

more interesting because he is less obvious. What concerns Kandel is how this artist conveys, and the audience reads, emotion in the human face. Kandel explores what the observer brings to the feast — the “beholder’s share” achieved through top-down processing that depends on memory and experience — and how innate processes in the brain filter incoming information from the “bottom up”. He suggests how artists may unconsciously exploit these brain functions, for example by using colour to convey emotions in portraiture.

Throughout, Kandel combines a professional knowledge of brain scans with a firm grasp of the ideas of another Viennese exile, the art historian Ernst Gombrich, whose seminal 1960 work *Art and Illusion* examined the mechanics of the artistic response. One might say that Kandel has taken up Gombrich’s torch, moving from the psychology of perception to the actual mechanics of it.

Kandel understands, and explains, how the observer brings a lifetime of experience to the simple act of looking at a painting; how “mirror neurons” elicit empathy in the brain; how “we are not only inspired and seduced by art, but also mystified, startled, frightened, and even repulsed by it”. And he knows where, in the brain’s 1.5 kilograms of fat and water, all these responses are located. It is quite a ride, and a beautifully scenic one with extensive, excellent and apposite illustrations.

Some of his arguments might be seen as contentious. Can our ideal of beauty really be hard-wired so that it has “varied surprisingly little from century to century or one culture to another”? (Has Kandel compared a seventeenth-century Rubens nude with 1960s Twiggy?) And is there really an adaptive advantage in our appreciation of art, or is it nothing more than a quirky by-product of a complex, self-conscious mind? But by and large, you go along with Kandel, because he simply knows so much.

Yet he would be the first to agree that this area of neuroscience is in its infancy. Marrying the sciences and humanities is a worthwhile undertaking, but Kandel admits what any serious observer of art will feel — that even when you have explained every neuron, every synapse, every glimmer in the amygdala or flicker in the prefrontal cortex, you still won’t have explained what it is actually like to stand in front of a Klimt or Kokoschka and feel the thrill. That is to do with consciousness, or what Kandel calls introspective experience: “a phenomenon not readily accessible to objective scientific enquiry”. I suspect that, even with the best neurobiology in the world, we will never be able to understand that. ■

Simon Mawer is a writer based in Rome. His latest book is *The Girl Who Fell From The Sky* (Trapeze in the United States). e-mail: simonmawer@tiscali.it

OCEANOGRAPHY

Ultra marine

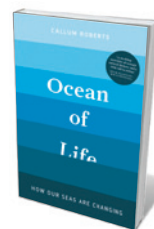
Stephen R. Palumbi finds both stark warnings and buoyant optimism in an encyclopaedic take on the state of the oceans.

The floating head of Prince Charles, 5 metres tall, chided us about global overfishing. On a February morning in Singapore, at the World Oceans Summit, Charles’s video highlighted a sobering fact: in the past decade, marine scientists have uncovered a growing list of serious problems that face the world’s oceans. In *Ocean of Life*, Callum Roberts charts these troubled waters.

Roberts, a marine conservation biologist, dives beneath the often deceptively calm surface of our planet’s great oceans to discover the agents of change, where they come from and the nature of their impact — as well as a range of pragmatic solutions. It is a story told with both scientific accuracy and narrative skill.

Roberts pulls no punches. In chapter after chapter of this encyclopaedic treatment, he summarizes the current scientific knowledge about crucial troubles facing the seas, almost all driven by humans. Pollution, acidification, shifting species ranges, the ‘decapitation’ of the marine food chain through over-exploitation of tuna and other predatory fish, invasions of species from other oceans, sedimentation, habitat destruction and more are laid out.

Overfishing is a much-documented issue, on which Roberts has focused his research career. More than one billion people depend on the ocean for food — and some can get animal protein only from the tiny fish left after decades of overfishing. The story of their unmet need is written here. Roberts gives us detailed personal tales, too, about the decline and fall of small fisheries such as the Firth of Clyde in Scotland; bigger-picture accounts look at why the British trawling fleet returns five times



Ocean of Life: How Our Seas Are Changing
CALLUM ROBERTS
Allen Lane/Viking:
2012. 400/416 pp.
£25/\$30

fewer fish now than it did 75 years ago. This steady rain of sobering news is neither exaggerated nor minimized, and Roberts’s clear, well-written accounts give us access to vast amounts of scientific information about ocean declines. Even in the realm of ocean conservation, scientists tend to specialize, and I know of no other volume that treats such divergent ocean issues as overfishing, decreasing pH, plastic pollution and biogeographic shifts with this much accuracy and acumen.

