nett argues, "is how a Joycean . . . serial phenomenon can come to exist . . . in the parallel hubbub of the brain." He maintains that philosophical fallacies frequently arise from viewing phenomena at the serial level, and that these phenomena would be more appropriately viewed from the perspectives of the parallel one. Take his dissolving of the well-known paradoxes described by the neurophysiologist Benjamin Libet. Libet attached scalp electrodes to his subjects to measure their brain activity, and then asked them to note exactly when in time they made a spontaneous decision to flex, say, their wrist. In each case, Libet found that the start of an electrical response known as the *Bereitschafts* potential occurred 250–400 milliseconds before the subject was conscious of making the decision. Such experiments led Libet to postulate a mysterious, almost dualist, gap between the real physical events in the brain and their conscious correlates. Giving many original illustrations, Dennett argues that Libet is in the wrong conceptual domain; at this time-scale and grain of analysis there is no Great Divide between before and after coming into awareness. The analogy that Dennett draws is with the dissemination of an article in today's electronic-mail age; the article can be available in numerous versions between an early draft and its appearance in a journal. There is no instantaneous appearance fully formed in the public arena.

Dennett gives impressive treatment to philosophical puzzles such as John Searle's Chinese Room and the concept of self. But when he moves to the processing level, he denies that consciousness relates to anything special about the cognitive systems of humans or higher animals if these systems are considered as machines. He believes that many partially separable processing systems exist, which fits the standard neuropsychological position, but that none has any central role that would fit it for the seat of consciousness. His argument, however, floats above the level of the many particular theories that have been put forward. No account at all is taken of theories that relate consciousness to the operation of a set of processing systems.

Instead, Dennett describes human consciousness as "a huge complex of . . . meme-effects (in the Dawkins sense) . . . that can be best understood as the operation of a 'Von Neumannesque' virtual machine *implemented* in the parallel architecture of a brain *that was not designed for any such activities*" (my italics). Here "virtual machine" is used in the computer-science sense — an environment for programs running within a computer that makes it seem to each of them that it has an appropriate

machine. An example would be a LISP virtual machine being implemented in the C programming language, with the machine it runs on being conceptually irrelevant. The hardware–software analogy is pushed to its extreme: "human consciousness is too recent an innovation to be hard-wired into the innate machinery . . . and its successful installation is determined by myriad microsettings in the plasticity of the brain . . . Besides the idea of the *user illusion* of a virtual machine is tantalisingly suggestive."

Unfortunately, we are given no real help in understanding how the virtual machine might come to run on this parallel hardware. Dennett discusses complex artificial-intelligence problem-solving programs that learn, such as the SOAR program of the Carnegie Mellon University group, and that have partly parallel architectures. But the serial-processing aspects of SOAR are a direct consequence of its design specification, not a product of its learning environment. More critically, he takes no account of the way in which several cognitive processes have a group of properties. They operate on or produce only a limited set of items at a time, but these can have many different types of content. They have a neurobiological basis. They seem to require awareness or to be intimately linked to it. They include attention, memory retrieval, error correction, intention formation and execution and the end-points or beginnings of language comprehension and production. Dennett would appear to maintain that the link between such processes and

'awareness' is merely a complex manifestation of our culture, but to a neuropsychologist this seems implausible.

He discusses in detail a few critical phenomena such as 'blindsight', where the rare patient with a lesion of the occipital lobe cannot consciously perceive stimuli in part of the visual field but can respond appropriately, for instance by pointing at the stimuli when 'guessing'. The visual information to which blindsight patients have access is held to be so "paltry" that they cannot base intentional actions on it. To deny being able to see is the only reasonable account they can give. Maybe, he speculates, they could be trained to use actively the information that they have. Then, maybe, they would say that they see. It seems though more likely to be the nature of the information and its structural base, in particular the use of extra-striate pathways in the brain, not the amount of information, that leads to their saying that they do not see. They can, after all, make an acuity judgement much better than a nearly blind person.

We are left then with an attractive tour through the science and philosophy of consciousness, a splendid dissolving of the supposed problems that functionalist accounts of consciousness are held to have. Yet to dissolve away consciousness itself as a biological phenomenon in the process is too easy a solution. □

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FOLLOWING in giant footsteps — Thousands of dinosaur tracks have been found in recent years. Once thought of as rare and interesting curiosities, the tracks are now recognized as important scientific data that can tell us much about the day-to-day activity of many extinct species. Dinosaur tracker Roland T. Bird spent the 1930s and 1940s working as a field collector for the American Museum of Natural History. He is pictured here at the Paluxy River site, Texas, now Dinosaur State Park, where he discovered some of the first tracks of brontosaurs in 1938. The picture is reproduced from *Tracking Dinosaurs: A New Look at an Ancient World* by Martin Lockley, a nontechnical, well-illustrated guide covering dinosaur locomotion, behaviour, ecology and environmental impact. Published by Cambridge University Press, price £27.50, $39.50 (hbk), £9.50, $14.95 (pbk).