of observational astrophysics, the founder of three major observatories, and a statesman of science on both the national and the international level.

Hale's discovery of the magnetic fields of sunspots was a major contribution to knowledge, and his invention of the spectroheliograph provided an important research tool for the study of the sun. In addition to his own research activities, cut short by poor health in 1910, he encouraged and actively supported the work of younger astronomers who wanted to embark on careers in the "new" astronomy.

Founder of the Yerkes Observatory (1897), the Mount Wilson Observatory (1904), and the Mount Palomar Observatory (1928), he created research facilities on a larger scale than anything previously in existence. At the time of its dedication in 1948 the 200-inch telescope was named the Hale Telescope, and more recently the combined Mount Wilson and Palomar Observatories have been renamed the Hale Observatories, fitting tributes to the memory of the man most responsible for their existence.

Hale's activities outside the field of astronomy are perhaps less well known. His organizational genius and ability to persuade wealthy persons and organizations to support scholarly endeavor were devoted to such things as the establishment of the Henry E. Huntington Library and Art Gallery in 1927 (after 21 years of discussion and persuasion) and the transformation of the Throop Polytechnic Institute into the California Institute of Technology. Following his election to the National Academy of Sciences in 1902, he took the lead in enlarging and reorganizing the academy to give it a larger role in American science. He also took the lead during World War I in the organization of the National Research Council under academy auspices, and after the war was responsible for the establishment of the National Research Council Fellowships for postdoctoral study and research. On the international level, in 1904 he pushed for the formation of the International Union for Cooperation in Solar Research, which was replaced after the war by the International Astronomical Union. In 1918 before the war had ended he proposed the creation of an International Research Council, and he took part in the organizational meeting in Paris immediately after the Armistice. This organization was later renamed the International Council of Scientific Unions.

The detailed enumeration and description of Hale's varied activities is to be found in Helen Wright's biography *Explorer of the Universe*. The book under review, *The Legacy of George Ellery Hale*, has a different purpose from a biography, and it does its task very well. The book is divided into three sections: (i) a 110-page broad-brush biography with many illustrations; (ii) 89 pages selected from the papers of George Ellery Hale, including his article in the April 1928 issue of *Harper's Magazine*, "The Possibilities of Large Telescopes"; and (iii) Perspectives, 75 pages devoted to four articles about subjects related to Hale and his work; the authors are C. D. Shane, I. S. Bowen, R. Howard, and D. J. Kevles. For the general reader who is not interested in minute biographical details this is an excellent book. The combination of a large number of thoughtfully chosen illustrations with a well-written text gives the reader a real feeling for what Hale was like and what he did for astronomy, and for America and the world.

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Unexplained Phenomena

UFO's—A Scientific Debate. An AAAS symposium, Boston, Dec. 1969. CARL SAGAN and THORNTON PAGE, Eds. Cornell University Press, Ithaca, N.Y., 1973. xxii, 310 pp., illus. $12.50.

The nature, history, and current status of the issues raised among scientists by reports of unidentified flying objects have been summarized recently by Bruce Murray in his review (*1*) of *The UFO Experience* by J. Allen Hynek (*2*). Since the observational data have a low signal-to-noise ratio, since the most widely publicized hypothesis (that UFO's are of extraterrestrial origin) seems to belong to science fiction, and since some reported sightings appear to contradict tenets of present-day science, one can hardly be surprised that many scientists refuse to take the problem seriously and that the discussion has sometimes proceeded in an irrational and unscientific manner. If we are to make any progress in understanding the UFO problem, the first requirement is that the treatment it receives, from friend and foe alike, should be sanitized.

Scientists generally regard the Condon Report (*3*) on the Colorado Project as being the principal published record, but that report has not settled the issues. Most scientific journals seem unwilling to publish articles on the subject, and the scientific world has therefore been deprived of further presentation, evaluation, and interpretation of the data. In these circumstances it was most commendable of the American Association for the Advancement of Science to arrange a two-day symposium on the UFO question in December 1969, organized by a distinguished panel consisting of Philip Morrison, Thornton Page, Walter Orr Roberts, and Carl Sagan; and it is useful to have now this volume containing the written version of contributions to that symposium.

