and their effectiveness. Here it would seem that the professional institutions themselves may be able to contribute directly, particularly the more specialized ones. Besides the influence they could exert through the Parliamentary and Scientific Committee they should be able to strengthen some of the research associations in their educational activities and probably even up to management level. It is, however, especially in the problem of communication of knowledge in its broadest aspect that most remains to be done: professional institutions have a great opportunity to help. Certainly, while the Iron and Steel Board's report establishes the need for more financial support for research, it gives no clear lead as to the limiting magnitude of such expenditure. On the contrary, it indicates that the real problem of the research association is as yet unsolved and that we need much more searching enquiry as to exactly how best to encourage, especially in the smaller firm, a keen appreciation of the importance of science and to secure a speedier application of existing knowledge quite apart from the continuous pursuit of new knowledge.

WHAT GUIDES THE SLEEPWALKER?

Method in the Physical Sciences

By G. Schlesinger. (International Library of Philosophy and Scientific Method.) Pp. vii+140. (London: Routledge and Kegan Paul, Ltd.; New York: The Humanities Press, 1963.) 21*s*. net.

THE methodology of science is in a similar relation to science as metamathematics is to mathematics. How is it then that while metamathematics has given an enormous impetus to mathematical thinking, most natural scientists, especially the young ones, would consider it as a loss of time to study the methodology of science? The short answer is, evidently, that physical science is not a purely intellectual pursuit. It is rather a game played with an only partially known opponent, and only partly with one's conscious mind. The rules which unsophisticated minds used to attribute to Nature turn out to be, more often than not, human preferences.

This is, very roughly, the thesis of this book by Dr. G. Schlesinger, senior lecturer in the Australian National University. The author, very wisely, makes no pretence of teaching scientists *à bien conduire la raison*—though his own reasoning powers are amply demonstrated. Nor does he undertake the unrewarding task of investigating the primary principles of science—such as, for example, Keynes's postulate of limited variety—which precede science, and which form the unprovable basis of all scientific endeavour. His object, more modestly, is the critical investigation of four secondary or supplementary principles, which might be dropped without making science impossible, but which are nevertheless followed, consciously or unconsciously, by as good as all scientific workers.

First of these is the "Principle of Simplicity". The author concludes that though a mathematization of this principle is not precluded, no such formulation has yet been found. Only tentative attempts exist, such as Karl Popper's that "the simplest of alternative hypotheses is also always the most falsifiable". The second, the "Principle of Micro-reduction", according to which entities belonging to a given level of complexity are always reducible to the level below, does not fare much better. The author admits that it is a powerful driving force in science, but it is an act of faith, and moreover, as he shows in some interesting examples, sometimes in conflict with the principle of simplicity.

The third chapter deals with the "Principle of Connectivity", which the author states in the clear and simple form that "two physical systems never differ in a single aspect only". I do not think that everybody will agree with him when he considers this as an extension of the principle of causality (a primary principle). Whatever its logical status may be, it remains an indispensable pragmatic postulate also in a non-causal physics, which, as Einstein said, "can be quite reasonable".

In the fourth and final chapter on the "Principle of Verification", I found particularly interesting the discussion of Gibbs's paradox: Two containers of two gases at the same pressure are connected by a tap. One opens the tap and the entropy always increases by a finite amount—except when the two gases are identical, in which case it does not change at all. One feels that it would be worth while to review this paradox in the light of the connexion of thermodynamics with information theory, and also with the view of the fact that self-diffusion, which in Gibbs's time bordered on metaphysics, has now become observable by radioactive isotopes. The verdict of the author on the "Principle of Verification" is similar to that on the others. This principle "does not place a methodological precision instrument into the hands of the scientists" because this would require an ascertained method of comparison between various operational definitions, and such a method does not exist.

One might get the impression that the author has exercised only destructive criticism—but in this field there is no such thing as purely destructive criticism. Distinguishing analytical statements from acts of faith, separating physics from psychology, is a meritorious achievement, perhaps the only one which the philosopher of science can undertake at the present stage, and the author has done this in an eminently readable book.

D. GABOR

THE EARTH BENEATH THE SEA

The Sea

Ideas and Observations on Progress in the Study of the Seas. Vol. 3: The Earth Beneath the Sea; History. General Editor, M. N. Hill. Pp. xvi+963. (New York and London: Interscience Publishers, a division of John Wiley and Sons, 1963.) 210*s*.

THE editors of this series of volumes have rightly adopted the modern view that oceanography cannot be divorced from the study of the atmosphere above and the Earth beneath the oceans. Volume 1 contained, among other topics, accounts by meteorologists of dynamical interactions between the atmosphere and the oceans. Now, Volume 3 is almost exclusively devoted to geological and sedimentary investigations of the sea-bed, and the information which may be derived regarding processes within the Earth such as convection and tectonics.

The various methods utilized in the geophysical exploration of the sea-bed are comprehensively surveyed in a series of review articles comprising the first section of the book. The principal technique makes use of the reflexion and refraction of seismic waves generated by explosions, periodic sound pulses or earthquakes. Both theory and practice are lucidly described together with the interpretation of the data dealing with the resulting compression and shear waves within sediment layers, the crustal layers and the mantle.

There follow equally readable accounts of the measurement at sea of the magnetic field, the acceleration of gravity, and the heat flux through the sea-bed. In each case the methods of observation and the analysis of results in terms of conjectured processes within the Earth are presented together with much hitherto unpublished material for the specialist reader, and with a care in presentation certain to attract the non-specialist. The only articles of a dynamical nature in the book concern the movement of sand over beaches including littoral

© 1964 Nature Publishing Group