The author tasted the flavour of the world's attitude towards the Germans when he was a child growing up in England. He states that an aphorism that echoed through his boyhood and youth was: "The only good German is a dead German." Others saw something "congenitally malevolent about German people". Some of this anti-German attitude has remained in his psyche and surfaces from time to time in the book, even though he engages the newer interpretations. According to Cornwell, no scientist who worked in Nazi Germany is exempt from blame; even an academic scientist working on the purest research is guilty by association. Cornwell, however, wants all scientists to have a conscience, not just those who worked during the Nazi period.

Cornwell extends his period to reflect on the terrorist attacks of 11 September 2001 and technology, and adds material that seems over-detailed and tangential. But like other recent books on science under the Nazis, the real story begins a century earlier. The first quarter of the book describes Germany in the early twentieth century as a scientific mecca, with scientists such as Haber developing poison gas for the fatherland. The science of eugenics, later so important to the Nazis, was also born in this era. Others have written about how science "survived the swastika", but Cornwell emphasizes the strain of the Weimar period, when Germany was under the yoke of the Versailles Treaty and suffered because of the resulting economic problems. Science flourished there nevertheless.

The more sensational topics, such as medical experiments and slave labour, receive the most attention. There is one chapter on sciences that flourished under the Nazis, which includes a summary of Robert Proctor's book *The Nazi War on Cancer* (Princeton University Press, 1999). But Cornwell ignores the literature that demonstrates that basic biological research also survived and thrived; he thinks it just stagnated. He also fails to mention the anomaly that three Nobel prizes were awarded to scientists of the Kaiser Wilhelm Society in the 1930s and 1940s for work they did during the Nazi period: Richard Kuhn in 1938 for his work on carotenoids and vitamins; Adolf Butenandt in 1939 for his work on sex hormones; and Otto Hahn in 1944 for his 1938 discovery of nuclear fission. He does, however, add some original research and comments to the controversy surrounding Werner Heisenberg's visit to Niels Bohr in Copenhagen.

Even if *Hitler's Scientists* is not based on original research and not all scientists belonged to Hitler, it is a useful compilation for readers who would like just one volume on science under the Nazis.

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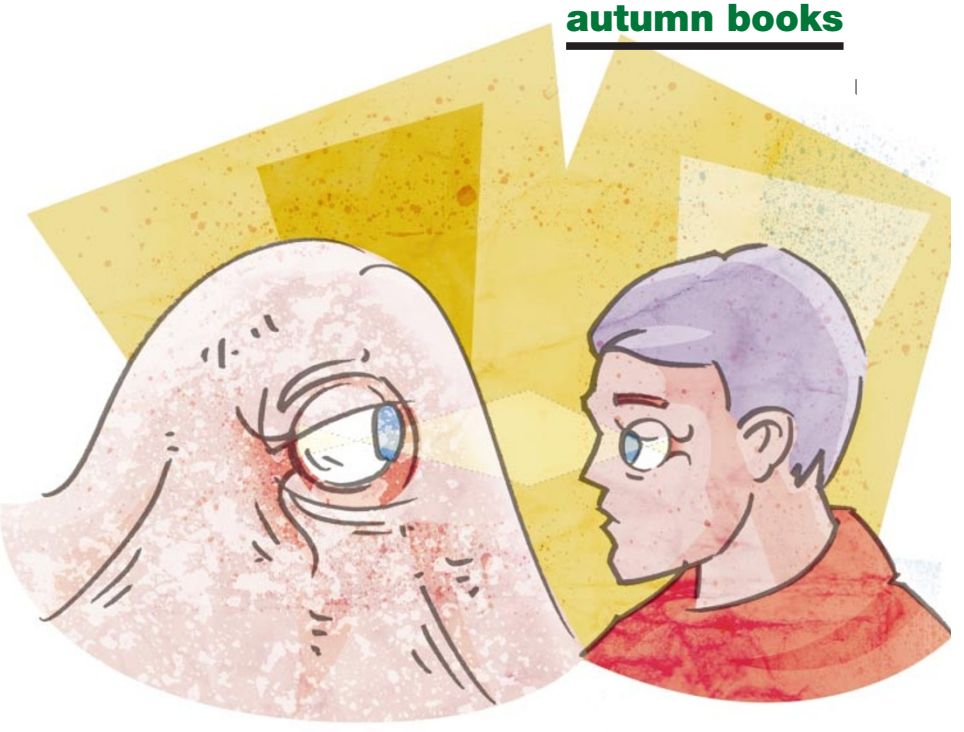

