Review of Peebles by Levesley and Fraser CSHPM/SCHPM
Bulletin 70 (May 2022), pp. 13-14

visited Yale University's Department of History of Science and Medicine where she stayed from 1960-1963.

After producing significant results with Price, she came back to Japan and obtained a Ph.D. from the University of Tokyo in 1965. Her next project was to write a biography of Hantaro Nagaoka, the most prominent physicist during the Meiji and Taisho eras, using his unpublished materials. After publishing this biography in 1973 with her colleagues, Yagi devoted considerable energy to history of thermodynamics developed by Clausius. Since 1976 she often visited Archives Deutsches Museum in Munich to gather Clausius' manuscripts. She published several papers on this subject, exchanging ideas with John N. Heilbron and Martin J. Klein.

Her contribution "Heat and Thermodynamics" to *Encyclopedia of History and Philosophy of Mathematical Science* edited by Ivor Grattan-Guiness gave her the occasion to join the British and Canadian societies of history of mathematics. In 2009, she was invited to the opening conference of Clausius Tower in Koszalin University of Technology in Poland. After leaving Tokyo University in 2002, she organized her colleagues at the Institute for History of Science to continue translating selected Clausius' papers in Japanese. These were published in 2012.

Japanese women obtained equal rights after World War II. Although their situation has been gradually changed even today they experience invisible discrimination. Looking back at her life in this context, we praise Yagi as a female pioneer in the realm of history of science in Japan.

Michiyo Nakane

Off the Shelf: Review of James Peebles' *Cosmology's Century*

James Peebles is a Manitoba-born Canadian-American astrophysicist and cosmologist. In 2019 he was awarded the Nobel Prize in Physics for "theoretical discoveries in cosmology." In his career at Princeton University, Peebles was involved in the 1965 discovery of cosmic microwave background radiation. He has made fundamental contributions to theories on nucleosynthesis, dark matter, and galaxy and structure formation. Through an analysis of influential papers, personal correspondence, and recollection, *Cosmology's Century* traces the development of "empirical cosmology" (physical cosmology) along six lines of relatively independent research, culminating in what Peebles identifies as the unification of and revolution in cosmology in 1998–2003.

Peebles' analysis of the first line of research, the establishment of the cosmological principle, the theory that the universe is, on a large scale, homogeneous and isotropic, is presented in Chapter 2. It begins with Einstein's general theory of relativity and related considerations in the early twentieth century, and then traces further developments from the 1920s to the 1970s. Chapter 3 discusses the discovery of the expansion of the universe and the two major cosmological theories that attempted to account for this, the big bang and steady-state theories. The third line of research Peebles identifies is the discovery of the fossil remnant from the big bang: cosmic microwave background radiation. As a member of the group in the early 1960s that predicted the existence of background radiation, Peebles provides a particularly rich exploration of his recollections of this discovery in Chapter 4. Chapter 5 explores the puzzle of the homogeneity of background radiation versus the clumpy distribution of matter and galaxies we view in the sky. An important piece required to solve this puzzle was an adequate theory of how galaxies and galaxy clusters evolved, several of which were proposed in the mid-twentieth century. A noteworthy empirical aspect of this research was the use of sophisticated statistical methods such as two-point correlation to analyze the distribution of galaxies, with another significant contributor here being renowned mathematical statistician Jerzy Neyman. The final research programs Peebles discusses are the detections of anomalies in galaxy motion, which pointed to the existence of subliminal (dark) mass, and the subsequent identification of this missing mass with non-baryonic matter identified by particle physicists. The penultimate chapter concludes with an assessment of the events of 1998–2003 in which these individual lines of research converged into the current preferred cosmological model.

Bookending these historical chapters are brief discussions of philosophical and sociological aspects of twentieth-century cosmology. Peebles believes the passive nature of cosmology implies that inquiry is restricted to observations: "we can look, but never touch" (p. 2). This partially explains the ubiquity of both empirical and non-empirical considerations in theory assessment throughout the twentieth century, which Peebles seems to consider inevitable but not

undesirable. The concluding chapter leaves the reader with food for thought on the role of technology in cosmology, social constructions of science, and counterfactual "What if?" questions about paths not taken.

True to its subtitle, *An Inside History*, this book provides insight into a practitioner's reflections. Peebles highlights the motivations that drove or deterred different lines of research, as well as physicists' underlying assumptions about what satisfactory cosmological theories needed to address. The selection of citations to original papers, equations, and figures illustrate what this scientist considered key to the development of cosmology. Readers familiar with Peebles' previous writings on cosmology will find it rewarding to compare this selection with those in his earlier books.

From the 1930s to the 1990s, the Einstein-de Sitter model was the preferred vision of the universe. At the end of the 1990s, teams of astronomers at Harvard and Berkeley used supernovae as distance indicators for far-flung galaxies. To their astonishment, they found that the expansion of the universe had begun to accelerate about five billion years ago. This remarkable finding led to the adoption of a new cosmological model characterized by the essential role of the cosmological constant lambda. This model is known as the lambda-cold-dark-matter, or ΛCDM model. It may be viewed as a descendant of the Friedmann-Lemaître universe that was discussed in the early years of relativistic cosmology, but which fell out of favour after the 1930s.

Peebles' key thesis is that the 1998-2003 developments constitute a *revolution* in cosmology. The culmination of the above research programs into the acceptance of the ΛCDM model as the "simplest" theory marked the period after which cosmological research was unified and a Kuhnian paradigm achieved. The implication of this view is, of course, that cosmology before 1998 was not quite unified. This seems a peculiar thing for a physicist highly active on the cosmological scene in the years leading up to 1998 to assert, particularly given Peebles' claim in the 1993 edition of *Physical Cosmology* on page 197:

> Those who would seek a revolution in cosmology must bear in mind that the days are gone when it was easy to think of viable alternatives. Now any serious attempt at a revision of the main elements of the standard world picture would involve a survey of a considerable (though certainly limited) store of observational and laboratory constraints.

The disparity between Peebles' 1993 view and that which he expresses in *Cosmology's Century* indicates the unexpected nature of developments in 1998–2003, demonstrating that even scientists intimately involved in their fields cannot predict the occurrence of revolutions. It could also be seen to illustrate a pervasive preoccupation with the *idea* of revolutions in science and elsewhere. Readers may rightly question where the line between revolution and major innovation should be drawn.

Semantics aside, *Cosmology's Century* provides a thorough and technical account of key developments in twentieth-century cosmology. Although clearly not a historian's history, it will be of interest to historians engaged with the mathematical and technical aspects of modern cosmology, historiographers studying practitioners' histories, and cosmologists curious about the historical development of their field.

Nichole Levesley and Craig Fraser

References

P. J. E. Peebles, *Cosmology's Century: An Inside History of Our Modern Understanding of the Universe*, Princeton University Press, 2020.

CMS Winter Meeting

Originally planned to take place in Vancouver, BC, the History and Philosophy of Mathematics Session organized by Maritza Branker and Nic Fillion on behalf of the CSHPM/SCHPM took place virtually on 5–6 December 2021.

A successful session took place with twelve talks spanning two days. Topics were equally balanced between history and philosophy of mathematics. The online format allowed speakers to attend from international locations including South America, Australia and the U.K. as well as the usual North American participants. The organizers also prepared a panel for the general meeting on the theme of Women in Mathematics that was well received.

Speakers and talks included Amy Ackerberg-Hastings (Independent Scholar) on the "Historian of Mathematic's Toolbox: Historiography and Methodology for Mathematicians," Tom Archibald (SFU) on "Hermite and Concrete Analysis," Maritza M. Branker (Niagara University) on "Black American Women Math-