

muddle through where it couldn't, and came away "with the definite impression that I had found the same game as with the seals: management reducing criteria and accepting more and more errors that weren't designed into the device, while the engineers are screaming from below, 'HELP!' and 'This is a RED alert!'".

Feynman and several of his colleagues on the commission soon recognized what they were up against: NASA management, scrambling to survive the catastrophe, had, in Washington bureaucratic parlance, reconfigured itself into the CYA (cover your ass) mode. The giant agency, strong in public relations, aimed to ride out the storm of national anguish and official inquiry, and emerge merely as the victim of technological happenstance. It might possibly have succeeded but for Feynman's irrepressible proings, which led to the heart of the matter: slovenly management that permitted wishful thinking to override basic engineering principles.

Feynman's final analysis of the malady of NASA should be mandatory reading for the managers of complex organizations, and in particular ageing complex organizations. The Apollo Moon landing, like the Manhattan Project of the Second World War, had succeeded, he concludes, because all hands shared the same goal and "everybody's interested in everybody's problems". After Apollo, NASA's survival depended on convincing Congress that a new project, the shuttle, would be a high-performing, economical means for reaping the benefits of space. The managerial salesmen thus put on a hard sell that could not tolerate cautions and doubts from engineers at the working levels.

"Well", writes Feynman, "the guys who are trying to get Congress to okay their projects don't want to hear such talk. It's better if they don't hear, so they can be more 'honest' — they don't want to be in the position of lying to Congress! So, pretty soon the attitudes begin to change: information from the bottom which is disagreeable — 'We're having a problem with the seals; we should fix it before we fly again' — is suppressed by big cheeses and middle managers who say, 'If you tell me about the seals problem, we'll have to ground the shuttle and fix it.' Or, 'No, no, keep on flying, because otherwise, it'll look bad,' or, 'Don't tell me. I don't want to hear about it'".

His final words on the *Challenger* disaster merit respectful consideration on every one of the issues of technology and public policy that vex modern society: "For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled". □

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Windows on heaven

David H. DeVorkin

Astronomical Centers of the World. By Kevin Krisciunas. Cambridge University Press: 1988. Pp. 320. £17.50, \$24.95.

A SURVEY of the anatomy and personality of astronomical observatories during any age reveals much about the astronomical enterprise of that time, as well as the society that fostered it. Developing from visual sighting devices limited to detecting positions and motions, to modern optical, radio and space observatories, over the centuries the compass of astronomy has extended to include all known regions of the electromagnetic spectrum, limited only by available technology and the Earth's atmosphere. At some times, astronomers were themselves the technological innovators, but most typically they benefited from devices created for other purposes. At some times, astronomers rapidly grasped the new opportunities provided, and at others, they balked.

One might expect that a history of astronomical centres would contemplate these matters. In a discipline as diverse, complex and popular as astronomy, there is much fertile territory to dig over. Why were some technologies assimilated more rapidly than others? What social drives promoted the study of astronomy, and led to funding for its instruments and institutions? And who were the builders: the instrument makers and technologists who made it possible?

Astronomical Centers of the World addresses these matters, but only very

briefly. In what is essentially an extended chronological narrative highlighting about ten of the most illustrious observatories and institutions of the past two millennia, an ocean of names, dates and anecdotal detail washes over questions of how and why each of these venerable centres was built and to what purpose. There is an attempt at an overarching theme: in the preface the author contends that "at a given time there was an astronomical center whose equipment and staff were such that crucial, path-breaking work could have been done nowhere else. Or in some cases it could have been done somewhere else, but was not". But I have to admit that I am not sure what this means.

There is pleasant diversion to be found in this broad-brush digest. For me, the early chapters on the Alexandrian library and Ulugh Beg were interesting, possibly because I know little about their histories. Later chapters, however, on progressively more recent institutions from Tycho's Hven, the Paris and Greenwich observatories, Pulkovo, Harvard, Lick, Yerkes, Mount Wilson and Palomar left me less and less satisfied as the author moved into realms with which I am familiar. The least compelling accounts are those of comparatively new (post-1945) institutions, including the ones in Hawaii that Mr Krisciunas is intimately acquainted with. My mixed reactions thus suggest that this book will provide a few agreeable hours of reading for those mildly curious about astronomical history, but who are not sufficiently involved in the subject to demand fresh, critical analysis. □

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Last supper—this beautifully preserved example of the primitive even-toed ungulate *Aumelasia* is one of the many fossils from the early Eocene deposits at Messel, near Darmstadt, West Germany, that are described in Messel —

Ein Schaufenster in die Geschichte der Erde und des Lebens, edited by Stephan Schaal and Willi Ziegler. Evidence collected 49 million years after its last repast shows that the diet of *Aumelasia* consisted of fruit and berries. The book, which is large in format and superbly produced and illustrated, is published by Senckenbergische Naturforschende Gesellschaft, Frankfurt. Price is DM69.