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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