

were infused with the optimism of the US space programme, responded to talk of scarcity with a visceral aversion. These teens and twenty-somethings latched on to O'Neill's visions of suburbs in space piping abundant solar power and lunar regolith back to Earth. O'Neill himself was ambivalent about their support, and when his star faded they moved on to form or follow other high-tech enthusiast movements, each of which took *The Limits to Growth* as its foil.

McCray's book is especially convincing in following the various movements that arose in reaction to the Club of Rome's 1972 book. At present, we face genuinely alarming limits to growth. Our ability to comprehend and act on such constraints — particularly with respect to climate change and alternative energy — is still distorted by the infelicities in the first edition of *The Limits to Growth* and the ferocious reaction to its conclusions. Some visioning ideas for overcoming limits to economic growth have contributed to inaction on climate change by promising an appealing but impossibly easy, sacrifice-free, small-government path to a limitless future. These have distracted attention from politically difficult, less technology-intensive solutions.

McCray's argument that visioners play an important part in the "technological ecosystem" is also compelling, but asymmetrically deployed. For one thing, as the book's subtitle implies, only those who propose a limitless future get to be visioners; technical experts who popularize visions of a future that is constrained by scarcity (Forrester or the biologist Barry Commoner, for example) apparently do not count. McCray also sometimes treats his visioners less critically than their foils. He describes *The Limits to Growth* as "refuted" by experts, but treats equally damning arguments against the visions of O'Neill and Drexler in a 'he-said-she-said' fashion. For instance, Nobel Laureate Richard Smalley's contention that Drexler's molecular gears and conveyor belts obey an impossible chemistry is dismissed as "Drexler and Smalley largely talk[ing] past one another".

Yet McCray is correct that visioners influence, and are influenced by, an ecosystem of philanthropists, politicians, funding agencies, entrepreneurs, undergraduates, scientists and others. That group spurs technological innovation, crafts science policy, and shapes and shares widely held visions of the future. ■

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ASTROBIOLOGY

The cosmological you

Birger Schmitz weighs up an exploration of how the Universe permeates us.

Neil Shubin's masterpiece *Your Inner Fish* changed the way I see myself.

Using evidence of the first fish-amphibians that left the oceans for land 375 million years ago, Shubin described with stunning clarity how every aspect of our anatomy goes back to our distant ancestors.

Now, in his follow-up *The Universe Within*, he takes the discussion a step further: how the Universe formed, our place in the Solar System and the intertwined evolution of our planet and life. He shows that all this is built into us as physical beings.

Inside us, for instance, are atoms that formed in exploding stars. The movements of heavenly bodies are inherent in our perception of time and in biological clocks. Physical parameters such as gravity determined our shapes and sizes. Had Jupiter formed closer to the Sun, we would have turned out short and squat; farther out and we would have been slender and elongated. This is because Jupiter formed before the inner rocky planets, and its position relative to the Sun determined Earth's size and gravity.

Shubin starts with the formation of the Universe 13.7 billion years ago, segueing into that of the Solar System 4.6 billion years ago. Much later, about 200 million years ago, when the supercontinent Pangaea broke up, the continents and ocean basins we know today began to form. This was accompanied by the rapid evolution of more complex life forms — dinosaurs, mammals and birds.

Shubin suggests a rather original connection between continental break-up and the evolution of such creatures: mud settling on the vast stretches of coastline created by the break-up of Pangaea buried biological material that would otherwise have decayed in water, using up oxygen. The result, Shubin says, was an increase in atmospheric oxygen, one of the key factors that allowed animals to conquer land. Mammals require a lot of oxygen to maintain their high-energy, warm-blooded lifestyle. Life on the low-oxygen Earth of 200 million years ago would have been like that today at 4,500 metres above sea level.

Much of the second half of *The Universe Within* summarizes the history of how our geological view of Earth developed. It incorporates stories such as how the discovery of

The Universe Within: Discovering the Common History of Rocks, Planets, and People
NEIL SHUBIN
Pantheon: 2013.
240 pp. \$25.95, £20

similar fossil organisms on distant continents led Alfred Wegener and others towards the idea of continental drift. We also meet William Smith, who invented stratigraphy, Louis Agassiz, who discovered ice ages, and geologist Bruce Heezen and oceanographic cartographer Marie Tharp, who were central to developing the theory of plate tectonics.

Shubin is at his best when he deals with anatomy and biology, as in his discussion of the inventive geologist Michel Siffre. In 1962, Siffre spent two months living in a subterranean cave to gauge whether he could track time without any tools with which to measure it. After two months, he was convinced that only 37 days had passed. This was in line with what we know about the role in 'internal clocks' of the pineal gland, which regulates the production of sleep-inducing melatonin depending on the available light. Shubin's storytelling in such passages is gripping.

The Universe Within is a charming and enjoyable read, but it does not reach the heights of *Your Inner Fish*. There is a familiar feel to some of the sections, and the book's title raises expectations that are not really met. Where are the mysteries of the brain, the laws of thought and our consciousness? These, to me, are the most amazing aspects of the 'universe within'. In my view, the popular astronomy writer Timothy Ferris has touched on these aspects of the relationship between the soul and the Universe in a more thought-provoking way in books such as *The Mind's Sky* and *The Whole Shebang*.

And what if our view of the Universe continues to change as much as it did in the past century? From Shubin, one gets the impression that much is now solved. But the mystery of why we are here is perhaps greater than ever. Maybe, as the physicist Max Planck put it: "Science cannot solve the ultimate mystery of nature. And that is because, in the last analysis, we ourselves are part of nature and therefore part of the mystery that we are trying to solve." ■

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