less, he does not elaborate on how these changes may be effected. In game situations in which an initial equilibrium is Pareto-inferior, some kind of concerted action or outside intervention is necessary to reach a new and presumably better equilibrium. It may involve the formation of a coalition or the modification of certain rules of the game. The process through which these changes may be brought about must be studied and understood before a concept such as X-efficiency can have any operational significance.

Of course, another way of effecting change in economic outcomes is to transform the objectives, attitudes, and behavior of the individual economic actors. For instance, the members of a firm may be educated to become more public-spirited and less selfish, and productivity may in fact rise as a result. It is not clear whether Leibenstein would include this type of productivity change under the rubric of X-efficiency, since there is virtually no mention of attitude or behavior modification in this book.

In order to study the behavior of a household or a firm as the result of a game, it is essential to study the determinants of the choices of the individual members at the individual level. Leibenstein discards the conventional perfectly knowledgeable, perfectly foreseeing, and mechanically and perfectly utility-maximizing economic actor and replaces him with an economic actor who may not possess complete information or perfect discriminatory power, and who may even have "thick" indifference surfaces. Leibenstein also assumes that the processes of decision-making, adjustments, and transactions are not costless. The economic actor is faced with both subjective and objective costs of information collection (or experimentation), processing (or calculation), adjustments, and transactions. Leibenstein does not use these terms, but the costs that he refers to are nevertheless the same as those taken into account by modern economic theorists in their analyses of these same economic phenomena. Given that these costs exist, and assuming that the economic actor does not derive any direct satisfaction from incurring them, it is immediately obvious that there will be a bias in favor of maintaining the status quo in the face of small perturbations of the system unless certain thresholds are exceeded. This bias leads to the existence of what Leibenstein calls "inert areas," which he uses to explain a variety of economic phenomena.

There is one other central idea in the book, that is, that certain "targets," or "standards," or "social reference groups" influence economic behavior. Leibenstein attempts to explain behavior in terms of an economic actor's desire to be in some sense "close" to these norms. However, his explication leaves unanswered the fundamental question of how these norms are determined. Conformity and emulation may have great power to explain the lack of dispersion of actions, but they do not explain why a norm is what it is for a given population. In this regard, Leibenstein's theory is really incomplete. This type of theory does not explain the underlying structure, and although it may do quite well in the short run, it may fail miserably if conditions change sufficiently to shift the "norm."

Has Leibenstein completely abandoned the notion of an "economic man?"

A careful reading of his book suggests that he has not. While the economic actor in Leibenstein's theory differs significantly from his classical counterpart in his knowledge, discriminatory power, and computational ability, and although he has to bear a greater variety of pecuniary and nonpecuniary costs, he is nevertheless assumed to choose from his possible actions the most preferred one. For example, Leibenstein assumes that "each member [of a household] wants as much as possible of the household income" (p. 184). The individual's motivation is still primarily economic; his objective is primarily private; and his considerations are primarily selfish. In fact, the economic actor may have become even more calculating, since he is now expected to take into account the actions and potential actions of the other members of his group. Thus it appears that Leibenstein has merely made "economic man" more realistic and sophisticated and less mechanical without making major changes in the assumptions about his nature and motivation.

It is relatively easy, however, to introduce into Leibenstein's analytical framework the assumption that the levels of well-being of each of the other members of a group, or the quantities of specific commodities consumed by each of the other members of a group, enter directly into the determination of each individual member's objective or utility function. This assumption represents a true departure from the "economic man" paradigm and may indeed lead to interesting new outcomes.

Finally, one cannot conclude this review without commenting on Leibenstein's view of the methodology of economic science, since he devotes a whole chapter to it. Leibenstein asserts that in economics "explanation without prediction is sufficient." Almost all economists agree that explanation is necessary. But to claim that explanation in itself is sufficient to validate a theory leaves one with no rational basis for discriminating among competing theories, all of which may appear to explain the historical data well but may yield different predictions. Leibenstein's view on this issue does not represent that of the majority of the members of the economics profession. Whether his theory as expounded in this book, promising as it seems, will become the foundation for a new microeconomic theory depends not so much on its ability to explain observed historical facts as on its ability to help economists predict outcomes more accurately.

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Paleoceanography

Jurassic Environments. A. HALLAM. Cambridge University Press, New York, 1975. x, 270 pp., illus. $32.50. Cambridge Earth Science Series.

The Jurassic Period (135 to 195 million years ago) is best known as the interval during which the present Atlantic Ocean began to be formed by rifting apart of the previously unified Pangean continent. To geologists the name Jurassic is inextricably tied to a host of famous rocks including the Solnhofen Limestone (with its *Archaeopteryx*), the Minette iron ores of Lorraine, and the western North American Morrison Formation with its renowned dinosaur faunas.

Previous monographs on geologic periods (including Arkell's monumental treatment of the Jurassic published in 1956) have been devoted to detailed descriptions of stratigraphic sections. Hallam's approach is different in that he provides an interpretative account. *Jurassic Environments* treats of geography, bathymetry, tides, currents, temperatures, salinity, and biogeography. In fact, the book might as well be called applied paleoceanography.

In matters geologic, approximately half the book is a synthesis of facies patterns of sand, calcareous, siliceous, and ironstone deposits of northern, central, and southern Europe and northern Africa. A brief chapter (15 pages) treats facies of the United States Western Inte-

rior. Special attention is given in these sections to evidence from geochemistry, sedimentary structures, electron microscopy, and (surprisingly) trace fossils in discussing the origin of bituminous shale horizons, nodular limestones, and chamosite oolitic iron ores. Hallam is quite fair in presenting alternative points of view on these controversial topics.

