Oceanographic laboratories

A. S. Laughton

Oceanographic Institutions — Science Studies the Sea. By P. Limburg. Pp.265. (Elsevier/Nelson Books: New York, 1979.) $9.95.

THE public image of a scientific laboratory and of the scientists who work in one is highly coloured by what is seen on television and by science fiction. It is therefore very valuable for a book to be published which explores the reality of research institutes and attempts to look at the motivation and day-to-day working of research scientists. By choosing a subject such as oceanography which has grown rapidly during the past three decades, but the roots of which go back to the last century, it is possible to relate the development of the science with the development of the laboratories studying it.

Limburg has written a book that tackles with varying success both the science and the laboratories. As a potted history of oceanography his first three chapters leave a good deal to be desired. There are inaccuracies (the first word in the acronym ASDIC is "Allied" not "Anti-"), a lack of understanding of some of the technology (the difference between reflection and refraction seismics) and a rather journalistic view of the development of scientific thought (from continental drift through stable continents towards plate tectonics). The historical review is very unbalanced. Two pages are devoted to diving and subsea habitats, whereas deep-sea drilling is limited to 11 lines, and oceanography from space to six. Near-bottom technology scarcely gets a mention nor do the achievements of long-term deployments of instruments in the ocean, which depend crucially on the developments of marine acoustics.

The accounts given of the work in the major (and some minor) oceanographic laboratories in the USA are both informative and interesting, and the unravelling of the complexities of US Government agencies' funding of ocean research is revealing, if perhaps somewhat ephemeral. As the book proceeds, it becomes clearer and clearer that the author is really concerned with oceanography in the USA and I wonder why this was not made clearer in the title. Oceanography in all other countries is limited to one chapter and appears to include only those laboratories which the author was able to visit. No mention at all is made of oceanographic institutions in the USSR or in Japan. It cannot therefore be said, nor is it claimed in the Introduction, that the book is a comprehensive review of oceanographic institutions. What it does provide, and in this is its success, is a peep in through the doors of some of the laboratories, an insight into the enthusiasm and motivation of some oceanographers both great and small, and an indication of the breadth of the subjects studied.

For a student wishing to start a career in oceanography, especially in the USA, I warmly recommend this book. □

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The wonder of it all

R.H. Dalitz

Knowledge and Wonder: The Natural World as Man Knows It. Second edition. By Victor F. Weisskopf. Pp.312. (MIT Press: Cambridge, Massachusetts, and London, UK, 1980.) Hardback $15, £9.30; paperback $5.90, £3.70.

TODAY we have knowledge of our Universe covering distances from 10^{-16}cm to 10^{+28}cm, and for time intervals from 10^{-24}s to 10^{+17}s. All the phenomena observed within these limits are apparently governed by a very limited number of physical forces. The aim of this book is to lead non-scientists to appreciate the wonder of this situation, first by indicating simply how we know the facts and then by illustrating the wide variety of phenomena governed by these forces. Such an endeavour necessarily involves some over-simplifications, of course. Here the job is done in low key, showing how simple concepts based on the laws governing these forces can lead to an understanding of this strikingly wide variety of phenomena.

The book begins with space and time. It estimates the lifetimes of Earth and of the Universe, and the sizes and distances in the visible Universe. Two major forces are obvious to us from daily life, gravitation and electromagnetism. Their characteristics are outlined and related to the variety of phenomena to which they give rise. We explore the Solar System, understand the Milky Way as our galaxy, and relate it with far-off galaxies, made visible by telescopes. On Earth, we explore the structure of the atom and learn of its tiny nucleus, first deduced from Rutherford's alpha-particle scattering experiments. Both electrons and light show both particle and wave characteristics, and we soon reach quantum mechanics, with discrete energy levels for atoms, each level corresponding to a standing wave of electrons circulating about its atomic nucleus. The Coulomb force accounts for the binding of these circulating electrons to the nucleus, and also for the forces between atoms. We are shown the most common bonding mechanisms between atoms, and use the atoms as building blocks to make molecules, crystals and other solids and liquids, and so account for the materials around us as due to electromagnetic forces.

