Book Reviews

Mathematical Ecology and Its Place among the Sciences

Geographical Ecology. Patterns in the Distribution of Species. ROBERT H. MACARTHUR. Harper and Row, New York, 1972. xviii, 270 pp., illus. $12.95.

I. The Biological Domain

Surely no scientific pursuit can be more pleasurable than geographical ecology, for, as Robert MacArthur writes in his new book, it "combines the adventure of field work in varied places with the discipline of making nontrivial theory." In addition to its dual intellectual and esthetic appeal, the subject has a unique, important place among the sciences. Only by comparing the characteristics of populations equilibrated in a variety of pristine habitats can many adaptations of species be functionally explained. The resulting "basic" theory is vital if more applied ecology is not to become merely a compendium of correlations.

The biological domain of this science is the large-scale distribution in space of particular species and of species diversity. According to MacArthur, to study the subject we must know the "structure of the environment, the morphology of the species, the economics of species behavior, and the dynamics of population change." The initial chapters provide some of this background. The first, on global climatic patterns, is fun but peripheral in a book not concerned with special cases. Little is given on morphology or local environmental structure, but two chapters treat extensively foraging strategies and dynamics of competition and predation. Anyone using equations of the Volterra type will have to read the comprehensive appendix on that topic.

The ecological chapters contain biases that will probably always be appropriate for geographical ecology. One is a de-emphasis of the dynamics in favor of the statics in population-growth equations. The statics, of course, are what the geographical ecologist usually assumes he is studying. A caveat is that there are many dynamics leading to the same statics, so determining the latter cannot discriminate the former. Because of the difficulty of studying long-term perturbations, however, this is a defect that will have to be lived with. A second bias is a devaluing of laboratory experiments: MacArthur's "lesson of the bottle experiments" is that experimenters failed to make their artificial habitats as heterogeneous as nature, so were unable to mimic it.

After a brief treatment of speciation from a nongenetical viewpoint, the book launches into the heart of the subject: islands, species distributions, diversity gradients, and history. Here, we discover that the "island view of competition" is one where fragmented populations are beset by frequent local extinctions, and a lovely appendix illustrates the enormous effect of competition on extinction probabilities. We learn of the interplay of climate and competition as it affects species distributions. We are given MacArthur's latest views on causes of diversity gradients, a subject to which he has made seminal contributions. To explain latitudinal differences, MacArthur emphasizes the seasonality of temperate areas by arguing that their fluctuating temperatures should have a more profound biological effect than the tropics' fluctuating rainfall. Lowered seasonality in the tropics reduces niche variance and increases niche overlap and, together with a wider range and dimensionality of resources, accounts for tropical richness. To entice ecologists toward the equator, MacArthur makes the unorthodox point that, in the more complex tropics, interactions among species are stronger and so patterns less random. Perhaps the most interesting feature of the chapter on history is a simple model for alternative, uninvadable communities.

Organized by key phenomena though it is, this book makes no attempt to be comprehensive in matters of fact. MacArthur issues a disclaimer: "Our effort is not to understand all cases. . . . That would be too complex to be rewarding. Rather, our aim is to select certain cases that reveal interesting things about the mechanisms involved." In fact, the book's attitude toward data is to be highly selective, giving examples rather than statistically fair surveys. Though the latter are sometimes cited from other work, there is little concern with discriminating the operationally good from the operationally bad. To be so inclined is appropriate for a textbook, but the inclination is less a property of the format than of the method: data are used as ornaments for ideas, and if these ideas have arisen inductively, that process is seldom made explicit. Rather, MacArthur writes, "To be great science it must also be guided by a judgment, almost an instinct, for what is worth studying." Though everyone can agree here at least a little, to depend heavily on subjectivity can be tricky business. Excellent naturalists sometimes thoroughly disagree even about supposed statements of fact, often because they are talking about different organisms and therefore operate in different sample spaces.

Though laced with examples, *Geographical Ecology* is thus essentially theoretically structured. The three principal devices whereby theory is brought into play each illustrate well MacArthur's provocative brilliance, which has led to his being the most cited ecologist of his time.

The first is purely verbal, sometimes little more than an appeal to common sense. For example, suppose we are trying to decide whether competition is important in determining distributions of plants or whether climate itself is sufficient. MacArthur points out that the existence of arboretums testifies that many plants can thrive where they are not native. This implies at least one of two propositions: exotics have never had the opportunity to colonize such areas naturally, or other species have kept them out by competition. But if only the former were so, we would never have to prune our gardens to prevent domestics from being overcome by native "weeds."