The eyes have it

Life's Solution: Inevitable Humans in a Lonely Universe
by Simon Conway Morris
Cambridge University Press: 2003. 464 pp. £18.95, $30

Richard E. Lenski

The late Stephen Jay Gould argued that evolution is unpredictable. His thought-experiment of replaying life's tape, in *Wonderful Life* (W. W. Norton, 1989), led him to assert: "Alter any early event, ever so slightly and without apparent importance at the time, and evolution cascades into a radically different channel." The aim of *Life's Solution* is to overthrow that historically contingent view of life. What is at stake, according to its author Simon Conway Morris, is more than the statistical mechanics of evolution: at stake is how we understand our place in the Universe.

Life's Solution builds a forceful case for the predictability of evolutionary outcomes, not in terms of genetic details but rather their broad phenotypic manifestations. The case rests on a remarkable compilation of examples of convergent evolution, in which two or more lineages have independently evolved similar structures and functions. The examples range from the aerodynamics of hovering moths and hummingbirds to the use of silk by spiders and some insects to capture prey.

Convergence is widespread, despite the infinitude of genetic possibilities, because "the evolutionary routes are many, but the destinations are limited", as Conway Morris puts it. Certain destinations are precluded by "the howling wildernesses of the maladaptive", where the vast majority of genotypes are non-viable and prevent further exploration by natural selection. Conway Morris is spectacularly successful at tracking down and organizing examples of convergent evolution, but he admits that work to place convergences "into any sort of quantitative framework is still in its infancy". In effect, he emphasizes the numerator (convergence) while skirting the denominator (all examples of evolution, both convergent and divergent).

Conway Morris is not content, however, to catalogue examples of convergent evolution. He wants to convince us that convergence implies the inevitability that some sentient human-like being will evolve on any life-bearing planet like Earth. Thus, he focuses his compilation on the attributes we associate with ourselves and the lineage that produced us. Fruiting bodies of slime moulds and myxobacteria show that multicellularity has evolved repeatedly. Warm-bloodedness evolved several times, as did live birth and even penile tumescence. Sensory organs exhibit numerous cases of convergence: the eyes have it, as seen in the camera-like eyes of vertebrates and octopuses, and the similar eyes of certain worms and jellyfish. So, too, mechanisms used by diverse organisms to smell, hear, echolocate, sense electrical fields and maintain balance are often convergent.

Complex social systems have evolved repeatedly, exemplified by termites, ants and mole-rats. Fungus-farming ants and tool use by crows remind us that even agriculture and invention have evolved elsewhere. Just as the availability of light to guide organisms has led repeatedly to the evolution of eyes,

the acquisition of complex information about an organism's environment implies selection to better store and use the information. The evolution of extra-large brains and corresponding intelligence in dolphins and primates illustrates that convergence. Conway Morris stops short of saying that another species has yet evolved the sophisticated language of humans, but suggests that "waiting in the wings of the theatre of consciousness are other minds stirring, poised on the threshold of articulation". These are provocative words and, whether or not one agrees with his conclusions, the examples are fascinating and indicate a prodigious knowledge of the scattered literature on convergent evolution.

Given this rampant convergence here on Earth, Conway Morris believes that "extraterrestrials with nervous systems will hear, see, and smell in very much the same way as we do, and if that is so will also possibly have similar mental processes". So where are these ETs? Alas, he doubts that they exist. Conway Morris and Gould both think that we humans might be alone, but for different reasons. For Gould, "the awesome improbability of human evolution" derives from contingency in adaptive evolution. Conway Morris argues that if our planet were even slightly different from the way it actually is, then life might not have emerged. His argument is based on the difficulties of getting life started, on the failure of scientists to synthesize life from scratch, and on some unusual features of Earth and our Solar System. He even suggests that intelligence might never have evolved here had not a cataclysmic impact jettisoned the Moon into its orbit. This sounds rather like Gould's historical contingency, except that Conway Morris emphasizes physical events creating opportunities for life to emerge and adapt, whereas Gould emphasized the idiosyncratic nature of adaptation itself.