Next we are led to still shorter distances, to the nuclear and subnuclear worlds. The atomic nucleus consists of protons and neutrons, bound together by strong nuclear forces, and we soon understand why the stable nuclei are limited in number. An atom's chemistry then depends primarily on the proton number of its nucleus, and a pure chemical element can have various atomic mass values, corresponding to the number of neutrons in its nucleus. The ancient dream of transmuting other elements into gold is now seen to be possible, although so expensive that it has no financial value.

Recent experiments on the scattering of electrons and neutrinos by nuclei have shown that the nucleons themselves are composite, each containing three quarks. The rich spectroscopies of atoms and nuclei, each due to their multiplicity of component particles, are now paralleled by a spectroscopy of nucleons, due to excitation of the motions and spins of their component quarks. These experiments also show us that quarks, as well as electrons and neutrinos, have no detectable structure larger than 10^{-16} cm.

We turn now to our terrestrial environment. Earth's long history is traced out, great changes occurring in its surface structure long before Man's emergence in recognizable form through evolutionary development. Thus, we come to the story of Life itself. The great steps are traced out, although not in detail, for we do not know them. We understand how the basic molecules needed to make up living material could form, perhaps through lightning flashes on the Earth's surface. The energy falling on Earth from the Sun was essential for the subsequent development of more complex organisms. Earth became covered in green, due to the chlorophyll which uses the energy reaching us from the Sun so efficiently. In the course of time, more complex organisms evolved, their structure being determined by the double-stranded DNA molecule, a thread carrying instructions for the construction of a living being, a thread replicated in its every cell. This evolution from simple to complex organisms, to living beings and to *Homo sapiens*, cannot be traced in detail but the general principles are outlined. The important role of mutations in this development is emphasized, and we see how the life on earth today could plausibly have resulted from such an evolutionary history. Finally, we recognize that evolution in Man's behaviour has become rapid relative to his lifetime, since mankind now gains new knowledge quickly and disseminates it efficiently, so that new situations for humanity can now develop in the space of years. This evolution is of a new kind, not concerned with Man's structure but with his ability to control and change his environment. It is still quite unclear where this new evolution may lead us.

This story is recounted in simple terms, with compelling logic. The original lectures were for a high-school audience, and this extended version is still suitable for them. But it has much interest for all, and I hope that it will become more widely known. It could perhaps be simplified more, or extended in several places where questions are left unanswered. The book will be valuable for scientists, since few are familiar with all of the areas covered. The presentation is stronger and more tightly argued in the earlier chapters concerned with chemistry and physics than in the chapters concerning Life, where the author's knowledge comes from other scientists. The story of Life is much more complicated than that of inorganic matter, and can only be outlined in such a short space.

Each reader will have his own short-list of significant topics not covered in this book. For example, the uniqueness of our situation on Earth might have been underlined by a brief comparison of Venus with Earth; why have two planets of such similar constitution, mass, and so on, turned out to be so different today. Again, neutron stars are well known now, some of them as pulsars, of which there are many in the sky, but they are not mentioned; nor are quasars nor black holes, but these are not yet understood and they lie on the edge of Einstein's gravitational theory, which the author consciously chose to omit. At the other extreme, the book gives no hint of the complexity of the quark world; we know 15 kinds of quark today, and other fundamental entities are also needed. There is no mention of the weak-decay interactions, the unification of which with electromagnetism to form 'the electroweak interaction' has been such a major theoretical triumph recently. Such topics would perhaps complicate the story without adding much enlightenment, but still they are part of our everyday world. Even the strange particles are being formed around us by the cosmic radiation incident on Earth, although they quickly decay, and this cosmic radiation can be made visible with simple equipment which can be constructed in any home; it is part of our environment. Perhaps the book should have a few appendices, which could take the interested reader further towards the extreme boundaries of present research. I found few errors in the book, but it is stated on p.179 that the highest energy accelerator today, producing proton beams up to 500 GeV, is in operation at the Brookhaven National Laboratory, Long Island; it is actually at the Fermi Laboratory, near Chicago. It also puzzled me that more than half a page should be devoted to the outmoded 'continuous creation' theory of the expanding Universe, definitely excluded by observation for some time past.