The second theoretical device is the graphical model, especially favored in qualitative mathematics, of which Levins (*1*) deems MacArthur's work to be archetypal. Certain models in this book illustrate well the extensive generality that a graphical approach can provide: for example, the equilibrium model of island immigration and extinction requires only monotonicity to produce worthwhile results. Other of its graphical models, however, are more specifically dependent on functional forms. An example is that for convergence and divergence. Here, assuming that isoclines for consumer equilibrium are sufficiently linear, MacArthur uses an ingenious mapping between two graphs to predict that where resources are similar (or equivalently, where consumers are generalized) convergence rather than divergence is favored.

Graphical models are superb for contrasting pairs of objects or effects, and, indeed, in highlighting such dyadic contrasts MacArthur and colleagues have fired ecological research in many directions: fine vs. coarse-grained, pursuers vs. searchers, jacks of all trades vs. masters of one, r selection vs. K selection—the list is long. But graphs are pictures and thereby severely limited in the dimensionality they can depict.

Of course, theorems of the same level of generality could be worked out entirely with the use of algebra. The third kind of theory in this book is in fact algebraic, but is heavily dependent on the use of specific equations, equations having equilibrium solutions expressible often as linear expressions in the variables. Despite the fact that the equations can often be written as polynomials with higher-order and some lower-order terms deleted, and therefore might be good approximations to many different models, they are considerably more specific than the ideal algebraic translation of most graphical models. In MacArthur's words, "The really good mathematician might be able to find necessary and sufficient conditions . . . without beginning with a specific system like Volterra's, but the ecologist and biogeographer find it easier to use specific equations." The hope is that "nearby equations have nearby solutions," because the equations are "probably never literally correct." By thus temporarily jettisoning some generality and hoping for good behavior, MacArthur is able to come up with a fairly complete deterministic theory of coexistence and species packing. Often the objective of the algebraic theory seems to be to show that there exists *some* mathematical theory that will make rigorous the naturalist's vaguer, verbal explanations—indeed, we are told that "the chapter texts are fully coherent without the mathematics."

An intriguing example is the derivation of a macroscopic quantity, Q, minimized by competition governed by Volterra dynamics. To get an easily interpreted Q, MacArthur assumes predator-prey systems with logistic resource renewal, equal and density-independent death and metabolic rates of consumer species, and a specific equivalence on resource utilization rates. There results a theory of species packing that asserts that sets of species whose utilizations best match "useful production" of resources will come to predominate. Perhaps its most interesting consequence is the prediction that where species are closely packed similar habitats may be occupied by very different sets of species, implying patchy species ranges. Some evidence for highly patchy species distributions in the tropics supports this result.

MacArthur also puts his algebraic cards on the table in a discussion of a predator's optimal diet. His rule for inclusion of an item j is that its pursuit time should be less than the mean pursuit time plus mean search time (all per gram captured) for items in the noninclusive diet. It can be shown from a more general inequality (*2*) that his argument is always exactly true if the energy cost of search is zero—otherwise the rate dimensions need to be changed. Although search cost is never zero, it is often low relative to other important quantities—search time, pursuit time, and net food energy—so if a simplification is convenient this is the appropriate one. Here is a case where "the ecologist's judgment based upon understanding of the nature of the equations and upon field experience with the organism being described is essential in assessing whether the equations are suitable."

Though of potentially numerical form, results obtained from the algebraic models, like necessarily those from graphical models, are used mostly only to make qualitative predictions. This strategy has provoked several kinds of reactions.

First, the qualitative approach, in seeking to maximize the domain of its results, can produce theory that is too general for many. For example, the systematist worries that the details he has so painstakingly worked out for his group will be "covered" by a few versatile models while the unexplained facts will be designated noise. MacArthur recognizes this when he writes that "the historian often pays special attention to differences, . . . the machinery person . . . to . . . similarities." Yet he also writes that naturalists who don't want to do science may "take refuge in nature's complexity. . . ." True enough, but nature's intricacy, more than just a refugium for many biologists, is one of its principal delights, luring them to their specialty. Indeed, the rapid conversion of ecology from natural history to analytical science has engendered a kind of two-mindedness among its diversity-loving practitioners. Even MacArthur, though booting complexity out the front door, lets it sneak back in disguised as environmental heterogeneity when explaining the failure of bottle experiments.

