lion or more) consisting of educational research and development, natural resources development, international development, and supersonic aircraft development.

Wiesner emphasizes the variety of uses to which the high-speed electronic computer can now be put. Most important among these is the simulation of complex dynamic systems not only for engineering design but also for the study of economic and social behavior, thereby making it possible to predict the consequences of human and social decisions in advance of their actual application.

From the hard realm of the dollars-and-cents relations of government with science and technology, Michael Polanyi's essay, "Science and man's place in the universe," changes orbits into that hazy realm of scientific philosophy which might more properly be known under its older title of "metaphysics." Polanyi's aim is to sketch "a theory of knowledge which abandons the idea of scientific detachment. . . . All knowledge is based on a measure of personal participation. . . . We can know more than we can tell." Speaking in terms of "subception" and "tacit knowing," he develops a theory of knowledge that "accepts indwelling as a proper way of discovering and possessing the knowledge of comprehensive entities." There is no possibility of the explanation of consciousness by the laws of physics and chemistry, he tells us, and we must not allow the ideal of strict detachment "to deprive our image of man and the universe of any rational foundation." The usual scientific theory of knowledge "requires that all stages of life be accountable by the laws governing inanimate nature," but Polanyi claims there are higher levels of existence that are inexplicable in terms of the laws governing the lower levels. Using the idea of evolution as his example, he finds that "evolution shows man arisen by a creative power inherent in the universe," thereby justifying the concepts of Teilhard de Chardin regarding emergent evolution. Although the editor's introduction claims that Polanyi's search to find a home for man in the universe "shatters the popular myth of the two cultures," the theories of personal knowledge and emergent evolution advanced in this essay are more likely to turn that myth into reality.

The final essay in this collection, Gerald Holton's "Presupposition in the construction of theory," does help to narrow the distance between the two cultures by showing that thematic hypotheses play similar roles in scientific and in humanistic scholarship. Demonstrating that Newton used thematic hypotheses in his theories of matter and gravitation, Holton points out the importance of such hypotheses in the early stages of a developing science, as a necessary component in efforts to bridge the gaps of ignorance. However, thematic questions "do not get solved and disposed of. . . . Rather, they rise and fall and rise again with tides of contemporaneous usefulness or intellectual fashion."

Despite its over-pretentious title—after all, as a "cultural force," science comprehends much more than is included within these four lectures—the book provides a useful compendium of the thoughts of some outstanding thinkers and doers with respect to some of the contemporary problems of science. But what about science as a cultural force in the arts, in literature, and in other fields of humanistic endeavor? We still await the "dialogue" that will convert that wordy battleground into a meeting ground and truly show science as a force of major dimensions over a much broader spectrum of our culture.

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On the Popularization of the Biological Sciences

A generation ago the popularization of science meant almost entirely the popularization of physics and astronomy. Today it is biology that receives the lion's share of the attention of public and publicizers. The change is only in part attributable to the greater visibility of the biological frontier. In addition, and for whatever reason, today's most able scientists-expositors are devoting their attention to biology rather than to physics. The Eddingtons and Jeanses have been replaced by the Stanleys and Stents and Boreks. Such a shift will surely affect the future recruitment of scientists.

The field covered by biochemist Ernest Borek in his latest book, **The Code of Life** (Columbia University Press, New York, 1965. 272 pp. $5.95), is a familiar one. It includes the story of the nucleic acids from Miescher to Nirenberg, Mendel's work, the development of x-ray analysis by the Braggs, Astbury, and Wilkins, and the growth of biochemical genetics from Garrod to Sanger. There is a good discussion of protein synthesis and the coding problem. Everywhere the text is enlivened by relevant anecdotes of the personalities involved. The reader is carried along by the enthusiasm and widespread interests of the author. Borek has a keen eye for telling historical quotation. At the very end of his account of the decoding of nucleic acids, he includes this now astonishing statement made by William Bateson in 1916:

> It is inconceivable that particles of chromatin or of any other substance, however complex, can possess those powers which must be assigned in our factors (genes). The supposition that particles of chromatin, indistinguishable from each other and almost homogeneous under any known test, can by their material nature confer all the properties of life surpasses the range of even the most convinced materialism.

This has been quite a half-century for materialists!

Of factual errors I found few. I reviewed the book from galley and noted a number of scrambled structural formulas, but these have been (I trust) corrected. The Danish geneticist W. Johannsen (misspelled) is wrongly identified as a Hollander. Nägeli is everywhere written as Nageli; if the umlaut is to be jettisoned the name should be Naegeli. The electron microscope is said to be only 50 times as powerful as the optical 'scope, an underestimate by an order of magnitude. But such errors are not terribly serious.