In conclusion, I can only say that this book is superb and far ahead of any other global accounting of our Universe, in both the large and the small. We all have friends and relatives who question us often about modern science; this is the book to place in their hands. It shows the physicist at his best, accounting for what he sees by simple order-of-magnitude estimates. The story of Life is less amenable to this approach, and so those chapters are more descriptive. However, as it now is, the book already satisfies a great contemporary need. □

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Star maps, old and new

David W. Hughes

The Sky Explored: Celestial Cartography, 1500–1800. By D. J. Warner. Pp.293. (Alan R. Liss: New York; Theatrum Orbis Terrarum: Amsterdam, 1979.) $70. *True Visual Magnitude Photographic Star Atlas.* By C. Papadopoulos. (Pergamon: Oxford and New York.) Three volumes. Vol.1. *Southern Stars,* 1979; £100, $225. Vol.2. *Equatorial Stars,* 1979; £145, $325. Vol.3 *Northern Stars* (by C. Papadopoulos and C. Scovill) publication due June 1980.

SINCE the dawn of history, mankind has been a fascinated observer of the heavens. The stars were arranged into groups of constellations and names were given to these constellations and also to many of the brighter stars. However, without a good celestial map the night sky simply dissolved into a trackless confusion of points of light. Maps were also a simple means of recording the knowledge gleaned from celestial observations. In the old days the constellations were depicted by artistic, symbolic figures, and many of the early star maps and globes became much more than just scientific aids but were also beautiful works of art in their own right.

The first important extant star catalogue was compiled by Ptolemy in AD 150 and contained 1025 stars grouped into 48 constellations. Ptolemy's work was the cornerstone of mediaeval star catalogues and, for more than 1,400 years, Islamic and European astronomers limited their observations to the stars listed by Ptolemy. The catalogue of Al-Sufi in the tenth century, Ulugh Beg's Alfonsine Tables in the fifteenth century and the Copernicus catalogue in the early sixteenth century were simply revisions of Ptolemy. These catalogues were usually just lists of stellar latitudes, longitudes and magnitudes.

Most astronomers found that a graphic form was more useful than a catalogue, and so maps of the sky were introduced. The first flat star map of any significance was published by Albrecht Dürer, the great Nuremberg artist and mathematician, in 1515. The date reflects both the development of printing and the upsurge in the study of astronomy initiated by such worthies as Copernicus, Regiomontanus and Piccolomini. The era of great celestial cartography probably ends with the publication of John Elert Bode's *Uranographia* in 1801. Bode used 99 constellations and included 17,240 stars down to eighth magnitude. After Bode the constellation boundaries became more rational, the constellation figures slowly disappeared and star maps lost much of their charm and beauty becoming the dull procession of differing sized dots we know today.

Deborah J. Warner, the curator of the History of Astronomy at the National Museum of History and Technology, Smithsonian Institution, has produced a comprehensive catalogue of all the flat star maps printed in Europe between the fifteenth and early nineteenth centuries. Also included are details of a few globes for comparison. It is a work of considerable scholarship and, as a source of detailed information, will be a much valued reference book for decades to come. The listing is alphabetical and the work of each cartographer is analysed according to the number and size of maps produced, the limiting star magnitude, the co-ordinate system adopted, the date and place of publication, and the non-Ptolemaic constellations introduced. It is intriguing to note how certain constellations come and go. For example Lalande charted Felis, his own cat, and also introduced his telescope as Quadrans Muralis. Thomas Young squeezed the Battery of Volta into the space between the head and hooves of Pegasus. Julius Schiller even attempted to de-paganize the complete zodiac by introducing the twelve apostles in the place of Pisces, Aries, Taurus, Gemini and so on. The Warner catalogue is profusely illustrated in black and white and the beauty of these illustrations is most impressive. Obviously only a few of the maps were coloured and even this would probably have been a laborious task of hand water-colouring. It is hard to fault this book but may I make a suggestion for a new venture. If Deborah Warner produced a large-format book, with some colour prints depicting the best artistic