Maya. Did the Teotihuacanos introduce Star Wars among the Maya? Teotihuacan lords clearly inspired Maya kings of the Early Classic period to innovate war practices, but it is the Maya who certainly tied battle to appearances of the moving stars, the planets. Hirth also examines militarism, particularly from the vantage of Xochicalco. He makes a persuasive iconographic and archeological case that the military orders and conquest warfare of the Aztecs are presaged in this and other states which arose after Teotihuacan.

Did Teotihuacan launch this military quality of the Middle Age? The consensus is that it did. Andrea Stone, Joseph Ball and Jennifer Taschek, and Jeff Kowalski offer a series of perspectives from lowland Maya country on the military and economic repercussions of Teotihuacan and its fall. Stone shows that the military art of the Late Classic Maya kingdom of Piedras Negras displays clear affinities with Early Classic Teotihuacan military symbolism. She argues that Maya kings, beginning in the Early Classic, used the symbols of a dominant foreign power to declare their "disconnected" superior status over their people. Ball and Taschek argue that the legendary Itza of the Postclassic invasions of Maya country are in fact not foreigners but southern lowland Cholan Maya speakers who began as intermediaries in the militant Teotihuacano trade networks. They see western Itza and eastern Ytza factions carrying on the trade after Teotihuacan, eventually linking up to establish new domains in the northern lowlands by means of armed force and commercial acumen. Kowalski, provides iconographic and epigraphic evidence that Itza factions were indeed circulating around the Maya area from the southern highlands through the northern lowlands, establishing an areal network of power and trade. Surely the Itza were successful warriors and international in their political symbolism. The case can be made, however, for a substantial indigenous lowland Maya source of military and political inspiration that this volume neglects.

Marvin Cohodas does envision a Maya role in the Mesoamerica of the Middle Age. He suggests a temporal overlap between the fall of Teotihuacan and the rise of Chichen Itza in the Maya lowlands. He further suggests that Chichen Itza may fill the gap in political and cultural innovation between Teotihuacan and Tula through its participation in a broad restructuring of Mesoamerican elite culture in the dying days of the great Mexican city.

Finally, the two papers on Oaxaca illustrate both the theoretical aspirations of scholars trying to understand this tempestuous period and the empirical problems facing them. Marcus Winters provides an alarming analysis to the effect that there is a virtual hiatus in the data of the Valley of Oaxaca in this A.D. 700 to 900 period, that flanking periods have been squeezed over it in previous studies. Joyce Marcus, on the other hand, compares this Middle Age to similar times of trial in the Old World. She suggests that the break-up of large "Classic" states often results in smaller city-states. She further suggests that the Classic Mesoamerican states may have had confederate governments, with pre-existing cleavage lines along political factions that formed them. The principle of confederation is certainly present in the imperial phase of the Aztec empire that follows the Middle Age. Perhaps most intriguing about it in light of these recent interpretations, however, is the increasing evidence that Mesoamerica experienced no broad hiatus in urban society or civilized institutions as in Old World counterparts; it was, seemingly, as much a revolutionary as a devolutionary era.

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Telescopes and Determination

Astronomer by Chance. BERNARD LOVELL. Basic Books, New York, 1990. xiv, 381 pp. + plates. $24.95. Alfred P. Sloan Foundation Series.

Too few scientists devote the effort to writing their autobiographies. In comparison with soldiers and statesmen, they may feel less compelled to justify their actions, or that their work would be of little interest to the general public. Yet, as the preface to Bernard Lovell's *Astronomer by Chance* points out, "An understanding of the scientific enterprise, as distinct from data, concepts, and theories, is certainly within the grasp of us all. It is an enterprise conducted by men and women who are stimulated by hopes and purposes that are universal, rewarded by occasional successes, and distressed by setback." The Sloan Foundation is to be commended for bringing us this book, which better captures the personal side of the Lovell story than Dudley Saward's recent, *Bernard Lovell: A Biography* (Hale, 1984).

The book is organized into some 24 chapters each of which stands somewhat on its own. Chapters 2 through 22 describe Lovell's life in historical sequence, commencing with his experiences growing up near Bristol and later studying physics at Bristol University. The war years and Lovell's role in helping develop airborne radar (H_2S) at the Telecommunications Research Establishment are dealt with next. Returning to Manchester University after the war, Lovell set out, using surplus wartime radar equipment, to try to detect electron showers created in the atmosphere by energetic cosmic ray particles, an experiment based upon what later proved to be faulty calculations. The radar detected the ionized trails from meteors and led instead to their study, the discovery of the daytime showers, and settlement of the question whether sporadic meteors are of solar or galactic origin. A 220-foot vertically pointing, parabolic reflector then built to improve the prospect of detecting cosmic ray showers led in turn to work in radio astronomy, the construction of the 250-foot fully steerable telescope, and Jodrell Bank's place among the large radio astronomy observatories of the world.

Years ago, when reviewing *The Sleepwalkers* by Arthur Koestler, Lovell took issue with the thesis that unraveling the motions of the planets in the solar system was accomplished by chance rather than design. There is a mild irony in that his autobiography makes it clear that his own career was very much governed by chance. This is, however, an interesting tale, well told. Lovell has a gift for explaining the science involved in his work with a minimum of words, making the book eminently readable to the non-specialist. Lovell has had a remarkable ability to surround himself with bright people and stimulate them to do great things. He is unstinting in his praise for these associates and for the many other important figures in the British scientific establishment and at the University of Manchester who helped him.