Places and times of mountain building and igneous intrusions are considered as the expected results of processes tied to plate tectonics. Mountain building is believed to have been increasing through the Jurassic, coinciding at the end of the period with a pronounced marine regression and faunal extinction. No new paleogeographic reconstructions are presented. Paleoclimatology is well discussed in a separate chapter, but in the next edition Hallam may wish to improve the discussion by including charts of inferred climatic zones. Hallam expresses serious doubts about the worth of paleotemperature estimates based on oxygen isotope ratios: "The more thorough the work, the more complications have arisen." Thus, "it seems extremely unlikely that [oxygen isotope analysis] can add anything to what we can already infer from fossils and sediments about Jurassic climates" (p. 196).

In matters biologic, the major debate among those concerned with the Jurassic is how to account for diversity gradients and biogeographic provinces in a world in which the latitudinal temperature gradient was much weaker than it is today. The range of sea temperature from the tropics to the poles is about 30°C today and in the Jurassic was only about 15°C, with the polar region much warmer than at present. Explanations for the paleobiogeographic patterns have centered on establishing a correlation with the inferred Jurassic trends in temperatures, physical barriers, salinity, and bathymetry. Hallam indicates that any explanation in terms of a single factor would be insufficient. He appeals to a correlation between overall environmental instability and latitude, instability presumably being greater at higher latitudes.

Regardless of whether any specific correlation between an environmental factor and a paleobiological pattern is apt, this approach highlights a lack of focus on causal mechanisms. For example, the zoogeographic influence of ocean currents is probably not, as Hallam states, "primarily one of temperature" (p. 211), but rather may be to enable (and prevent) dispersal and gene flow. A couple of degrees of latitude may make very little difference in temperature but an enormous difference in a current system and therefore in species distributions. Hallam's discussion of Western European and North American biogeographic provinces (in the appropriate Jurassic geographic framework) is well done and interesting, but again the approach is strictly empirical. There is little effort to establish a deductive model of what biogeographic provinces should have been expected. Hallam's discussion of diversity and provinces therefore is not as rigorous as the facts of the case may warrant.

Hallam is also not particularly rigorous in his paleoceanographic models, which, nevertheless, are well presented and stimulating. Of greatest interest is the claim that the presence of a reduced latitudinal temperature gradient resulted in a weaker atmospheric circulation to the point that ocean circulation was measurably more sluggish, thus leading to a significant reduction in mixing of nutrients and oxygen. Indeed, he writes, "In the more equable periods of the past, such as the Jurassic, much of the ocean bottom could have been more or less stagnant" (p. 60). A firm paleogeographic basis for this model is nowhere developed. To cite another example of assertion that could have been better substantiated, Hallam concludes that the Jurassic epicontinental seas were "quite possibly almost tideless over large regions." Hallam presents some sedimentological evidence to support this claim, but one might reasonably expect that a paleogeographic analysis would also be forthcoming.

The counterbalancing and considerable strength of Hallam's book is that these hypotheses force us to address directly the new paleoceanographic questions, and they therefore move us a major step beyond customary stratigraphic reporting. Hallam has played an active role in work on Jurassic geology for the past 20 years. It is to his great credit that he endorses the view that the appropriate Jurassic research question is not only What are the Jurassic sediments of (say) Greenland? but also What would be the effect of a lower temperature gradient on ocean circulation? Hallam's book not only clearly shows us the necessity for students of geologic history to ask both geologic and oceanographic questions, but also tries to provide reasonable answers.

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The Interstellar Medium

Atomic and Molecular Physics and the Interstellar Matter. Proceedings of a summer school, Grenoble, France, 1974. ROGER BALIAN, PIERRE ENCRENAZ, and JAMES LEQUEUX. Eds. North-Holland, Amsterdam, and Elsevier, New York, 1975. xxii, 632 pp., illus. $66.75.

It is difficult to view in perspective the diverse recent developments in research related to the physics of the interstellar matter. Many new interstellar molecules have been discovered and mapped by radio astronomers. The diffuse interstellar medium has been studied to advantage in the far ultraviolet by instruments on spacecraft. Advances in infrared astronomy have made possible probes of relationships between gaseous and solid material and between cloud structure and the process of star birth. Collectively, the 11 lecture courses of the 26th Les Houches Summer School of Theoretical Physics provide a much-needed, broad perspective on the field. Although some of the details may be ephemeral, the lectures in this volume all reflect sound physical intuition and will therefore remain useful for some time to come.

The chapters on atomic physics (H. Nussbaumer), collision theory (D. Flower and R. McCarroll), and gas dynamics (F. Kahn) are well organized in the manner of textbook presentations and generally succeed in covering vast amounts of material concisely. S. Green provides a theoretical treatment of molecular structure and collision processes with attention to recent work relevant to interstellar clouds. W. D. Watson's very thorough course on molecule formation handles the subject with physical insight. Watson shows how molecules provide probes of conditions in clouds and also discusses in detail the physics of interstellar grains. D. Flower contributes a clear, concise treatment of ionized nebulae. A. A. Penzias's discussion of dense neutral clouds makes clear the connection between instrumental measurements and physical conditions of the clouds. It reflects, however, a somewhat parochial view, dealing only with observations at millimeter wavelengths. The intricacies of interstellar maser processes and the baffling body of observational data are reviewed by P. Goldreich. The lecture on heating and ionization by G. B. Field is a provocative treatment of the thermal and dynamical state of the interstellar gas. Field deals with the large questions of the evolution of diffuse matter in the Galaxy by painting global pictures while paying attention to micro-