Book Reviews

Undoctrinaire Inspections

Induction and Intuition in Scientific Thought. Jayne Lectures for 1968. PETER BRIAN MEDAWAR. American Philosophical Society, Philadelphia, 1969. xii + 64 pp. $2. Memoirs of the American Philosophical Society, vol. 75.

The Relations between the Sciences. Based on the Tarner Lectures, Trinity College, Cambridge, 1959. C. F. A. PANTIN. A. M. Pantin and W. H. Thorpe, Eds. Cambridge University Press, New York, 1968. xii + 208 pp., illus. $7.50.

Writings about science remind one of the old joke about the international essay competition on the subject of elephants. The Englishman wrote "Elephants I Have Shot"; the American wrote "Bigger and Better Elephants"; the Frenchman wrote "L'Eléphante et Ses Amours"; the Pole wrote "The Elephant and the Polish Question." The experimental physicists say "Science is measurement"; the theoretical physicists tell us that the aim of science is to reduce the universe to mathematics; "It's all done by mirrors," complain the logicians; "Don't stop me; buy one!" is the theme of the technologists; the psychiatric interpretation seems to be "Look what a lovely mess I've made!"; and some of our more doctrinaire sociologists embroider the slogan "Give him the money, Barney!" Science is so elephantine that one tends to see it only from the standpoint of one's own particular experience and interest.

The present authors both speak, with immense authority, out of the central regions of biology. Their writings refute the assertion that all scientists are unlettered and lacking in true culture, for they are witty, charming, and full of humanity.

Induction and Intuition in Scientific Thought is (as the author admits) a rather long title for a rather short book —no more than three lectures in a semiphilosophical vein. The theme is simple, and not unfamiliar: the traditional description of scientific methodology as the apotheosis of inductive reasoning is shown to be inadequate; the role of intuition in the practice of science is too important for it to be neglected in philosophical principle. Yes, the theme is familiar enough by now (may I suggest Polanyi, Hanson, Körner, and Kuhn as recent candidates for an enlarged bibliography of the subject?), but it can bear repetition in this clear, incisive, and elegant formulation. Unphilosophical scientists quite rightly turn up their noses at boiled Bacon, which is what many of them still imagine to be the view of science taken by the philosophers; books like this are admirable antidotes to that stale, unpalatable stuff. The argumentation is too tight to be summarized here, but the spirit of it can be judged from the sentence in the final paragraph:

> The scientific method is a potentiation of common sense exercised with a specially firm determination not to persist in error if any exertion of hand or mind can deliver us from it.

Yes! Yes, indeed!

When Pantin died in 1967, he had not completely revised for publication his Tarner Lectures for 1959. But the editors (A. M. Pantin and W. H. Thorpe) say that "the version was not far from the definitive state" and that "their task was a light one!" Certainly, the author himself speaks from these pages. I knew Carl Pantin slightly, as a sweet-natured, courteous, thoughtful, and modest man, and it is a pleasure to renew the acquaintance—too late, alas—by reading his book.

The Relations between the Sciences is an attempt to explain the general "philosophical" problems that arise in what Pantin calls the "unrestricted" sciences, such as biology and geology. The treatment is tentative, undogmatic, and illustrated by many practical examples from his own experience. He does not cut as sharply as Medawar, but perhaps his book is the more valuable from the evidence it gives of honest perplexity in the effort to deal with genuine difficulties. One can almost regard it as a piece of natural history in its own right—a record of a journey taken into unfamiliar realms, with descriptions of the peculiar creatures observed on the way.

For example, Pantin too is deeply concerned about the contradiction between the official deductive scheme of scientific proof and the obvious fact that research is guided largely by intuition. Like Medawar, he takes Whewell as his hero. He talks of the ease with which he was able to say "That is *Rhynchodemus bilineatus*" upon sight of a tiny worm, and contrasts this "illative sense" with the step-by-step verification of an identification by means of a taxonomic key.

This aspect of scientific methodology is peculiarly obtrusive to the working biologist; but undoctrinaire inspection reveals the same problems in chemistry, physics—even mathematics. Nor are true philosophers especially abashed by being told that more can be learned or discovered about the world than can actually be proven. As I have hinted, this is old hat.

The puzzle, which Medawar and Pantin do not pose, and to which neither hint at a solution, is why anyone should think otherwise. Why are so many ordinary scientists, to whom these books are really addressed, so susceptible to the spell of naive Baconism that it must be exorcised, with bell, book, and candle, generation after generation? The reason seems to have something to do with a Platonic ideal of "objectivity." In these pages, research is described as a purely personal activity, by which a preexisting Truth is discovered. The findings are not really meant for a human reader, but for the sweet Princess *Reason* herself, in her high castle, to say yea or nay.

This is an unattainable standard of proof. The fact is that science is a purely human pursuit, and the best we can achieve is systematic intersubjectivity or "consensibility"—an agreement that "thus it is" between well-informed minds. Logical deduction from hypothetical premises—the scheme which Medawar favors, following Popper—is

then only one of the forms that the persuasive communication of knowledge can assume. The human brain has an unequaled capacity for the recognition of meaningful patterns, and there can be certain and complete agreement between two persons concerning the congruence of patterns that they both perceive. Surely the illative sense is no more than the introspective occurrence of this mental phenomenon—a comparison of such potentially consensible patterns within the memory of the same individual? Or must we pay tribute also to Princess *Rhyme*, who dwells on the same distant crag?