Much of the drama in Lovell's story is centered on the construction of the 250-foot (Mark I) telescope, and the largest part of the book is devoted to this (and has been chronicled earlier by Lovell in *The Story of Jodrell Bank* and its sequel *Out of the Zenith* [Oxford University Press, 1968 and 1973]). Surprisingly, Lovell makes no mention of the partial stroke he suffered at the time of greatest stress during those years and would have readers believe that only his family knew the extent to which he suffered; this really wasn't entirely so. Some other minor inaccuracies are evident in descriptions of some of the events with which I am familiar, but it is not clear whether these have arisen through an effort to compress the story or simply from the passage of time.

Lovell draws interesting comparisons between the management of this project and the subsequent growth of "big science" with its plethora of oversight committees and checks and balances. In hindsight, it is clear that the task of building a 250-foot fully steerable telescope was embarked upon with

a certain naiveté on the part of all concerned. Lovell's dogged determination eventually saw it through to completion. If his story sheds any light on how science progresses it may be in revealing that, in the global scheme of things, persistence can be just as valuable as the flash of intellectual genius.

The last two chapters deal with various lifelong activities or concerns touched upon in the earlier chapters but better suited to being dealt with separately. Prominent among these is Lovell's interest in the relationship between science and theology. Stimulated by his upbringing (his father was a lay preacher) and an interest in church music (he is an accomplished church organist), Lovell appears to have long wrestled to reconcile his scientific and religious beliefs (see his *Science and Civilisation* [Nelson, 1939] and *In the Center of Immensities* [Harper and Row, 1978]) and confesses at one point to having considered entering the church. He argues that science and theology must not be viewed as mutually exclusive forms of human endeavor. Rather, they must be harmonized to provide a self-consistent view of reality. Moreover, science alone is not enough—it lacks an ethical basis and fails to speak to much we humans experience. Unfortunately, Lovell offers no profound insights that might bridge the gap that exists between the concept of a Creator responsible for the "big bang" and for the laws of physics that have governed the universe since and his own presumably Christian beliefs in a personal God.

At lunch one day in 1958 in the Jodrell Bank cafeteria Lovell mused aloud that he might yet be sent to prison (over the handling of the building of the telescope). An uncomfortable silence followed until one of my colleagues, a recent Cambridge graduate, quipped, "Well, sir, all great men in the British Empire either end up in prison or being knighted!" At this Lovell visibly brightened. History will record he was justly knighted.

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Changing Galaxies

Evolutionary Phenomena in Galaxies. J. E. BECKMAN and B. E. J. PAGEL, Eds. Cambridge University Press, New York, 1989. viii, 468 pp., illus. $69.50. Based on an institute, Tenerife, Canary Islands.

The recognition that galaxies change measurably in composition and appearance over the time span we can study and that the changes are both calculable and important dates back only a little more than 20 years. Before the pioneering work of Beatrice M. Tinsley in 1967–68, a typical astronomical text did not even contain an index entry for "galactic evolution"; and here we have a whole book on the now-mature subject. The volume includes the invited review papers presented at a conference held in the Canary Islands in July 1988. The locale has resulted in galactic evolution with a strong European flavor. Of the 29 papers, 24 have authors located in Common Market countries, 4 in the United States, and 1 in Australia.

Because the subject has been around for a while, the book contains few surprises, and most of what it says could have been collected from other sources. The flip side of this coin is that the volume is likely to remain a good picture of our understanding of the subjects covered for some time. The core topics addressed are: stellar populations, ages, and dynamics for our own galaxy; stellar populations in other galaxies; processes of star formation from interstellar gas; the feedback of heavy elements and energy from supernovae; and chemical evolution of galaxies. Shorter sections consider whether the nuclei of the Milky Way and other galaxies contain black holes and the effects of close encounters between galaxies.

As conference proceedings go, this one is rather well indexed (for individual astronomical objects, chemical elements, and spectral lines, as well as according to broad subject headings). Thus one can use it easily to check up on the current status of one's favorite old astronomical problems. For instance, a classic one is the relative paucity of metal-poor stars in the Milky Way (still true for disk stars, though not for the halo, and best explained by continuous infall to the disk of pure hydrogen and helium gas, according to Bernard E. J. Pagel).

Another is the correct explanation for the concentration of heavy elements like oxygen, nitrogen, and sulfur toward the centers of galaxies (neither varying the star formation rate and mass spectrum nor allowing gas to flow inward yields a perfect fit to the data, according to Angeles I. Diaz and Francesca Matteucci). And the relationship between spiral arm patterns and other properties of galaxies is sufficiently complex, according to Bruce G. and Debra Meloy Elmengreen, that several different physical processes (including bar driving, density waves, and galactic interactions) must be capable of generating arms.

The real focus of puzzlement in the astrophysics of galaxies has, however, shifted from evolution to formation. According to the opening contribution by Martin Rees, "We do not know why such things as galaxies should exist at all." That is, the physical processes that cause the most conspicuous large objects to be the sizes, masses, shapes, and densities of the galaxies we see have not yet been identified. The situation is really even worse—no matter which processes you choose to invoke, we don't really see how the galaxies can have formed by the present time in a universe previously as homogeneous as the microwave background radiation says ours must have been. That 90% or more of the matter in typical galaxies is non-luminous and can be traced only through its gravitational effects on the stars and gas does not, at least in the short run, help. A list of astronomers working on and thinking about galaxy formation over the past decade would run into the hundreds. But if the right basic idea has been proposed, it is currently hidden by the trees. I would bet only about 50-50 that the proceedings of a conference on galaxy formation dated 2002 will present a subject as organized and settled as the evolutionary phenomena discussed in this volume.

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