Since the volume is entitled *UFO's —A Scientific Debate*, a reviewer is immediately faced with two questions: Was it a debate? and Was it scientific? My answer to each question is an unenthusiastic "Yes, to some extent," but this is probably the most that could be achieved at that time, and the organizers and editors deserve our thanks.

A debate is usually conducted between two teams arguing for and against a certain proposition. In this case, the proposition can be taken to be that UFO reports represent a real and significant phenomenon deserving the attention and efforts of the scientific community. The principal protagonists are J. Allen Hynek, astronomer, and the late James E. McDonald, atmospheric physicist. Among their supporters are Robert M. L. Baker, Jr., film analyst, and Robert L. Hall, sociologist. The opposition is spearheaded by Donald H. Menzel, astronomer, who is supported to various degrees by Frank D. Drake, radioastronomer; Lester Grinspoon and Allen D. Persky, psychiatrists; William K. Hartmann, astronomer; Philip Morrison, astrophysicist; and Carl Sagan, astronomer. The remaining contributors, who do not give strong support to either side, are Kenneth R. Harvey, expert on radio propagation; Thornton Page, astronomer; Franklin Roach, astronomer; Douglas R. Price-Williams, psychologist; and Walter Sullivan, science writer.

The principal shortcoming of this

"debate" is that the contributions of the two teams have little common ground. The protagonists cite a number of "hard-core" cases which cannot easily be identified in terms of known phenomena. The opponents cite primarily cases that can readily be explained. McDonald devotes 67 pages to four important cases, two of which (*4*) have been published in the journal *Astronautics and Aeronautics* at the instigation of a subcommittee appointed by the American Institute of Aeronautics and Astronautics. All four are radar-visual cases, and all are discussed in the Condon Report.

The first case (identified as South-Central U.S., 17 July 1957) is summarized by McDonald approximately as follows: An Air Force RB-47, equipped with electronic countermeasures gear, was followed by an unknown object for a distance of over 700 miles. The object was, at various times, seen visually by the cockpit crew as an intense luminous light, followed by ground radar, and detected on ECM monitoring gear aboard the RB-47. Of special interest are several instances of simultaneous appearances and disappearances on all three physically distinct channels, and a rapidity of maneuvers beyond the prior experience of the air crew. It is to be noted that McDonald's account is based on a contemporaneous case report in Air Force files which was not located by the Colorado Project staff because of an error about the date. Nevertheless the Condon Report account (*3*, pp. 56, 136, 260), as far as it goes, substantially agrees with McDonald's.

The second case (Lakenheath and Bentwaters RAF/USAF, England, 13–14 August 1956) is notable in that objects were observed over a period of five hours both visually and by radar, both from the ground and from aircraft. This seems to be the case taken most seriously by contributors to the Condon Report (where it is listed, rather oddly, as "Greenwich, Summer, 1956"). Thus the abstract of the case (*3*, p. 248) ends on the following note: "The preponderance of evidence indicates the possibility of a genuine UFO in this case"; and elsewhere concerning this case one finds (p. 164), "The apparently rational, intelligent behavior of the UFO suggests a mechanical device of unknown origin as the most probable explanation of this sighting." It is greatly to be regretted that no designated representative of the Colorado Project took part in the AAAS debate.

The other cases discussed in detail by McDonald are Haneda, Japan, 5–6 August 1952, and Kirtland Air Force Base, 4 November 1957, both of which are discussed briefly in the Condon Report.

