immunology was becoming too complicated and technical. His dismissal of the reductionist approach to the discipline prevented him from appreciating the amazing discoveries made in immunology during the last 15 years of his life.

Is Söderqvist successful in his attempt at existential biography? The answer must be hedged in uncertainty. Did Jerne use the experiences of his inner life, his understanding of himself, to construct the natural-selection theory? It seems far-fetched, but who has the right to be dogmatic about the wellsprings of human creativity? Where Söderqvist has undoubtedly succeeded is in revealing the startling personal journey of one of the twentieth century's great biological thinkers, and in sketching the milieu within which cellular immunology came of age. This serious work of scholarship will be devoured both by immunologists and by a wide general readership. ■

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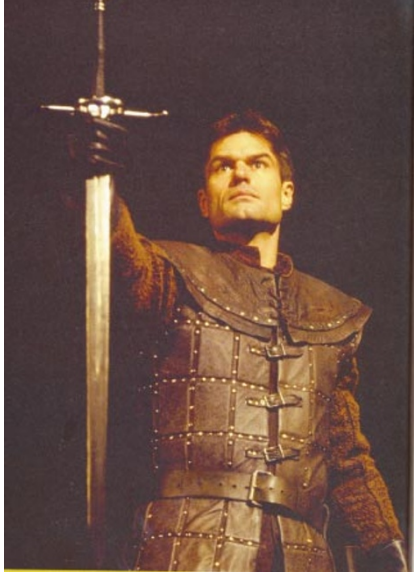
Scanning Shakespeare

The Bard on the Brain: Understanding the Mind Through the Art of Shakespeare and the Science of Brain Imaging
by Paul M. Matthews & Jeffery McQuain
Dana Press: 2003. 192 pp. £24.50
University of Chicago Press: 2003. 192 pp. $35

Kevan A. C. Martin

Every now and then, an editor will come up with what seems to them to be a brilliantly original wheeze. Here, Jane Nevins of the Dana Press persuaded Paul Matthews, a neurologist, and Jeffery McQuain, an English scholar, to use Shakespeare's plays as a vehicle for describing the brain correlates of cognitive function. Perhaps she was prompted by the popular success of the 1998 film *Shakespeare in Love*, in which the audience meets the young Shakespeare, then struggling with writer's block and trying to meet a deadline for his new play, *Romeo and Ethel the Pirate's Daughter*, whose plot is suggested to him by his rival, Christopher Marlowe. More significantly, the film conveys the powerful effect of a live theatre performance on an audience. How does theatre weave its magic spell? In the film, Phillip Henslowe, director of The Rose Theatre, gives his answer: "I don't know. It's a mystery."

The connection between theatre and the brain explored in this book is less mysterious when we learn that the remit of the Dana Alliance for Brain Initiatives is to publicize



"Once more unto the breach": Shakespeare's Henry V used mental imagery to rally his troops.

information about the benefits of brain research. The most visible and successful of the initiatives is Brain Awareness Week, a popular event held annually in many centres worldwide. It provides an invaluable forum for members of the public to meet patient-support organizations and local brain scientists, who usually cover a wide breadth of basic and clinical research.

Square and 'coffee table' in its aspect, there is much that is artful in this book. It is itself a play in seven 'acts'. Each act covers different topics, such as "Minds and Brains", "Our Inner World" and "The Seventh Age of Man", and each contains a number of 'scenes', whose titles range from the straightforwardly banal, "The Wonder of the Human Brain", to the dramatic, "Let Me Clutch Thee", to the boggling, "Putting an English Tongue in a French Brain". Each scene begins with a précis of a plot or subplot from one of the plays, which is followed by an excerpt from a scene and finally a commentary that interweaves topics evoked by the excerpt and its speculative neurological correlate. With 34 such scenes, this unrelenting format does wear a little thin. Writing anything worth reading alongside an excerpt from Shakespeare is a challenge, but here even the shortest sentences can somehow contrive to emphasize the difference, as in "Shakespeare has Juliet ponder what defines a 'Montague'".