The tension between inevitability and loneliness leads Conway Morris towards a higher objective, which is to re-establish "notions of awe and wonder" in evolution and thus "allow a conversation with religious sensibilities". He dismisses Fred Hoyle's "strange ideas about the origins of biological complexity" but admits a grudging respect for Hoyle's remark that the Universe is a "set-up job". Conway Morris's metaphysical vision occasionally becomes overwrought, as when he says: "Not only is the Universe strangely fit to purpose, but so, too, as I have argued throughout this book, is life's ability to navigate its solutions." Whatever Conway Morris may think about the Universe and its predispositions, *Life's Solution* invokes the standard darwinian explanation of adaptation by natural selection for life's ability to navigate.

I recommend this book to anyone grappling with the meaning of evolution and our place in the Universe, and to biologists interested in adaptation and constraints. I am obliged, however, to caution readers about the deprecating way in which Conway Morris sometimes refers to evolutionists whose views he opposes. He is especially dismissive of Gould, who died a year ago: readers interested in their conflict can read an exchange elsewhere (*Natural History* **107,** 48–55; 1998). Conway Morris's antagonism to Gould becomes more puzzling when one reads — in a chapter titled "Towards a theology of evolution?" — of his disdain for "ultra-Darwinists" and "genetic fundamentalism", as these were also frequent targets of Gould's pen. But while Gould argued for the separation of science and religion, Conway Morris is searching for common ground.

Conway Morris derides the "almost gleeful abasement of humans" by ultra-Darwinists, and claims that Darwin himself "retreated into a gloomy agnosticism". But the closing passage of *The Origin of Species* is far from gloomy: "There is grandeur in this view of life, with its several powers having been originally breathed into a few forms or into one; and that … from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved." In the second edition Darwin inserted three words (italicized here): "… breathed *by the Creator*". In *Life's Solution*, Conway Morris has perhaps explained why, in his view of life, the second edition might be preferable to the first. ■

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Listen, learn and construct

Constructing a Language: A Usage-Based Theory of Language Acquisition
by Michael Tomasello
Harvard University Press: 2003. 388 pp. $45, £29.95

Eve V. Clark

In 1965, Noam Chomsky posited that linguistic theory should be able to account for how children acquire a first language. In so doing, he triggered debates that have lasted ever since. What is innate? What and how much language do children hear? Are children's errors corrected? Do children use two different mechanisms for learning grammar: one for regularities in syntax and morphology that can be described with rules, another for irregular forms?

But few linguists have spent much time looking at language acquisition itself, preferring to debate the logic of the enterprise within linguistic theory. They have tended to ignore findings from studies of acquisition that are inconsistent with their favourite theories. In short, they have not recognized that describing a language is not the same as describing the process by which people acquire it.

By contrast, in the past few decades, psycholinguists have documented many of the facts of acquisition. They have examined what speech children hear, studied the processes for learning complex systems, and identified factors that influence development. But they have also generally ignored changes in syntactic theories — descriptions of the rules that govern language — and the associated issue of just what is innate about language in humans.

Tomasello has added a new perspective to these debates from the psycholinguistic side, based on his work with primates as well as children. He has brought together a number of the topics that psycholinguists have worked on: language studied as a system for communication, the relationships between language, memory and attention, how inferences about meaning are made in context, choices of conceptual perspective — the decision to call a dog a "dog" rather than an "animal" — how common ground is built up in communication, and how a speaker's intentions are interpreted. He emphasizes that language is essentially social and that it relies not only on vocabulary and linguistic constructions, but also on non-linguistic elements such as gesture and gaze.

He starts from the premise that children acquire language by attending closely to the language they hear. To do that, they must analyse speakers' intentions and find any patterns in the language that speakers use. Tomasello argues that children acquire constructions in the same way as they do words: they have to learn both, and just as they slowly build up their vocabulary, they also slowly build up a repertoire of constructions. Words, in fact, are stepping-stones to constructions. For instance, children first use a verb like "want" only with "that" ("want that"), then with a following verb ("wanna go"), and only later still with a direct object and following verb ("want him [to] go out"). They build up larger constructions by combining smaller ones. Because Tomasello looks at speaker intentions as well as patterns of use, he integrates the cognitive and the social in language development from the start.

Researchers have always assumed that children acquire vocabulary by learning, but many have argued that learning alone can't explain children's acquisition of the regularities of language that can be described in rules for syntax and morphology. Acquisition of these, propose Steven Pinker and others, depends on innate language-specific