The Art of Discovery

The Origins of Creativity. Edited by *Karl H. Pfenninger* and *Valerie R. Shubik*. Oxford University Press, Oxford 2001. 268 pp., hardcover £ 20.00.—ISBN 0-19-850715-1

What is creativity, how can it be nurtured, and where does it come from? These questions are puzzling, important, and much discussed, most recently in this symposium-in-print, made up of contributions from one of the editors and a dozen authors as well as an introduction and a summarizing chapter by the editors.

The book is in four sections: 1. "Eureka! Discovery versus creation", with chapters by the molecular biologist Thomas Cech, the glass artist Dale Chihuly, and the philosopher-biologist Gunther Stent; 2. "Body, brain, and mind: emotion and reason", with chapters by the physician David Rogers, the neurobiologist Antonio Damasio, the composer Bruce Adolphe, and the cell biologist Karl Pfenninger; 3. "The adaptive mind: deprivation versus rich stimulation", with chapters by the child psychiatrist Janina Galler, the neuropsychologist Howard Gardner, and the cell biologist George Palade; 4. "Patterns of perception", with chapters by the painter Francoise Gilot, the neurophysiologist Charles Stevens, and the mathematician Benoit Mandelbrot.

Even with such a list of accomplished individuals, whether or not the book achieves its aim of integrating the several threads of insight and experience will depend crucially on the editors' ability to guide the discussion and to highlight the points where ideas from different disciplines intersect and illuminate each other. Pfenninger and Shubik make strong but not always successful efforts to achieve this aim.

For example, I for one would have been fascinated to read a more confrontational treatment of the apparent discord between Gilot (pp. 165 ff.) and Palade (p. 151) regarding realism versus abstraction in painting. The painter feels that "the symbol doesn't have to resemble what it invokes", whereas the biologist thinks that "by giving up realism, modern artists risk exiling themselves in an esoteric world". This issue has been one of the most hotly debated in the philosophy of art for over a century, but we hear no more of that here.

Scattered throughout the book there are cross-references to Mandelbrot's chapter on fractals. The fractal concept describes structures that can be considered to be made up of "self-similar" elements. One example is the imagined construction of a cauliflower from individual florets, each of which itself has a cauliflower structure and can be made by combination of smaller such florets, etc. Mandelbrot illustrates the concept with several arresting images created by artists using the fractal approach, but gives little specific guidance on how the idea applies in other areas of science, art, or cognition.

Nevertheless, several authors express enthusiasm for the fractal concept and for the promise they think it holds for their individual disciplines. For example, Pfenninger's chapter predicts that fractals and chaos theory will be important in developing understanding of higher cognitive functions, and that they will be "used to decipher highly complex sets of interdependent natural phenomena". Just how this would happen is left vague.

One of the illustrations in the chapter on fractals bears the caption "[a] fractal landscape that never was, reminiscent of a full synthesis of a complicated chemical from the elements". To this chemist, no such reminiscence arises, since the essence of a such a "full" (by which I presume the author means "total") synthesis is not the repetitive addition of "self-similar" elements, but precisely the opposite, namely the use of the differences among the substructures combined to build up the final product. A more apt analogy would be the synthesis of a rather simple molecule, a polymer or a dendrimer, for example, by stepwise addition of identical monomeric units.

A few other questionable opinions might be pointed out. Thus, Cech, in a rather tightly focused account of his part in the discovery of catalysis by RNA, points out the importance of serendipity. Thus, he says he "stumbled upon a particular field of science that I had not planned to enter". His success makes him wonder "how many people … might reach much greater achievements if they moved just a little bit from their specific area of interest …". Of course, many scientists do re-invent themselves perforce at least once during their careers, because the intellectual growth of the subject matter inevitably brings them into contact with unfamiliar territory. There are others who persist undeviatingly on their early track. In the absence of some motivating preparatory finding or insight, as for example from a serendipitous "stumble", the latter group is likely to remain there, despite advice to move.

For this reader, the most interesting and instructive chapters are those by the neurobiologists Stevens and Damasio. They give fascinating introductions to the findings of modern neuroscience, which promise to elucidate the actual working of the brain and to locate accurately in it the foci of specific types of cognitive function. Stevens outlines the inadvertently prescient role of the French Academy a century ago in nurturing a debate about the very founda-

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tions of the art of painting. This disagreement put the advocates of the superiority of line, led by Ingres, against those who chose color, led by Delacroix. As Stevens shows, we now know that these are not entirely aesthetic choices but are intimately involved with the mechanisms by which the brain processes visual information received by the retina. These chapters offer the lay reader tantalizing glimpses of discoveries in brain science that may be just over the horizon. One might hope that these developments ultimately may give some insight into higher cognitive function, among the highest of which we put creativity.

