

chology has long stressed these facts, and Jean Piaget's epigenetic approach posited a developmental interplay between the active organism and its environment. These ideas are now being reinforced by research on enactive cognition (in animals and machines), by cognitive and developmental neuroscience, and by situated and evolutionary robotics.

In primate vision, for example, saccadic eye movements direct the high-resolution fovea to the points of interest within the scene; movements of the head and body provide information about relative depths; perception provides affordances for adaptive action (so a space may be seen as a pathway); and specific cerebral mechanisms are devoted to distinct types of visual information. The apparent unity and all-inclusiveness of our visual phenomenology is an illusion.

For instance, you probably believe that you are experiencing the whole of this written text simultaneously. But experiments show that you would believe this even if the page consisted of nonsense-words, provided that a fixed-length 'window' of sensible (and continuously changing) text was moving along the page in precise coordination with your eyes. By implication, there is no reason to believe in a stable, 'whole-page' visual representation in the brain, or memory, underlying the visual phenomenology.

This is just one of the book's many provocative challenges to Cartesianism, and to classical (and most connectionist) cognitive science. As a philosopher, Clark is alert to the fundamental assumptions that underlie scientific research. He gives convincing arguments, backed up by neuroscientific and psychological examples, against the extreme (but increasingly fashionable) view that cognitive science has no need to posit internal representations, and that the vocabulary of dynamical systems can explain all our cognitive achievements.

Clark admits that a dynamical approach can be surprisingly helpful (in studies of human decision-making, for instance). But he argues, on philosophical and experimental grounds, that internal representations of some sort must exist. They are, however, intriguingly different from the objective and enduring representations favoured by classical artificial intelligence: most are partial, fleeting and subject centred.

The environment includes artefacts as well as natural objects, but this distinction is less clear than it may seem; for example, pheromone trails and termites' nests are part of the natural history of the creatures who made them. And, as Wittgenstein pointed out, speaking is as much a part of our own form of life as is eating or breathing. Clark regards language and (social and physical) culture as artefacts that function

to restructure the computational tasks we face into a form better suited to the human brain; that is, a basically connectionist, pattern-recognizing system. As such, they are integral to our thinking — and to our minds. In assessing the boundaries of mind, Clark questions the common (Cartesian) assumption that the human individual is theoretically basic. Much as some social psychologists and philosophers deem it impossible to define an individual human being without reference to participation in some social group, so he argues that the mind, or self, is — in a very real sense — extended across the human (social and physical) environment.

Clark's book is an excellent introduction to this new movement in cognitive science. It is clear, wide ranging, well informed, and full of fascinating examples. And, unusually, it manages to be both eminently sensible and highly provocative. □

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In deep water

Deep Atlantic: Life, Death, and Exploration in the Abyss

by Richard Ellis

Knopf, 1996. Pp. 395. \$35/Robert Hale £25

Tony Rice

Even though the deep oceans cover well over half of the Earth's surface, they have been the subject of remarkably few books for either specialist or general readerships. Only a dozen or so half-decent books have appeared in English since Wyville Thomson's *The Depths of the Sea* was first published in 1872, and most of these were written for the cognoscenti. And how many memorable science-fiction books based on the deep ocean can you think of apart from *Twenty Thousand Leagues Under the Sea* and *The Kraken Wakes*? Does this matter? Well yes, I think it does.

The vast amount of rubbish written and spoken during the recent Brent Spar debacle graphically highlighted the need to educate and inform the public and politicians about this largest of all environments on the planet, if only to try to ensure that far-reaching decisions are based on fact and not ignorance. Richard Ellis, a respected American marine artist but not a professional oceanographer, has tried to fill this gap. Although the book deals specifically with the deep Atlantic Ocean, much of it is relevant to other oceans or draws on knowledge of them.

The first part, about exploration, reviews the history of Atlantic marine science and includes sections on the Gulf Stream, and

informative accounts of the discovery and significance of seafloor spreading and hydrothermal vents. The second part, roughly two-thirds of the book, is devoted to deep-sea biology. But of some 200 pages in this section, no fewer than 150 deal with just the cephalopods, fishes and whales.

The book is generally well written, with a wealth of anecdotal detail and nice touches, such as a layman's guide to zoological nomenclature and graphic 'translations' of the unwieldy scientific Latin names that are often the only ones the unfamiliar deep-sea creatures have. As one would expect from Ellis, it is profusely illustrated by his own often beautiful drawings, particularly of the fishes, though sadly only in black and white.

Unfortunately, however, some aspects of the book detract seriously from its overall value. First, it contains an alarming number of factual errors, ranging from a picture of a *Challenger* beam trawl labelled as a plankton net to some classic taxonomic howlers. Although not particularly important, they suggest a certain lack of care. A quick read by one of the many scientists whom Ellis clearly consulted should have removed most of them.

But a much more serious shortcoming is the curious imbalance in the treatment of the major subject areas. A reader might come away with a good knowledge of the amazing morphological range of Atlantic deep-sea fishes and their almost unbelievable feeding and reproductive arrangements, yet have no idea of how the ocean actually works.

There is, for instance, almost no reference to the myriad of tiny animals inhabiting the deep sea floor, which are much more important in the overall economy of the abyss than the squids, fishes and whales put together. Nor is there any attempt to discuss the apparent enormous species diversity among these little beasts, or the relatively recently discovered small-scale variability of the deep sea that may well explain it.

I also admit to being somewhat miffed that the knowledge we have had for 15 years of the coupling between events in the surface layers and large areas of the deep sea floor, through the previously unsuspected rapid deposition of aggregated phytodetritus, is ignored. Because my research team was deeply involved in this discovery I am perhaps a little oversensitive, but by any standards it was an important discovery — and it was made in the Atlantic! It should certainly be writ large in any up-to-date book on the deep ocean.

In summary, the world needs a good, general, wide-ranging book about the deep oceans for the interested layman. This isn't it. □

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