer" Felix Moore, a journalist in meltdown, is commissioned to write an exclusive on Melbourne radical Gaby Baillieux. Through Moore's eyes and taped conversations, Gaby's relationship with proto-geek Frederic Matovic emerges as a fury-fuelled mission to right corporate wrongs. The two, with thousands of others, are eventually, paradoxically, liberated by malware. Peter Carey's novel jolts us out of a collective amnesia about political trouble Down Under.

The Book of Beetles: A Life-Size Guide to Six Hundred of Nature's Gems
Patrice Bouchard IVY *(2014)*
A beetle with "dense, decumbent golden pubescence" inhabiting an air bubble in submerged wood: what's not to love? Imaged in glorious, furry close-up, *Lutrochus germari* is just one of the 600 species (out of a total of 400,000) featured in this paean to the insects that entranced evolutionary-theory pioneer Alfred Russel Wallace. Curator Patrice Bouchard has picked a bevy of beauties, from the tubercle-covered *Gagatophorus draco* to the stunning Atlas beetle (*Chalcosoma atlas*) — three-horned, lustrous and the size of a human hand. Barbara Kiser