state of knowledge of the workings of our local star, the Sun, and also of the instruments by which that information has been obtained. Unusually for such non-specialist books it maintains a running theme of highlighting the intellectual processes being followed to obtain this knowledge, and as such is a valuable addition to books on the more general topic of 'doing science'. — BARRY KENT.

Catchers of the Light: The Forgotten Lives of the Men and Women who First Photographed the Heavens, by Stefan Hughes (ArtdeCiel Publishing, Paphos, Cyprus) 2013. Volume 1, pp. 735; Volume 2, pp. 877, 30·5 × 21·5 cm. Price $199 (about £123) (hardbound; ISBN 978 1 4675 7992 6).

There are only four major milestones in the development of astronomy. The first, the introduction of the telescope in 1609, saw astronomers race past the limitations of the naked human eye. Suddenly we could see fainter, and more-distant objects, and also much more detail. But if we wanted to record what was seen we had to get out pen and paper and start drawing. That was rather unsatisfactory because subjective differences were introduced and it was extremely difficult to ascertain whether astronomical objects, like nebulae, were changing with time. The second milestone was the introduction of photography in around 1840. Fortunately the sensitivity of the photographic process increased gradually by a factor of about a million over the next century and a half. Photography removed subjectivity and also meant that much less time had to be spent with one's eye metaphorically glued to the telescope eye-piece. It also produced a permanent record of the positions and brightnesses of stars, nebulae, planetary features, and spectral lines. The other two milestones came together around the 1960s. One was the introduction of the computer and this enabled astronomers to tackle a completely new range of problems that previously they merely dreamt about. Finally there was the escape from the Earth's blanketing atmosphere. That not only opened up a much expanded range of wavelengths to astronomical investigation, but also, for the planetary astronomer, took us to the near vicinity of asteroids and comets and into the atmospheres and onto the surfaces of our planetary and satellite neighbours.

Catchers of the Light covers the second astronomical milestone mentioned above. It is a thorough and insightful history of both the aims, technicalities, and results of astronomical photography and the lives of the pioneers of this vital part of our subject. This huge two-volume book benefits greatly from the fact that Stefan Hughes (unfortunately no relation to the reviewer!) was a professional astronomer at the universities of Leicester and London (Queen Mary College) who then morphed into a highly skilled astro-photographer, genealogist, and historian.

This book divides into nine sections. We start with an historical review of the first faltering footsteps of photography and its capturing of celestial images. We read about the daguerreotype and the calotype and the first imperfect images of the Moon and the Sun. Then in 1851 came the major breakthrough of the wet collodion process. This produced a sensitivity increase by a hundredfold and a concomitant decrease in the exposure time. Another leap forward occurred in 1871 with the introduction of the gelatino-bromide dry plate. Messy chemicals near the camera were eliminated and plates could be easily carried around and developed at leisure. By the early 1880s sensitivity had increased sufficiently to enable the Orion Nebula to be imaged, and also stars were being recorded that were invisible to the eye. This speedily led to photography being used for both celestial mapping and accurate photometry using large glass plates that did not warp or shrink when being handled and developed. Over the next hundred years or so the subject underwent a steady improvement until there was a revolutionary breakthrough in the early 1980s with the introduction of the charged-coupled device and its associated computer software.

Section two covers the Moon, a field that ended with the production of a series of major lunar atlases and the USA's *Orbiter* spacecraft using 70-mm Todd-AO photographic film to record lunar features from low lunar orbit. Section three considers the Sun and solar-eclipse photography and investigates the pioneering images of sunspots, granulation, prominences, and the solar corona. In section four we move to comets and planets and investigate the way in which astrophotography took over the task of discovering faint asteroids. Much is made of the use of primitive cinematographical techniques when it came to following Venus as it transits the Sun. Astro-photographers then turned their attention to deep space, and we read of the early images of clusters such as Praesepe and the Pleiades. By 1880 Henry Draper recorded the first image of M 42, the Orion nebula. Soon followed the imaging of Milky Way star fields and external galaxies.

Section six turns to one of the most important uses of photography in astronomy, which was the recording of spectra. Here we have a topic that led to the measurement of the chemical composition of the stars, their surface temperatures, and their radial velocities. It also led to the realization that some of the nebulae were gaseous and non-stellar. Harvard University Observatory then introduced the objective prism which meant that over 200 spectra could be recorded on a single photographic plate. This opened the floodgates to spectral classification, the Hertzprung–Russell diagram, and the details of stellar evolution with its main-sequence, giant, and supergiant stars. The combination of photography, spectroscopy, Doppler shifts, and large telescopes also enabled us to measure the size of the Universe and opened the way to modern cosmology.