The most important contribution from the opposition is Menzel's, which occupies 60 pages. It may be charitably described as a hearty polemic, aimed at "UFOlogists," otherwise termed "believers." Menzel regards the "extraterrestrial" hypothesis as a myth invented by modern man to explain any of a wide range of natural phenomena. He gives a two-page list of familiar phenomena which have been reported as UFO's, but attaches special importance to anomalous propagation of radio waves, which he invokes in explaining UFO reports based on radar observations. It is therefore somewhat disappointing that he does not deal with any of the four notable radar-visual cases described in detail by McDonald. Only one case is discussed both by Menzel and in the Condon Report (*3*, pp. 170, 310)—that of Colorado Springs, 13 May 1967, which is a curious instance of a radar return (seen on two radars) accompanying an aircraft as it came in for landing, no corresponding object being visible. Menzel attributes this case to a ground reflector, an explanation which is considered and rejected in the Condon Report.

Photographic evidence is discussed by Baker and by Hartmann. The case treated in most detail is that of Great Falls, Montana, August 1950, discussed in this volume by Baker and in the Condon Report (p. 407) by Hartmann. They agree that the images are difficult to reconcile with aircraft or other known phenomena. Baker finds the analysis of old material to be frustrating, however, and calls for more sophisticated analysis of fresh observational data.

Since the bulk of UFO reports are narrative in nature, the views of sociologists and psychiatrists are significant. Grinspoon and Persky discuss the possible significance of psychological aberrations of the witnesses, without referring to any specific case except in a heavily veiled manner. Hall takes the view that "when reasonable men report events which receive no social support from their friends and do not fit their own prior beliefs, we have to take these reports seriously," especially when "witnesses report details which are consistent with other reports that have *not* been described in the mass media."

Theoretical discussions are not completely missing. Both Roach and Sagan discuss the probability of extraterrestrial visitation, on the basis of our existing knowledge of astronomy and physics, and conclude that it is unlikely but not impossible.

Questions of scientific methodology are more difficult and more important in discussing a nebulous problem such as UFO's than in discussing an established problem of "hard" science. On the one hand, some scientists (including Condon, Hartmann, Menzel, and Morrison) call for one case with irreproachable credentials and inescapable significance, as the best, if not the only, means of establishing the reality and nature of the UFO phenomenon. Others (including Hall, Hynek, and Price-Williams) take the view that we should work with what we have (while trying to obtain better data) and examine the weight of evidence. The most specific and cogent recommendations for future research are set out in the article by Price-Williams. He divides the necessary research into four stages which may be described briefly as data-gathering, data-evaluation, pattern-recognition, and hypothesis-testing, and points out that almost all the research that has been done (including the Colorado Project) ends at the second stage.

A reading of this volume leaves many questions in one's mind. What, for instance, is the responsibility of scientists in confronting a problem which is neither of their making nor to their liking? Are we entitled to ignore it until someone produces unimpeachable and irresistible evidence, or should we (as recommended by Price-Williams) use the Bayesian model of scientific inference, or some other scheme, to see which hypothesis stands up best in comparison with the available evidence? One may also ask who is competent to judge whether the UFO phenomenon is as important as McDonald believed, or the "nonsense problem" Menzel takes it to be. Hartmann's advice, "In the UFO business one can trust nothing secondhand," rules out scientists who have never examined and verified the data—which certainly disqualifies this reviewer and probably disqualifies the National Academy of Sci-

ences panel that reviewed the Condon Report. On the other hand, scientists who *have* looked closely at the data may come to be termed "UFOlogists" and held in disrepute. It seems that, in this business, you are damned if you do and damned if you don't!

As one can see from this volume, the UFO problem was not solved by the Condon Report, nor is it settled by this debate. The crux of the difficulty is perhaps that UFO reports have spawned not merely a problem but a heresy. It may be that concerned parties are not recognizing phenomena which are comprehensible in terms of present-day science (a view to which Menzel subscribes); or it may be that we are faced with a phenomenon which present-day science is unable to comprehend (a view to which McDonald would have subscribed). Modern heretics may not be consigned to the dungeon or the stake, but they could nevertheless call —with some justification—for less heat and more light.

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Dilemmas and Sure Things

Paradoxes of Rationality. Theory of Metagames and Political Behavior. NIGEL HOWARD. M.I.T. Press, Cambridge, Mass., 1971. xxiv, 248 pp., illus. $12.95. Peace Research Studies Series, 1.