The subsequent analyses are largely unrevealing: "Shakespeare was a keen observer of human nature", or "some of his characters talk to themselves in sonnets". Unfortunately, much of the commentary on Shakespeare's text is reminiscent of the cribs one crammed the night before the English literature examination in the hope of impressing the teacher with such pearls as "Shakespeare lived intimately with a rich world of imagination, which he communicated to others through words and stage action".

The book's illustrations are prodigal. The full-page photographs of performances of Shakespeare's plays appear without context or connection to the text. The neurological illustrations are small, 'arty' graphics of the computer-generated variety, a technique that has too easily enabled images of the brain, each postage-stamp-sized, to multiply on obscure and complicated backgrounds. Again, the repetition of style makes these brain images interchangeable. What's actually being illustrated is not only hard to see, but is poorly explained, despite lengthy captions, albeit of variable fidelity. The caption of figure 9, for example, implying that the right and left visual fields map onto the primary visual cortex of the same hemisphere, could be written off as a schoolboy howler, were it not that the accompanying text confirms that the authors really have misinterpreted the experiment illustrated, which shows the distribution of cortical visual areas and not, as they state, the well-known 'ocular dominance columns' of the primary visual cortex, which are beyond the spatial resolution of the scanners used.

The neurological material is restricted mainly to functional imaging of the human brain, principally the "folded surface of the brain (called the cortex) … where neurons are found". Unfortunately, the different imaging methods — for example, positron-emission tomography (PET) and functional magnetic resonance imaging (fMRI) — used in the various studies referred to in the book are not properly explained. There is no doubt that fMRI has revolutionized cognitive neuroscience. The method, however, does not actually detect "the amount of fresh blood flow", but records changes in the levels of the paramagnetic molecule deoxyhaemoglobin. How this blood-oxygen-level-dependent signal (the so-called BOLD signal) correlates with neural activity has been the subject of intense and technically difficult invasive experiments with animals, but such experiments are vital steps in developing a deeper understanding of the basic physiology and anatomy underlying human brain function.

This information would help lay readers to understand why the non-invasive techniques now used in human studies cannot, on their own, "define the brain mechanisms responsible for thoughts, emotions, and disorders that Shakespeare wonderfully described". The reader is left with the impression that imaging techniques all produce multiple images of tiny brains decorated with rainbow-coloured blobs of unknown significance. This is a missed opportunity to explain why different techniques of brain imaging are used in the clinical setting, and how the images are interpreted.

A danger inherent in popular science books is that they try to be popular and so simplify too much. The lesson we learn from the theatre, and from Shakespeare's plays in particular, is that complex ideas and emotions can be effectively communicated to a receptive audience, even if the language is

unfamiliar. The large audiences at Brain Awareness Week indicate overwhelmingly their eagerness to learn about the brain, but if these audiences leave with the impression that scientists have discovered that communication between humans arises from coloured blobs in our left hemispheres, then we have missed the essential humanity of brain sciences. Encouragingly, the dialogue between brain researchers and their lay audiences is growing, thanks in good measure to the Dana Alliance, so, strangely enough, things will probably turn out well. How? I don't know. It's a mystery. ■

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Portrait

Updating Hooke

In an immaculate seventeenth-century interior reminiscent of Jan Vermeer's painted rooms stands Robert Hooke, who died 300 years ago. He is equipped with a set of instruments, including the microscope needed for his *Micrographia*. Isaac Newton, whom some say is responsible for the loss of the only authentic painting of Hooke, lurks outside the window. Glancing out uneasily, Hooke teasingly spins his globe. This ingeniously contrived 'photographic' image (right) is Guy Heyden's winning entry in the competition "Portraying Robert Hooke – Recreating the Hidden Genius". Heyden carries off the £500 prize, awarded by the Royal Institution of Chartered Surveyors and the Royal Society. The brief was to create a "replacement" portrait, not as a recreation of the lost picture but in a twenty-first-century style. Just as Vermeer used the high-tech of his day, a camera obscura, so Heyden has used a computer to create a 'reality' analogous to the optical realism of the paintings known to Hooke. **Martin Kemp**