For a book of this sort it is more apropos to discuss stylistic lapses. In his preface the author puts himself firmly on the side of the angels in the debate started by C. P. Snow with the following assertion: "The dichotomy is not between two cultures; it is between culture and no culture," and expresses his great admiration for a polished paragraph. Having made this public commitment, he can expect criticism of stylistic details that a writer of lesser quality would be spared. In

several places the writing shows signs of haste. In discussing the teleological reason for meiosis, Borek points out that, if fertilization existed without meiosis, "In not too many generations a cell would be as crowded with chromosomes as a football stadium and would have to be as big to accommodate all of them." The biologist knows what he means, of course; but the image is out of focus. A little later the author perpetuates an old mistake by saying: "As the cell divides so does the precious chromosome. . . ." And when Borek speaks elsewhere of "the successful breach of the laws of gravity" by satellites he is (at worst) denying Newton's work or (at best) coining an awkward mixed metaphor.

In several places the writing turns purple with unhappy results—for example, "The writers of the Old Testament, with perceptive intuition, placed the turning on of light very early on the agenda of the task of creation. Light is the bountiful seminal source of all life and the chloroplast is the womb which reshapes light into the stuff of life." The second sentence does not stand up under repeated reading, and the first is an ill-advised tying of the tail of theology to the kite of science. The fact is, the writers of the first book of Genesis decided that Day and Night were created on the first day, although the sun was not produced until the fourth—hardly a convincing example of their "perceptive intuition."

Fortunately, such lapses in taste do not loom large in the book. For the most part the author evokes the correct picture in the minds of his readers, correct not only in the details but also in the spirit of excitement. "I recall," says Borek, "that, when I first read Dr. Vincent du Vigneaud's brief description of his synthesis of the hormone of the posterior pituitary, I experienced the same spine-tingling excitement as when I first heard Toscanini conduct Beethoven's Ninth Symphony, or when I first read Melville's description of the Pequod sailing through the night, sails billowing and the fires under the melting kettles sparking the dark Pacific night. Lawrence Durrell wrote somewhere: 'Science is the poetry of the intellect.' Organic chemistry contains some of the noblest—and least appreciated—passages in the collected volumes of the poetry of the human mind."

Therein is the tragedy of the poetry of science—that it can be heard by so few and for so short a time. As each poetic creation comes to birth it sounds out for only a short time, leaving behind only the echo of an echo which is embalmed in the brief, almost colorless formulas, graphs, and diagrams of textbooks. The excitement of anatomy under Vesalius is gone, leaving behind only useful diagrams. The excitement of molecular biology will likewise disappear all too soon in this day of accelerated scientific succession, leaving behind only useful facts. Men like Borek who spread the excitement of scientific discovery a little wider and maintain it a little longer serve the cause of both culture and science.

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Coast and Geodetic Data

Shore and Sea Boundaries. vol. 2, *Interpretation and Use of Coast and Geodetic Survey Data.* Aaron L. Shalowitz. U.S. Department of Commerce, Washington, D.C., 1964 (order from the Superintendent of Documents, Washington, D.C.). xxvi + 749 pp. Illus. $5.25.

Shore and Sea Boundaries was published to meet the need for a treatise on the technical aspects, interpretations, and uses of the surveys and charts of the Coast and Geodetic Survey of the U.S. Department of Commerce, mainly of nautical and aeronautical charts, magnetic charts, tide and current observations, geographic and plane coordinates, and elevations. These data, which extend back to the Act of 1807, comprise invaluable basic material for settling litigation relative to many problems but principally to shore and sea boundaries. They cover the continental United States, parts of Alaska and Hawaii, and the marginal seas and are accurately coordinated so that all parts are shown in correct relation to every other part. There are no serious datum discrepancies.

In connection with his official duties the author has searched the federal files and statutes covering a period of 155 years. Owing to his early experience as navigator, hydrographer, cartographer, geodetic engineer, and editor in the Coast and Geodetic Survey, and to his special studies in law, he is extremely well qualified to make engineering evaluations; to interpret old and new maps, charts, and other Bureau publications; and to aid in legal actions. Almost all, if not all, boundaries originate with an agreement or legal enactment. This applies to local, state, national, and international boundaries.

In those cases where boundaries were marked on the ground and charted by the early Coast Survey, manuals and letters of instruction to the engineers in the field, and to those in the office, provide an understanding of the practices of the day. But a thorough knowledge of the scientific basis for the engineering practice is also required. The histories of the adoption of the Clarke Spheroid of 1866 and the various geographic datums culminating in the North American datum of 1927 vividly brings out the complex interrelationship of the Bureau's scientific and engineering activities.

The author has organized his material into three main parts: the introductory material; Early Surveys and Charts; and Application to Engineering and Legal Problems. Part 2 contains the more technical information, but is so clearly presented that the layman will find it interesting. The other parts are of extremely wide interest. Part 3 brings out many aspects of the legal uses of the Bureau's publications and includes a glossary of terms and selected cases relative to tidal boundaries. The glossary and Appendix E (by Admiral Raymond S. Patton), which is concerned with the relation of the tide to property boundaries, contain information that is almost essential to all owners of shoreline and water front property.

This book, which represents the relationship between science and engineering in its highest form, describes the establishing of national and international geodetic networks for accurately coordinating all continental surveys, maps, and charts. Uses of the data in court cases of the past are narrated as a method of pointing to possible uses in the future.

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