For the neo-Baconian, however, the controversy now centers about the logical status of the recognition of congruent patterns. He would, one supposes, like to reduce this activity to a succession of simple operations, along the lines of a mathematical formula. He wants to apply a Turing machine—an idealized logical computer—to the problem. But we know now, from bitter experience in attempting to construct actual programs for pattern recognition with real computers, that this is an extraordinarily difficult task, of which we can say only that it ought to be possible in principle. Until a practical procedure of this kind has been found, we do better to rely upon the undoubted fact, emphasized by Pantin, that living brains—animal as well as human—have this power to a very high degree, and that scientific knowledge, acquired, verified, and critically assessed with its aid, is as certain as is humanly possible.

We approach here, indeed, another of Pantin's problems—the status of emergent characteristics of very complex systems. Because the biologist fastens his attention on such systems—cells, organisms, societies of individuals—he must face up to the present impossibility of cerebrating the phenomena of life and mind from the known properties of the elementary constituents of such systems. As Pantin points out, there exist complex inanimate systems, such as thunderstorms, which show many of the features we associate with living things, but these lack the fantastic functional organization, part by part, limb by limb, cell by cell, organelle by organelle, down to the molecular level, to be found in all living creatures. Here he wisely refrains from dogmatism, whether mechanistic or vitalistic; the point is to observe how scientific progress can uncover relations of structure and function at all levels, and thus gradually change the terms in which these problems are posed. The discovery of the structure of DNA, for example, does not solve the puzzle of heredity, but at least we can now avoid such mystical concepts as "germ plasm" and "gene" in our attempt at a description.

He makes a very interesting point about taxonomy. Because of their complexity, living things might be expected to be extremely difficult to classify. But because of their evolutionary origin, they turn out to belong to a simple linear-branching classificatory scheme, which is quite easy to grasp mentally. In another dimension, the functional relations of organs to the organisms that they serve provide simple classifications, which are the stuff of anatomy and physiology. In other words, the diversity of biological systems is quite rigidly restrained by the forces of the environment and of natural selection. The biosphere itself is of surprisingly low entropy.

It is fun, of course, to invent other worlds in which there are other creatures with different emergent properties—Black Clouds, say, or "men whose heads do grow beneath their shoulders." In a later paper published as an appendix to the Tarner Lectures, Pantin deals pretty firmly with such frivolities and plumps heavily for Life as a mode of being of the carbon atom in aqueous surroundings. As an experienced zoologist and geologist, with a sound grasp of physics and chemistry, he is almost certainly in the right—but there is a touch of Dr. Pangloss in his argument. Just at this moment I can't decide whether it would be more amusing for life to be found on the moon, thus confounding such predictions, or for all those extravagant precautions against biological contamination to prove ludicrously uncalled for.

There is much else of value, that cannot be summarized here. In the interdisciplinary essay competition proposed at the outset of this review, the biologist often does no more than croon "Ripeness is All!" The best recommendation I can give to the present books is that they are different. They present science through the eye of the biologist, neither blinkered nor sentimentalized. They have the power to provoke further constructive thought in the mind of any well-educated reader.

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Backyard Oceanography

A Coastal Pond. Studied by Oceanographic Methods. K. O. EMERY. Elsevier, New York, 1969. xiv + 82 pp., illus. $8.50.

Few of us are fortunate enough to have the staff and facilities of a Woods Hole Oceanographic Institution available to focus on the geology, hydrology, chemistry, and biology of a small pond. Oyster Pond, 25 hectares in area and with an average water depth of 3 meters, is probably little more water than is contained in the research tanks at the Oceanographic Institution. Located near the town of Falmouth on the southwestern tip of Cape Cod, the author's home since 1962 has overlooked the pond, and the results of his observations are summarized in an authoritative and eminently readable volume. The application of sophisticated oceanographic gear to the "mini-volume" of Oyster Pond cannot fail to have its lighter side as one visualizes the author rowing H. T. Edgerton and his Acoustic Bottom Penetrator in a small skiff while taking continuous seismic profiles of the bottom sediments of the pond.

The history of the pond is traced from its geologic beginnings as a multiple kettle some 12,000 years ago. Subsequently, as sea levels rose, salt water entered the lower end of the pond and produced salinities suitable for the oysters that gave the pond its name in early colonial times. The decline of the oyster fishery in the 1760's is attributed (on historical and geochemical grounds) by Emery to the growth of a bay-mouth bar which closed off access of salt water to the pond and thus lowered the salinity of the pond waters. At present, salinity in the pond is about 1.7 per mill, and a gradient of 5 percent exists from the north basin through the south (seaward) basin owing to inflow of ground water through the very porous, coarse sandy till and outwash in which the pond is situated.

Chemical analyses of the pond water and ground water indicate that the salt contribution to Oyster Pond is a simple dilution of the ocean water that enters the pond about 2 percent of the year. A deeper body of water in the south basin (5 to 6 meters) is virtually isolated from the rest of the pond because of its much greater salinity (3 to 6 per mil), except during overturn, when it is mixed with the overlying water, raising the salinity of the whole pond.