Section seven reviews one of the great 'dead ends' of astronomical photography, the *Carte du Ciel* project. The idea sprang from the successful *Cape Photographic Durchmusterung* in which David Gill imaged the southern skies down to a magnitude of 10·2. But the *Carte du Ciel* decided to 'up the stakes' and the plan was to photograph, catalogue, and map the whole sky down to 14^{m} — a huge leap. An 1887 congress was held in Paris to parcel out different celestial areas to the world's observatories. Unfortunately the project was hugely over ambitious and it ended up as a complete and utter shambles. It was eventually overtaken by the technological breakthroughs of dedicated astrographic telescopes such as the 48-inch Schmidt telescope at the Palomar Observatory which took only ten years to polish off the National Geographic Society Palomar Observatory Sky Survey.

Section eight deals with the telescopes that were specially designed with astronomical photography in view. Here we see a great advance in the reflectors, their lack of chromatic aberration being a significant bonus. Lick Observatory's use of the 36-inch *Crossley* reflector showed the world what was possible. A string of great imaging instruments followed, the most memorable being the 100-inch *Hooker*, the 200-inch *Hale*, and finally the *Hubble Space Telescope*.

The last section deals with the role of the amateur astrophotographer, and also the usefulness of the 'pretty picture' in the advancement of astronomy. Many professional astronomers will happily spend all their academic life without including a 'photograph' in their publications. But the influence of seeing, for example, the first coloured picture of the solar green flash, the wispy nebulosity around the Pleiades, the dark foreboding of the Horsehead nebula, the majesty of the *Hubble* image of the 'Pillars of Creation' in the Eagle nebula, and the haunting fragility of the blue planet Earth rising over the barren lunar surface, an image taken by *Apollo 8* astronaut William Anders, is immense. The fact that astronomy is beautiful and image-rich has opened the doors of many funding sources. And we must be extremely grateful that the advances of modern small-telescope design coupled with readily available CCD cameras and laptop image-processing has meant that many dedicated amateur astronomers can now produce absolutely amazing celestial images.

What I loved about *Catchers of the Light* was its skilful combination of astronomical understanding, technical knowhow, and a realization of the historical and scientific importance of specific advances, all coupled with a deep interest in the biographical and genealogical details of the personnel involved. I learnt a huge amount. Let me give you one typical genealogical example. Take our great astronomical hero Edwin Powell Hubble. Before reading Stefan Hughes' book I had absolutely no idea that the 'Hubble' family, when leaving Ribblesford, Worcestershire, in the 1630s and emigrating to Connecticut, USA, was originally called Hubball. This eventually was changed to Hubbell, and finally Hubble. I also did not know that Edwin tried never to use his middle name because his maternal granddad, Major General Joseph Powell, was dismissed from the military for indiscipline and law breaking.

I was greatly impressed by the tables, a few examples being the key stages in the chronology of photographic processing, important lunar photographs and Moon atlases, major steps in solar photography, highlights of astronomical spectroscopy, key images of Solar System objects, spacecraft images of planets, significant historic images of the Horsehead nebula, the world's major astrographs, a time-line of deep-sky-object imaging, and the 109 most important astronomical photographs.

This book is truly a *magnum opus*, a labour of love, and a great work of scholarship. It is authoritative, detailed, thorough, superbly illustrated, well referenced, and all-encompassing. There is no nook or cranny of the history of astronomical photography or its proponents that has not been investigated, noted, and embellished with a relevant image. It is worth every single cent of its price. It is an essential addition to every astronomy library. Anyone with even a vague interest in the development of astrophysics will need to have this book to hand; it is a vital and reliable starting place for any historical research into the last two centuries of astronomical endeavour. — DAVID W. HUGHES.

A Tale of Seven Elements, by Eric Scerri (Oxford University Press), 2013. Pp. 270, 21 × 13·5 cm. Price £12·99 (hardbound; ISBN 978 0 19 539131 2).

Having looked at all of *The Periodic Table* in 2007 (see **130**, 175), Maltese-born author Eric Scerri has now turned his attention to the last seven elements (with atomic number less than $Z = 92$) to be discovered. These are, in order of discovery, Protoactinium (1917), Hafnium, Rhenium, Technetium, Francium, Astatine, and Promethium (1945). All were difficult, two because they are rare earths (Hf, Re), and the others because they are radioactive, with only very sparse natural presence on Earth, either as decay products of U, Th, Rn, and Ra or as made by the natural uranium reactor at Oklo, Gabon. Several had to be synthesized in terrestrial reactors and bombs, though recognized naturally thereafter. At least three were discovered or co-discovered by women (Lise Meitner, Ida Tacke Noddack, and Marguerite Perey, with C. S. Woo, Bertha Swirles Jeffreys, Maria Goeppert Meyer, and Charlotte Moore Sitterly involved in various ways).