A related disadvantage is that a tendency to seek a single functional form as an approximation to all reasonable forms can impair the integration of related disciplines. Specifically, those mostly concerned with population and community models have so far paid little attention to the autecology that should specify their components. Of course, all modelers stop at some level of organization and "curve-fit" relationships at the next lowest level, rather than model them mechanistically. However, especially Volterra equations lump lower-level effects central to many ecologists' interests—at present, there is a large gap between these equations and behavioral and physiological ecology. To illustrate, even though MacArthur devotes a whole chapter to foraging, he can present this material *after* that on population dynamics of predation.

The second disagreement prokoved by qualitative modeling is over precision. Levins (*1*) has written that quantitative results are "only important in testing hypotheses." The "only" in this statement is frustrating to those ogling the extensive feedback between data and theory that has served so well to reject misshapen models in the physical sciences. It is difficult to conceive of results depending upon precise measurement, such as those of Michelson and Morley, having the same impact in ecology as in physics, especially since ecological generalizations often cover enormously varied organisms and systems, so are highly statistical. Yet, if we abandon attempts to fit models precisely to data, messy though the fit may be, systematic deviations will go unnoticed. The outcome may be a constipating accumulation of untested models.

MacArthur in this book seems to waver in places about the usefulness of quantitative theoretical constructs. For example, he neatly dispatches the numerology arising out of obsession with measures: "Those who have used diversity to mean a number . . . have wasted a great deal of time in polemics about whether [one or another measure] is 'best.'" Yet the prescription for the diversity measure preferred ($1/\sum_i p_i^2$, where p_i is the abundance of the ith species) is that it has "a biological interpretation" relative to a measure of competition which itself is justified primarily by a specific equation-system. Even here, of course, one could argue that something near to the measure proposed would play a similar role for alternative systems, but the temptation to use such numbers to validate the equations may be irresistible for empiricists.

If quantitative predictions are going to be important in ecology, how are the generating models to reflect the complexity that ecologists agree is intrinsic to nature? One way is the Holling-Watt model: large, holistic, and with many parameters, but often requiring numerical experimentation to determine its properties. But there is another way to match nature's complexity with quantitative models. That is to construct a *family* of analytically tractable models focused upon some major phenomenon (such as predation), but each differing in the limited parameters or processes incorporated and each having a specifically designated applicability.

Levins (*1*) has argued that population biology's modelers can achieve only two of three virtues: generality, precision, and reality. But it is doubtful that many would admit deliberately sacrificing reality, and perhaps the alternative desideratum most coveted, as Levins (*3*) later also suggests, is analytical tractability (often implied by structural simplicity). In this scheme, the qualitative approach has tractability and generality, the Holling-Watt approach precision and generality (in Watt's [*4*] "supermodel" sense), and the ad hoc approach precision and tractability. The two precise approaches are not a priori equally good. Though more easily tested, especially where parameters must be estimated from data, the ad hoc models cannot incorporate many interactions between factors. Which is better depends largely on the importance of interactions, and that is as yet, certainly statistically speaking, a wide-open empirical question.

From a historical perspective it seems inevitable that the next years of model-building in ecology will result in a gradual buildup of alternative, analytically tractable models with both qualitative and quantitative ends, models that will not all claim or be shown to mimic the same phenomena. This should lead to an embracing of the empiricist's precious detail with mathematical theory and a lessening of hostilities. Where will MacArthur's models fit in? Perhaps because they are primary and were constructed with great naturalist's insight, they will have the largest or most central domain, a place they already enjoy in many areas today.

For the present, MacArthur's book is the outstanding example of the qualitative-mathematical approach to ecology. And though some may disagree with the method, there is an uncluttered crispness to the book that other styles cannot match. It is difficult to imagine an ecologically minded person who would not profit in some major way by reading this book.