There and back again

The Development of Animal Form: Ontogeny, Morphology, and Evolution
by Alessandro Minelli
Cambridge University Press: 2003. 342 pp. £55, $75

Axel Meyer

"There and back again", the alternative title of J. R. R. Tolkien's *The Hobbit*, is a fitting way to describe the intellectual journey that every generation of self-respecting biologists has travelled since Ernst Haeckel, Karl Ernst, Ritter von Baer, Georges Cuvier and Johann Wolfgang von Goethe before them. What they and, in cycles of 20 years or so, intellectual giants such as John Tyler Bonner and Stephen Jay Gould have tried to understand is the interwoven relationship between development and evolution. Every new generation of comparative biologists goes 'there' and advances the field further, building on the insights of the previous generation's work by applying new methods and techniques. But much of what had been thought about a generation before is often forgotten and, importantly, new questions are raised as well. So, every generation of biologist goes 'back again' to this big issue.

Selection can only act on things that are developmentally possible. In other words, developmental mechanisms constrain evolutionary possibilities, and they are often very conservative, carrying the "load" of previous evolutionary lineages, as Alessandro Minelli puts it. Sometimes, however, as in the case of the direct and indirect development (without and with free-swimming larvae, respectively) of closely related species of sea urchin, development can also be surprisingly variable. But how do developmental mechanisms themselves change during evolution, and how does evolution in turn affect development? Every generation of biologists during the past 180 years or so has made progress on the quest for a deeper understanding of these questions, through both the conceptualization and the application of the new techniques of their time.

Gould's 1977 historical treatise *Ontogeny and Phylogeny* (Harvard University Press) was probably the most influential contribution to this field in the previous generation. In its current reincarnation the field now has a name, evolutionary developmental biology, or evo-devo, and is influenced by the thinking and research of a new range of scientists, including Minelli.

What new ideas have emerged in the past 10–15 years? In a nutshell, the comparative application of molecular developmental methods that are interpreted in a rigorous (often molecular) phylogenetic framework. Recent comparative developmental and genomic studies have yielded the apparently paradoxical insight that many genes (particularly Hox genes) and their interactions in genetic networks are astonishingly conserved in evolution. These results were unexpected and raised the question of how the diversity of body architecture in different phyla has arisen, given that genetically so much has remained the same during the past several hundred million years. The historically static view of homology proposed in the nineteenth century by Richard Owen, and still widely taught today, has also been revolutionized by these comparative developmental studies and, in my opinion, has been largely abolished. Subsequent phylogeny-based theories of homology are increasingly being questioned because it is unclear whether developmental processes and mechanisms should be part of the definition of homology. Minelli carefully dissects the concepts of absolute and relative or partial homology into its components and discusses them from an evo-devo perspective.

'Renaissance man' is a term often used for a member of the (now all too rare) breed of scientists who have a wide range of intellectual interests — those who are still real scholars. This seems a very appropriate descriptor for Minelli. If you want to make significant advances in the ancient evo-devo field you need to be able to see the big picture and — listen up students — know the old literature. Minelli's daily bread-and-butter research deals with the taxonomy, systematics and comparative morphology of arthropods, particularly the myriapods, which have many segments. But he has long been an important contributor to evo-devo with his conceptual work on segmentation, modules, homology, appendages and body axes, all of which is founded on an impressive knowledge of biodiversity and comparative morphology. This impressively scholarly book summarizes and further develops his work of the past 30 years on basic features of the organization of animals, such as body axes, symmetry, segments, appendages and homology.

Rather than asking small questions, Minelli presents insightful hypotheses and concepts. If you want to look up from your myopic concentration on your single model system and broaden your horizons, you should read this book. It is a 'must read' for any practitioner in the fields of developmental and evolutionary biology — fields that, at long last, are beginning to be unified. ■

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