As a balance to the bad news, each chapter is edged with fascinating details about the life of the sea, such as how currents move through the deep oceans and what problems are caused by invasive marine species. Roberts’s exuberance about the ocean bubbles to the surface: he delights in the historical context of how people have used the oceans. Even when he is describing the dire

collapse of the tuna catch in the Mediterranean Sea, a historical description of garum (the infamous fermented fish sauce that was crucial to ancient Roman cuisine) creeps in.

Roberts deftly interweaves ocean facts with conversational whimsies, such as the only aphorism that Oscar Wilde got really wrong (“Nothing succeeds like excess”). And he occasionally offers a passage right from the heart; for instance, when he describes a squid’s responses to a human encounter as “written on their skin in quick-fire color changes that pulse and

CRUCIAL TROUBLES FACING THE SEAS ARE ALMOST ALL DRIVEN BY HUMANS.

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ripple in incandescent waves”.

Roberts's personal anecdotes bring the struggle of one scientist, in service of the sea, into sharp focus. I can just imagine his cheery face as he dressed down the head of the Marine Stewardship Council for sanctioning fisheries with questionable sustainability. I would like to have been there.

About two-thirds of the way through, with the statement “I am an optimist”, Roberts starts to introduce solutions to his litany of seemingly intractable problems. In the subsequent chapters, he discusses aquaculture, pollution abatement and his signature research achievement: marine protected areas. These are all fields in which tremendous strides have been made, some by Roberts himself, to help the future oceans and the human communities that rely on them.

Yet Roberts cannot help pointing out that the problems are still huge. This is partly because some of the easiest apparent fixes — such as aquaculture — can do more harm than good in practice. But it may also be partly down to Roberts's need to keep the parlous state of the ocean in the public and governmental eye. Environmental problems can become so polarized in society that any excuse to downplay or deny them is trumpeted by special-interest groups — a reaction that surfaces with greater and greater frequency.

Back at the World Oceans Summit, Steve McCormick, president of the philanthropic Gordon and Betty Moore Foundation, declared that there has never been a time in ocean conservation like now, when the solutions to ocean problems are laid before us and some of the challenges, particularly overfishing, are conquerable. *Ocean of Life*, in detailing sobering facts about the ills that afflict the largest biosphere on Earth, is a call to action. At the heart of this book is a deep love of the ocean and a profound concern for its viability as a resource for us all. ■

Stephen R. Palumbi is a marine biologist at Stanford University in Pacific Grove, California. His most recent book, with Carolyn Sotka, is *The Death and Life of Monterey Bay*.
e-mail: spalumbi@stanford.edu



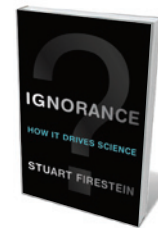
PHILOSOPHY

What we don't know

Michael Shermer enjoys a reminder that cutting-edge research is a step into the unknown.

At a press conference in 2002, Donald Rumsfeld, then US secretary of defence, used epistemology to explain US foreign entanglements and their unintended consequences. “There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say, we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know,” he said.

It is this last category that is the focus of Stuart Firestein's sparkling and innovative look at ignorance, and how it drives the scientific process. Firestein is a neurobiologist at Columbia University in New York, where he teaches a wildly popular course on ignorance, inviting scientists to tell students not what they know, but what they don't. He muses, would you rather earn an A or an F in a class called Ignorance?



Ignorance: How it Drives Science
STUART FIRESTEIN
Oxford University Press: 2012. 256 pp.
£14.99, \$21.95

Firestein introduces the concept of ignorance by contrasting the public's perception of science — as a systematic process — with a scientists' understanding that it is more haphazard. Most people think of science as a stepwise algorithm, in which researchers grind through experiments that churn out data sets that are analysed statistically and published in peer-reviewed journals: part of an endless cycle of observation, hypothesis testing and adjustment.

In reality, as mathematician Andrew

MARTIN O'NEILL

NEW IN
PAPERBACK

Highlights of this
season's releases



Changing Planet, Changing Health: How the Climate Crisis Threatens Our Health and What We Can Do About It

Paul R. Epstein and Dan Ferber (University of California Press, 2012; \$24.95)

Public-health expert Paul Epstein and science journalist Dan Ferber confront an under-recognized and crucial issue: the effects of climate change on health. Too great a focus on immediate concerns, such as cost, is threatening the planet's basic life-support systems, they argue. Reviewer Tony McMichael called it “an excellent corrective for climate-change myopia” (*Nature* **472**, 292–293; 2011).