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II. Analogues in the Social Sciences

Mathematical population biology and mathematical social science have long been loosely linked. Partly this linkage derives from long-standing analogies between ecology and economics; partly it is the result of the existence of mathematical fields such as demography which fall on the borderline between biology and social science. Despite these connections, however, few contemporary social scientists are *au courant* of hot areas in mathematical ecology and evolutionary biology which logically should be of considerable interest to them as theorists of human society. This situation is unfortunate. Population biology, broadly defined to subsume ecology, population genetics, evolutionary theory, and comparative studies of social behavior, has been moving rapidly in the past 15 years. This progress has in great part been due to the work of mathematically oriented theorists and phenomenologists including, among others, MacArthur, R. Levins, R. C. Lewontin, E. O. Wilson, and W. D. Hamilton. These investigators have shared the common objective of transforming large areas of descriptive natural history into a single basic science. The aim of this science is to deduce as much as possible about the behavior of biological populations from a limited set of central principles having to do with such concepts as competition, predation, cooperation, niche and habitat structure, colonization, and extinction.

MacArthur's book should serve as an excellent introduction for social scientists interested in becoming aware of these developments. *Geographical Ecology* is in some ways the first such survey since Lotka's classic *Elements of Physical Biology* (*1*), though MacArthur's personal tastes, combined with the complexity and constant development of contemporary population biology, make his choice of topics far less broad than Lotka's. For quick and enjoyable reading by mathematically oriented outsiders to his specialty, MacArthur's book is ideal in its emphasis on principles without a great burden of biological detail. The models are based largely on work of MacArthur and his colleagues that for the most part has previously been available only in a scattered periodical and monograph literature. By contrast to that used in contemporary mathematical economics and psychology, and to a lesser extent mathematical sociology, the mathematics itself is typically very simple, seldom involving more than ingenious use of graphs and algebraic manipulation at the level of elementary ordinary differential equations. There are occasional lapses from mathematical exactitude, as when "function" is clearly taken to mean "elementary function" on page 35; and in some cases it is unclear how much the results depend on simple functional forms in the equations chosen for reasons of analytical and expository convenience. On balance, however, the pervasive atmosphere of simplicity and the originality of the formulations should be refreshing to the economist bored with the aridity of axiomatic utility theory or the sociologist tired of Markov chains.

As with all good model-builders, MacArthur's instinct is to start with very simple models and look at once for nontrivial effects. There are many brilliant examples of his success in this quest. Of particular interest to economists will be the discussion (pp. 231ff) of a quantity Q which is minimized under interspecific competition and the use of this quantity to predict a relation between species packing and patchy species ranges. Some of the simplicity of the discussion is a facade: the ramifications of competition theory can be made virtually as complex as desired. For example, a recent paper of May and MacArthur (2) confronts the mathematical problem of determining minimum eigenvalues of certain competition matrices whose elements are convolution integrals. This question arises in connection with attempting to specify maximum possible niche overlap, and leads eventually into the theory of Toeplitz forms and related algebraic eigenvalue problems, not to mention the additional complications that arise when we add stochastic forcing terms to our differential equations (as turns out to be of more than simply technical interest since environmental variability has an important effect on species packing).

Interesting from the standpoint of economic analogies is the treatment of immigration-extinction curves in the MacArthur-Wilson theory of island biogeography (see especially pp. 97ff, originally published in more detail in a monograph by the same authors [3]). Here graphical equilibrium ideas, highly reminiscent of determining the Marshall point by intersecting demand and supply schedules for one commodity, are used to develop a theory of colonization of islands by mainland species. Many nontrivial qualitative patterns can be derived from the analysis of colonization phenomena. For example, recent birth-death process results of Goel and Richter-Dyn (4; extending work of MacArthur and Wilson; see pp. 121ff) show that there typically exists a critical threshold size after reaching which a population of colonists is virtually certain to climb to the carrying capacity of the site and live an essentially infinite period in the absence of other than demographic pressures, and below which the population has a non-negligible extinction probability. This kind of result illustrates one of the many kinds of threshold phenomena that can be found in population biology models, both in ecology and in genetics. It is probably fair to say that the population biologists have been more ingenious and successful in capturing threshold effects in formal models than have theorists of economic takeoff and social change, and the possibility of feedback from population biology to modeling in these specific areas of sociology and economics may be considerable.