"Free enterprise" is sometimes defended on the grounds that if everyone pursues his individual self-interest the result will benefit the collectivity. This simple economic notion has something of a counterpart in political thought, namely the idea of pluralism, where the "individuals" are special-interest groups rather than enterprises. Unfortunately the free interplay of political or economic actors need not lead to optimal results. A classic example of a nonoptimal outcome arises with nuclear armaments, where the actors are nations and where nonregulation leads to arms races and proliferation. We return to this example later. Another appears in Garrett Hardin's "The Tragedy of the Commons" (*1*), in which the self-interest that leads each individual to increase his herd finally renders the commons virtually useless to all for grazing (*2*).

The book under review confronts this dilemma of "individual rationality" at odds with "group rationality" on the level of highly abstract constructions called metagames. To move part way along the path to abstraction, consider the following gross simplification of an arms race: The actors are two nations, and it is assumed that each has two alternatives: to arm and not to arm. Individual national interest calls for arming, since if the other nation fails to arm the first can gain a diplomilitary advantage which outweighs the cost of arms, and if the other nation does arm then the arming of the first prevents unacceptable inferiority. Individual interest thus prescribes arming whatever you believe the other side will do. But if both nations arm the result is worse for both than if both decline to arm (*3*). This incompatibility between collective and individual rationality constitutes the second, and most celebrated, of Howard's three "breakdowns of rationality."

To resolve this paradox and to unify certain aspects of game theory, Howard introduces the concept of a metagame. Before defining metagames it is necessary to put in a word about games. To tie the discussion together, we shall use as a sample game one which has precisely the outcome-preference structure of the simplified arms race above.

A game in "normal form" has some number of players each of whom must choose one strategy from a set of available strategies. Choices are made simultaneously and privately. The particular alternatives chosen by the various players, taken together, constitute an "outcome." Players may have preferences among the outcomes. Thus in Matrix 1 (next page), player No. 1 chooses a row and player No. 2 a column. The cell so determined contains the respective "payoffs" to the two players. A payoff of "4" designates a player's most-preferred outcome, "3" is next best, and so on. This particular game is called Prisoner's Dilemma and (as promised) has the structure of the arms race model, above. The cell with payoffs 2,2 is an "equilibrium" because if either player unilaterally switches his choice from there the outcome is worse for him. This equilibrium is "deficient" or "group-irrational" because both players could simultaneously do better at the "group-rational" cell (3,3) which, however, is not an equilibrium; hence the dilemma and paradox.

"A *metagame* is the game that would exist if one of the players chose his strategy after the others, in knowledge of their choices" (p. 23). Thus for player No. 2 with Matrix 1, there would be four possible contingent strategies: unconditional C (choose C no matter what player No. 1 does), match player No. 1, do the opposite of player No. 1, and unconditional D. In Matrix 2 these strategies are denoted by C|C, C|D, D|C, and D|D, respectively, the letter before the vertical stroke indicating the response to No. 1's choice of C, the letter after it the response to No. 1's choice of D. This particular metagame is called the "2-metagame" (the "2" is for player No. 2) of Matrix 1; here Matrix 1 is called the "basic" game.

If now Matrix 2 is taken as basic and the 1-metagame is formed from it, we obtain a matrix with 16 ($=2^4$) rows, corresponding to all the ways of assigning C or D in response to the four alternatives for player No. 2 in Matrix 2. It is in this 16×4 second-order metagame, called the 1-2-metagame of Matrix 1, that the "second paradox" is resolved, for here there are no fewer than three equilibrium cells, two of which have the payoffs 3,3 and thus correspond to the cooperative or group-rational outcome in the basic game. Howard proves that no equilibria can be introduced or lost by ascending to still higher meta-levels.

Will it solve any political, or even philosophical, problems to know that the 1-2-metagame of Prisoner's Dilemma has an outcome which is both individually rational and group-rational? After all, players of a game—or real-