Archaeoceti, Odontoceti, and Mysticeti (though not on p. 35); Pholidota and Edentata are used instead of Nomarthra and Xenarthra; the Pinnipedia are treated as a full order; Hyracidae replaces the familiar Procaviidae. For the most part (though not invariably) this usage follows that of Simpson (1945). Such changes are properly documented and discussed briefly where pertinent.

This is a convenient compilation of material from many scattered sources. There are here no keys for identification, no lists of species, no figures of skulls or teeth. With one exception (a graph showing numbers of fossil and Recent genera) the 70 figures are maps depicting the world distribution of families. There is a bibliography of over 700 sources cited, and an index to the common names of many groups and the technical names of all genera and higher categories. The volume is well printed and nicely bound but, considered merely as a product of the bookmaking art, it is overpriced. It should prove an invaluable reference for students of mammals and should be very helpful to specialists in many other disciplines as well.

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The Indirect but Constant Process of Innovation

Technology and Change. The New Heraclitus. DONALD A. SCHON. Delacorte Press, New York, 1967. 270 pp., illus. $7.95.

In the compass of slightly over 200 pages Schon has attempted to write two books, one a philosophical tract for our times, the other a manual for R & D innovation in the American corporation. Since Schon is only an amateur philosopher but a professional research consultant (he has done stints with Arthur D. Little, Inc., the office of Technical Services of the Department of Commerce, and the Institute of Applied Technology of the National Bureau of Standards, and is now head of OSTI [Organization for Social and Technical Innovation], a research and consulting firm), it is not surprising that his discussion of the workings of innovation within an organization is more illuminating than his social philosophizing. Yet there is a great deal of merit in both elements of his book.

Seven-eighths of the book is devoted to the processes of invention and innovation. Invention Schon defines as "the process of bringing new technology into being, or again, the new technology created in the process"; innovation is "the process of bringing invention into use." Our rational view of invention as a series of orderly steps intelligently directed toward an objective spelled out in advance is both oversimplified and false, he points out. In actual experience, invention occurs as a nonrational process building on unexpected phenomena, and "once a process of technical development has begun, *it does not usually move in a straight line, according to plan, but takes unexpected twists and turns.*" Schon similarly destroys the rational view of innovation as a manageable process, like other functions of the firm, in which risks are controlled by the mechanisms of justification and review. Nevertheless there is utility in acting *as if* the rational view of the process of invention and of innovation were correct. It allows for planning, which is useful, provided it is done in a flexible way, with the plan treated as "something from which to deviate" in response to new requirements and new discoveries.

Attitudes toward technological innovation in American industry today are contradictory and complicated, Schon explains. Most corporation executives say in public that American industry must engage in product innovation simply in order to keep up with competition; but, Schon holds, many corporations actually resist innovation. For the corporation is a society in microcosm, and societies resist attempts to change their value systems and operations. Because innovation threatens the corporate hierarchy, disrupts the established technology, and, most important, imposes on corporate society a "confrontation with uncertainty," the corporation either rejects it outright or isolates it from the rest of the corporation, pursues a policy of containment, or attempts to convert it to an activity which can be carried on without disrupting effects.

It is not surprising, therefore, that the principal source of major technical change in mature industry is innovation by invasion, that is, the flow of technology from one industry to another. Certain American industries—Schon uses textiles, machine tools, and building, 1930–1960, as his examples—have remained traditional until new R & D-based industries (particularly chemical, electronics, and aerospace) have invaded and thereby changed them. But how does major technological innovation occur in the industries that invade the tradition-bound industries? Schon points out that these industries are science-based (their R & D function is an integral part of the firms, not an appendage to other functions), their capital resources are considerable (in many cases they have federal support), and they have established a style of research-oriented entrepreneurial activity. These factors enable them to overcome the resistance to technological innovation and to invade other industries with new technology.

What should the role of the federal government be in matters of technical innovation? Since the government cannot affect entrepreneurial activity within individual firms, its contributions must be indirect. It can provide models of innovation; it can encourage mobility on the part of labor, adjustment on the part of companies, and assistance to depressed areas in the development of new industries based on new technology; and above all it, and especially the President, can set the "tone" for innovation by replacing the prevailing mutual distrust between industry and government with a climate of trust.

Schon gives us no specific ways in which this atmosphere of mutual trust can be developed, nor any particular measures which the government might take to encourage technical innovation; he does, however, suggest what the government ought to do to prevent traditional industry and industrial patterns from interfering with technical innovation. In this connection, it is perhaps illuminating to compare Schon's general recommendations with the specific recommendations for government policy contained in the recent RAND Corporation and Brookings Institution study, *Technology, Economic Growth, and Public Policy*, by Richard R. Nelson, Merton J. Peck, and Edward D. Kalachek. These authors' specific recommendations for government action to promote technical innovation would not, I suspect, lead to the atmosphere of trust which Schon "ranks highest on the list of

measures aimed at creating a national climate favorable to innovation."