Underlying all of MacArthur's formal considerations, and deeper than the mathematical models themselves, are a series of substantive ideas and emphases of central importance to contemporary ecological theory. A very important group of these ideas centers around the crucial importance of environmental complexity as the basis of many ecological phenomena. Typically, for example, a variegated physical environment may give a less efficient or prey species some zones of sanctuary from a more efficient or predator species, if only because complete exploration of the environment is excessively costly for the dominant species (pp. 22ff). Here environmental complexity has the effect of introducing what in economics would be called a kind of transaction cost inhibiting the competitive exclusion process, and a variegated environment plays an essential creative role in the maintenance of species diversity. The function of complexity in creating and stabilizing patterns of coexistence is the basis of MacArthur's profound skepticism about the value of laboratory studies as a foundation for ecological theory. "What distinguishes the whole intertidal zone from a laboratory bottle," he comments (p. 30), "is its size and the lack of synchrony of its parts." He then continues by pointing out that here lies the reason for the coexistence of starfish and barnacles in the intertidal zone even though the starfish can be shown to be fully capable of eating all the mollusks and barnacles on the beach. In the orientation of ecological theory which MacArthur favors, the difficulty of designing and implementing ecological experiments is hence converted from the putative Achilles' heel of the field to one of the main directions of ongoing investigation. The desirability of focusing ecological research on complex environments is very clearly argued in the discussion of the relative analyzability of temperate and tropical regions (p. 199):

> A few decades ago it was fashionable for ecologists to study communities in the arctic on the grounds that these would be very simple communities and hence easy to understand. Many excellent ecologists still follow this belief, but there are others who feel that it may be easier to understand the extremely complex communities of the tropics. This sounds paradoxical: How can a more complex community be easier to understand? A possible answer might be that the complex community has strong interactions among species so that the lives of the separate species are less independent than in a simple community. Where there is greater interdependence, patterns may be more conspicuous.

A different aspect of the role of environmental heterogeneity appears through the existence of random effects: complex environments can usually be described in probabilistic terms, and random effects may usually be interpreted as the result of degrees of freedom in the environment not taken into account in a particular model. Population geneticists have long been aware of the creative potential of random processes in evolution, exemplified in the key role of genetic drift in Wright's island model of group selection (5). As the more recent fitness set models of Levins (6) show, environmental randomicity of various kinds may have important implications in triggering evolutionary sequences that would be impossible or unlikely in nonstochastic environments. A particularly elegant example of the subtleties involved in adapting to changing environments is a model of Cohen (7; discussed by MacArthur, pp. 165ff) which shows that the response of annual desert plants germinating in variable climates crucially depends on the dispersal ability of the species involved.

The creative role played in mathematical ecology by environmental heterogeneity and fluctuations has suggestive implications when compared with the situation in much of economic and social theory. Most areas of mathematical social science have been heavily influenced by probabilistic modeling, but the major models do not seem to have been nearly as effective as those in population biology in turning the existence of complexity and variability to advantage. Exceptions, of course, include queuing and inventory models in operations research, where the stochastic nature of demand and supply flows creates the problem to be attacked; but these models have seen few applications in fundamental social and economic theory. The picture of economic structure underlying neoclassical price theory is not at all that of a complex and constantly shifting MacArthur-Levins environment. Despite a few refreshing exceptions (for example, the essay on uncertainty and medical care by Arrow in *Essays on the Theory of Risk-Bearing* [*8*]), latter-day extensions of economic formalism to include uncertainty in consumption outcomes and other effects of environmental complexity are often developed largely as afterthoughts, and their implications for the fundamental nature of economic activity are not exploited. Some of the differences between neoclassical economics and ecology in this respect may be conveyed to the economist if he is asked to envision a disaggregative economics built *ab initio* around the existence of market imperfections. Interestingly enough, at least one noneconomist mathematician, Schwartz (*9*), has been highly receptive to a similar point of view, as when he lays stress on a model where in a situation of absolute oversupply (in perfect market terms) imperfections allow nonzero profits to persist.

As far as structural sociology is concerned, the handling of complex environments in formal models is even less convincing. An important strand of model-building in this area stresses a picture of social organization as being archetypically derived from elegantly balanced and symmetric algebraic structures (balanced graphs, linear hierarchies, lattices, mathematical groups and semigroups). These patterns are viewed as being imperfectly realized in reality, but play the role of "deep structure" which it is the job of sociometry and related fields to divest of an overlay of random noise (see, for example, Lorrain, *Réseaux Sociaux et Classifications Sociales* [*10*]). Many mathematical developments in organization theory and social mobility work equally well in deterministic or stochastic versions, an indication that random factors are inessential to the structure of these models (see White, *Chains of Opportunity* [*11*]). Once again, the models make little constructive use of the muddiness which real social life evinces in even the most tightly organized social system. The failure of the models to derive power from the complexity and uncertainty of social environments is rendered more conspicuous by the fact that many institutional sociologists have an intuition similar to that of population biologists that an essential element of their subject may be connected with apparently "frictional" phenomena (one recalls Crozier, *The Bureaucratic Phenomenon* [*12*], and the vacancy chain concept of White [*11*]).

