Gadolinium and friends

R. J. P. Williams

Biochemistry of the Lanthanides By C. H. Evans. *Plenum: 1990. Pp. 444. $95.40.*

THIS book has a somewhat strange title. If one thinks of a book on the biochemistry of an element, copper for example, then there lies behind this title the presumption that copper has a biological function. The lanthanide ions have no known biological function. It is a further remarkable fact that the group of the periodic table to which the lanthanides belong, IIIA, has only one representative with a biological function, boron, and even its role is not known to be of significance in animals. All the other elements of the group give trivalent cations in solution, M^{3+}, as the lanthanides do, and are either innocuous or considered to be poisonous, for example Al^{3+}. It hardly seems as if a book on lanthanide biochemistry is warranted.

There are two good reasons why this is not so. First, the author shows the way in which experimentalists can use the properties of lanthanides to understand the functions of other elements in biology which have similar properties. The chemistry of elements in the periodic table shows that as well as relationships within groups, there are some diagonal relationships between neighbouring groups. Li^+ has somewhat similar chemistry to Mg^{2+}, Be^{2+} to Al^{3+}, and in biological systems Ba^{2+} blocks K^+ channels. The underlying reason for the diagonal relationship is ionic size. The lanthanides are close in size to Ca^{2+}. Thus we can make use of their properties to undercover features of biological interest, especially of Ca^{2+}. Second, it may be that the introduction of lanthanides into biological systems will lead to useful drugs, much as lithium is used. Lanthanides antagonize some functions of both calcium and magnesium.

Evans leads the way carefully into both fields, devoting much of the first six chapters to the physics and chemistry of lanthanide interactions with biologically interesting molecules and even cells. The essence of their value is that given the choice of about fourteen elements — the whole lanthanide series which is a 'transition' metal series — almost every physical technique can be used in association with their introduction. Lanthanides are then invaluable as probes of molecules, membranes and even cellular states, always as substitutes for Ca^{2+}. Some of the prettiest work illustrated here involves fluorescence and nuclear magnetic resonance studies of proteins. Of course, lanthanides can also be used as heavy atoms in electron-microscope stains or in X-ray diffraction studies.

Probing the properties of a biological site does not just involve spectroscopy or structure. We would like to understand the full power of biological selectivity of binding, so-called molecular recognition. No better opportunity is given to the researcher to understand the power of simple electrostatic recognition factors in aqueous solution than the analysis of binding of lanthanide ions to organic surfaces. In the series from La^{3+} to Lu^{3+} there is a change of ionic radius over a range of about 0.15 angstroms in steady increments of about 0.01 angstroms. If ever there was an opportunity for theorists to have an ideal test for their understanding of electrostatics, then this must be it. As Evans shows, there are plenty of data but very few attempts to explain the results of studies of these inorganic site-specific reagents. An outstanding problem, as always, is hydration of the free and bound states.

The use of lanthanides as drugs is considered in the later part of the book and testings are described at some length. The feeling grows on reading that the problem is a matter of delivery of the lanthanides to the right place, for there is no doubt that there are effects that could be useful not just on enzymes, pumps and channels, but also on bone. The only considerable value of the lanthanides in medicine to date is their use as contrast agents in nuclear magnetic resonance scanning, in which context gadolinium is the most powerful ion.

Evans has written a well-balanced book. I am left with the impression that lanthanides will reveal a great deal about the way calcium acts and the theory of electrostatic binding, for example, but also that we are missing a trick in application. The use of inorganic drugs has only started on a long trek of exploration, and by the time I finished this book I had the distinct feeling that the lanthanides have considerable potential in biochemistry. ☐

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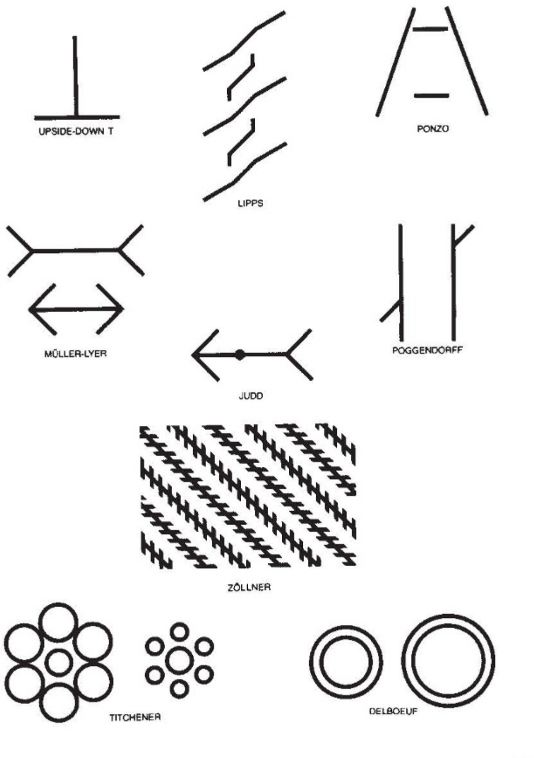

Geometrical illusions such as those on the left abound in one of the new volumes in the Readings from Scientific American series. Edited by Irvin Rock, *The Perceptual World* is published by Freeman, price £10.95 (paperback). The articles in the book review many of the significant developments in research on sensory and perceptual processes during the past ten years. The panel below, for example, demonstrates the phenomenon of perceptual grouping. In the picture on the left, the shape of a dalmatian dog can be segregated from a speckled background, and the centre panel shows how slanted lines can appear to occupy a separate plane from vertical ones. But mirror-reversed letters cannot be grouped and segregated from normal letters, as shown on the right. Other volumes in the series are *Microorganisms*, edited by T. Brock, *The Workings of the Brain*, edited by R. Llinas and *Particles and Forces*, edited by R. Carrigan, Jr and W.P. Trower. All are issued in paperback, price £10.95 each.