Schon's venture into social philosophy is far less thorough than his analyses of invention and innovation; nevertheless it contains some provocative ideas. Curiously enough, the jacket bears the subtitle "The impact of invention and innovation on American social and economic development," while the subtitle within the book itself is "The New Heraclitus." Neither subtitle is wholly apt. The book cannot in any sense be said to be a critical analysis of technological change in American industry and its impact on society; that would require another entire book (or books), and quite a different one. As for "The New Heraclitus," a quotation from this ancient Greek philosopher appears in the book's introduction, but only to provide us with the truism that everything is in process of change, and that change in industry through invention and innovation is an element in change in our society as a whole.

In his final chapter, An Ethic of Change, Schon points out that the conventional view of technological progress is based upon the Parmenidean concept of stability; change is considered only as a series of transitions from one stable state to another, and technology is regarded as a neutral instrument of change that can be used to enable men to march steadily forward toward a good society whose objectives remain clear and unchanging. This conventional view of technological progress has recently been subjected to doubts. We sometimes gloss over these doubts by claiming that the defects in our society come from the improper use of technology. But Schon is more concerned about the fact that technological change "has been eroding established identities . . . undercutting the sense of self . . ." The changing nature of work, caused by technological development, has created a threat to identity because it makes it difficult for us to classify ourselves in terms of our jobs, and this has led in turn to an erosion of our conception of human needs. There has thus been progressive disillusionment with the notion of technology as an instrument for human well-being.

How are we to react to this changing situation? Schon calls for a new ethic—a set of principles for change. Our old norms no longer suffice; we must renounce our past myths and develop new norms. These norms are not only for the individual but also for the corporation, and, above all, for society. Schon suggests that the process of invention might provide a model for such norms. It places the emphasis on process, contribution, and discovery as against the stable states of success or failure, and thus allows for experimentation and for new objectives to emerge in the process. To ask whether these new objectives are better than the old would, of course, be the mark of the outmoded Parmenidean approach, so we can only hope that the future will indeed justify Schon's "new Heraclitus."

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Plant Substance

The Chemistry of Lignin. IRWIN A. PEARL. Dekker, New York, 1967. 355 pp., illus. $15.75.

Ligninology is a field where organic chemistry ceases to be an exact science. This is an opinion undoubtedly shared by Pearl and most of his prospective readership among researchers working on current problems in lignin chemistry and the related fields of wood science and technology. Polymeric lignin molecules are encountered in most terrestrial plants but show little uniformity, not only from species to species, but even between individual members of single species, between the heartwood and sapwood of individual trees, between the springwood and summerwood of a single year's growth, and ultimately between the various wall layers in an individual plant cell. The association of lignin with plant polysaccharides and the alterations in its structure that occur during its isolation or removal from plant tissues, for example by pulping, complicate this already unsurveyable situation. The approaches adopted by scientists to attack the lignin problem—so acute because of the monstrous amounts of lignin wastes disgorged annually from the world's pulping industries—are probably equally variegated.

Pearl has undertaken the gargantuan task of assembling, ordering, and critically presenting the results of recent years of work on this inchoate natural product. Of necessity, an author of a book on lignin must assume a position of bias that will be enthusiastically acclaimed by some workers in the field while vehemently disparaged by others. Assumption of a controversial stand of this kind—here a preference for the empirical over the biochemical approach—does, however, have the benefit that the resultant survey of lignin literature is more vivid and intriguing than the mere compilation of facts, theories, and dubious implications that might otherwise be made from the flood of publications on lignin.

Pearl's book is intended as an edited wide selection of the significant results garnered over about the last decade on lignin and allied topics. As such, it is a worthy sequel to its predecessor volumes, F. E. Brauns's *The Chemistry of Lignin*, and *The Chemistry of Lignin: Supplement Volume*, edited by F. E. and D. A. Brauns (Academic Press, 1952 and 1960), and does in fact build upon these classics as foundations. For information on earlier work, the reader is frequently referred to the pertinent sections in "Brauns."

At the Institute of Paper Chemistry in Appleton, Wisconsin, Pearl has had access to numerous publications, translations, and abstracts not readily or punctually available to most workers in the field. Broad coverage of articles originally published in Russian or Japanese is one outstanding asset of the present volume. Occasional erroneous interpretation or representation of facts from more familiar sources may imbue some readers with skepticism toward the accuracy of the reports from obscure journals, however. Moreover, although the literature has been finely gleaned up through 1965, some papers that well merited inclusion have been overlooked.

One of the best features of the book is the delicate balance struck between the technological and academic aspects of the subject. Discourses on the biogenesis of lignin and on laboratory methods of isolating and assaying lignins are complemented by descriptions of wood pulp and spent liquor analyses and of the behavior of lignin in the main pulping and pulp-bleaching methods. Current concepts of the chemical constitution of lignin provide a sound basis for the discussion of the reactions of lignins, the individual formulations by various authorities being carefully related to experimental observations. Other chapters important to industrial workers cover the physical properties of lignins and their derivatives, the biological and thermal decomposition of lignin, lignin-carbohy-