After having read the book, I cannot say that I was conscious of the mental fatigue tempered by exhilaration that one feels after a stimulating symposium. Rather, the afterthoughts were more like those following a good dinner party which one has been privileged to be invited to share with a brilliant company. Such occasions are to be valued, but the opinions expressed in the conversation may be offhand and unsupported. Sometimes, they remain unchallenged because the distinguished guests want to avoid disturbing the air of good fellowship. Also, one must expect that some of them may arrive in an unsociable mood and may not be especially interested in the thoughts of their fellow guests. Nevertheless, those who attend owe thanks to the hosts for making the gathering possible and to the assembled savants for an occasional spark of enlightenment.

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Metal Dihydrogen and σ-Bond Complexes. By *Gregory J. Kubas.* Kluwer Academic/Plenum Publishers, New York 2001. 472 pp., hardcover $ 95.00.—ISBN 0-306-46465-9

The study of complexes containing nonclassically bound ligands is a flourishing field of research and several hundreds of examples have now been reported. Broadly speaking, these can be defined as complexes in which electron density from a coordinated X–Y σ bond is delocalized onto an otherwise coordinatively and electronically unsaturated metal center, a view going far beyond the classical Lewis concept of localized two-electron bonds. For this reason it is not surprising that, although first postulated more than 30 years ago, such complexes were not unambiguously established until the early 1980s when Kubas reported convincing evidence for the existence of a molecular dihydrogen complex, and Green and Brookhart clearly defined the class of agostic compounds. Several seminal reviews dealing with selected topics (such as H–H, C–H, and Si–H coordination and activation) within this broad theme have been published since that time. Specifically, those written by Crabtree, Morris, Heinekey, Schubert, Corey, Eisenstein, and Lledos should be mentioned. In particular, in 1993 Crabtree reviewed and generalized in *Angewandte Chemie* the whole field of σ complexation (R. H. Crabtree, *Angew. Chem. Int. Ed. Engl.* **1993**, *32*, 789). However, the limited scope of that review, and the significant recent progress in studying nonclassical complexes (such as recent studies of the dynamic properties of dihydrogen complexes, the discovery of dihydrogen bonding, and the synthesis of borane B–H σ-bond complexes) required a fresher look at this field. It is only now that a comprehensive account covering the whole family of nonclassical complexes, including their synthesis, structures, dynamics, spectral properties, and reactivity, is available from a true expert and the author of the original discovery. There is no doubt that the appearance of such a book is a timely and significant event in the chemical review literature.

As the book's title implies, complexes of molecular hydrogen are the prime focus of Kubas's contribution. This is not only associated with the predominance of dihydrogen complexes in the family of nonclassical compounds, but also reflects the great importance of hydrogen in industrial hydrogenation processes, and the intriguing recognition of how (apparently) easily some naturally occurring systems, such as enzymes, can produce and/or activate H_2.

The book consists of 13 chapters. The first chapter (Introduction) provides the reader with a concise and clear introduction to the area, establishing a convenient genealogical link with classical Werner complexes, π complexes, and also nonclassical main-group element species such as H_3^+ and CH_5^+. An account of the relevance of these topics to the activation of small molecules such as dinitrogen, dioxygen, etc. is also given. The comparatively short Chapter 2 gives a historical overview of the discovery and development of the coordination chemistry of dihydrogen. As is often the case with great milestone discoveries, the initial claim for the existence of an intact dihydrogen molecule in the coordination sphere of a tungsten complex met with considerable skepticism. This chapter not only conveys the excitement of scientific discovery, but also nicely illustrates the difficulties in publishing truly paradigm-shifting ideas and getting them accepted by the scientific community. Indeed, four years passed between the first observation of H_2 coordination and the publication of the communication! At this initial stage in the story of dihydrogen complexes theory and experiment developed in parallel. However, the success and recognition that the area enjoys nowadays would not have been possible without the truly synergistic interaction of both approaches as is currently practised. Modern computational techniques, such as MP2 and DFT calculations, not only allow us to explain and predict the experimental results, but also serve as powerful (and, some would say, often even "superior") tools for identification of nonclassical bonding, particularly when the exact position of hydrogen atoms is under consideration.

Chapters 3–9 form the core of the book and deal with the synthesis, theory, problems of identification, dynamics, and reactivity of coordinated dihydrogen molecules. The complexation of σ bonds to a metal is described in this book by a Dewar–Chatt–Duncanson type model, and the crucial role of back-bonding from the metal and the key role of the ligand *trans* to the H–H (or Si–H, etc.) bond is emphasized throughout. Apart from the simple (if this term can be appropriate at all!) coordination to a metal, dihydrogen σ complexes are relevant to heterolytic hydrogen splitting and σ bond metathesis reactions. These processes are manifestations of an im-

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