Another major set of themes in *Geographical Ecology* is the importance of the dual processes of extinction of local populations and colonization of vacant sites. Several sections of the book are devoted to the circumstances surrounding these phenomena. A number of the most intriguing results are connected with the effects of species packing upon likelihood of extinction. For example, it is shown in quantitative terms (pp. 44ff) how difficult will typically be the position of a species sandwiched between two other species along a resource continuum, a model situation which should be suggestive to theorists of oligopoly. The focus on extinction and colonization is especially strong in the discussion of the island view of competition, which views a species as consisting of a network of largely isolated subpopulations having a comparatively high frequency of local extinction. This phenomenology is consistent with sites including mountaintops, patchy forest, logs, and a wide variety of other natural habitats in addition to islands in the conventional sense.

The emphasis on colonization and extinction events is in sharp contrast to the tendency of most social science to evade the analogous problems in its mathematical models. Sociological model-building seldom progresses beyond dealing with processes involving fixed sets of categories such as attitudes or social classes; the ontogeny or dissolution of such a categorical system, even in a highly local environment, is almost never tackled from a formal standpoint. In economics, as Koopmans has pointed out (*13*), the neoclassical theory in general avoids dealing with the possibility that households may not receive a survival consumption bundle under a competitive allocation; Koopmans stresses that the most suitable interpretation of the theory might be as a model of comparatively self-sufficient farmers who do a little trading on the side. Growing populations are similarly embarrassing. On the production side, neoclassical economics handles the conditions for firms to enter or leave a market somewhat more explicitly, but evolutionary processes such as the formation of new product markets and the death of old industries are usually modeled at quite a primitive level, far removed from the central theory. By contrast, ecological theory is full of interesting predictions for analogous phenomena, such as the way in which heavy predation of the most common resource species may make all resource species rare and hence have the effect of creating new niches and increasing possible species diversity (pp. 193f).

Work in biological ecology and in population biology as a whole can at most stimulate human social science; it can neither subsume nor be subsumed by it. Many of MacArthur's cleverest points turn out to depend crucially upon some highly specific biological facts which enter the argument at key places. There is no role in basic ecological theory for decisions taken by a single individual or a small number of individuals which affect a far larger population; biological populations are in general simply not that highly organized. Because of the absence of written or oral tradition, the role of history in ecology is quite different from that in human society (though evidence from the past in a sense can enter into the makeup of a species population by such phenomena as second-order selection controlling the mutation rate at a genetic locus). Again, as far as ecology and economics are concerned, there is no ecological analogue to the full Banach space duality between prices and commodities upon which neoclassical price theory is founded, though partial forms of price theory may be found implicit in Levins's fitness sets.

Despite these caveats, there is considerable promise in more frequent interaction between model-builders in mathematical population biology and in social science. Observing contemporary mathematical social science, one tends to be suspicious that modeling in this area is showing incipient arteriosclerosis, with few real innovations and much elaboration of long-known results. Population biology is an energetic field which has many open avenues along which further progress will certainly be made in the next five years, especially in the direction of sociobiology and evolutionary ecology in complex environments. Social scientists would benefit from knowing more about this discipline, not merely because of the routinely affirmed importance of knowing man's biological heritage, but much more importantly because ecology and related disciplines are showing enviable ingenuity in attacking some of the same theoretical problems that social science faces.

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Medical Practice in China: A Compendium

Nongcun yisheng shouce (Peasant Village Physician's Handbook). Compiled by the Medical Revolutionary Committee of Hunan. People's Hygiene Press, Peking, ed. 4, 1971. 1200 pp. Soft plastic cover.

The consequences of the Chinese Cultural Revolution ramify over vast areas of Chinese thought. Medical practice, research, and education have undergone great changes. In place of the priority formerly given to sophisticated and centralized care, large cadres of what we would call paramedical personnel have been educated to offer public health services and basic therapy to the rural majority of the population. Whether "barefoot doctors" with only half a year of formal medical training can competently discharge their responsibilities for hygienic education, low-level treatment, and referral to higher facilities has been the object of much speculation.

The present book, of which copies are on sale at exhibitions of Chinese products in Japan, is of extraordinary interest. Said to be printed in over a million copies, it is intended for general use in the Chinese countryside, to be studied as a textbook by all those having to deal with health- and sick-care and used as a handbook by doctors with more extensive theoretical training. The picture it gives of treatment methods in common (or recommended) use shows that modern Western medicine and traditional Chinese medicine have to an astoundingly high degree been synthesized into a kind of eclectic medicine since the last prejudices against the native medical tradition were eliminated in the Cultural Revolution.

Citations of Chairman Mao, of course ubiquitous, appear not only in the headings of different chapters but also in discussions of particular problems. They are especially prominent in the discussions of matters on which public health policy has focused popular attention—general hygiene, harmful insects, schistosomiasis, venereal diseases—and of disorders for which new treatment methods recently have been introduced, such as deaf-mutism.

The book covers a vast range of subjects from protection against nuclear and biological warfare (43 pages) to ear acupuncture (which involves a choice among nearly 100 points on the ear to affect various parts of the body). The first chapter is entitled "Extinguish the four pests," these being rats, flies, mosquitoes, and bedbugs. Poisons for these four, as well as for cockroaches, fleas, and lice, are described in detail. Descriptions of secure latrine constructions follow, and attention is paid to sanitation and water and food hygiene, as well as to labor hygiene. Special stress is put on the prevention of epidemic disease.

Ten pages of basic statistical methods with stress on error analysis are of utmost interest, in view of the notorious disregard of statistical methods in traditional medical thought. In exercises the reader is informed (whether accurately or not I cannot tell) that in "a certain commune" the incidence of splenomegaly among the population between 1951 and 1957 decreased from 42.1 to 1.7 percent, and further, that of 1655 deaf-mute patients subjected to the new intensive acupuncture treatment 176 gained "normal hearing," 396 made "definite improvements," 923 experienced "improvements," and 160 showed "no result." The causes of noncongenital deafness are said to have been "infection" in 16.9 percent of patients, otitis media in 12.4 percent, meningitis in 6.5 percent, streptomycin nerve damage in 0.9 percent, "high fever" and "pulling wind" (two traditional terms hard to correlate with Western terminology) in 27.8 percent, and "other causes" in 35.5 percent. Which type of deafness is best affected by the treatment is not noted.

Traditional Chinese medicine comprises an independent nosology, diagnostics, pharmacology, and stimulation treatment (the last including acupuncture, moxibustion, and massage). Classical diagnostic methods such as pulse palpation and tongue inspection are described in a separate chapter into which modern conceptions do not enter. Paradoxically, traditional methods are not used in the ensuing reviews of specific diseases, where the disorders are classified, named with a terminology purely Chinese in formation but modern in character, and diagnosed by methods familiar to Western doctors. Not until the treatment sections are the "Western" diseases subclassified in a classic terminology. Herbal treatment is given following analysis of the modern disease entity in classical terms. Traditional drug therapy for, say, rheumatoid arthritis follows three main lines depending upon whether this disease is "cold," "damp warm," or "blood empty" (literal but admittedly unfair translations of highly technical designations). The procedures for taking the patient's history, as well as describing symptoms, and making physical examination and differential diagnosis are throughout in accordance with the Western pattern.

Bronchial asthma can be taken as an example. Diagnosis is completely Western. The first treatment is needling of up to five specified acupuncture points. In case of negative results prescriptions of ephedrine, aminophylline, isoprenaline, and adrenaline are recommended. This failing, two complicated herbal medicines are suggested. The choice between them is decided under guidance of the impression of the radial pulses, the pulse frequency, and the condition of the expectorate and the tongue. In the most severe cases corticosteroids are given intravenously, as well as licorice and potassium iodide orally.

Diseases treated almost exclusively by traditional methods include acute bronchitis, chronic gastritis, nonspecific urethritis, portal cirrhosis, rheumatoid arthritis, polyneuritis, neuralgia, and paretical conditions. Exclusively Western treatment is given to heart diseases (mainly mechanical diseases and cardiac insufficiency, not angina pectoris), endocrinological disorders, electrolyte disbalances, and many surgical conditions. Most other ailments are given combined treatment. Most interesting are hypertension, ulcus duodeni, appendicitis, cholecystitis, hemorrhoids, malignant tumors, shock (up-to-date fluid therapy including dextrane, *and* acupuncture), and psychic disturbances.