1481 through to 1978, I found, not surprisingly, the most recent entries the easiest to read and absorb. The jewel in the crown for me, and I suspect for many readers of AJP, was Feynman's 1965 essay *The Character of Physical Law*, but a (fairly distant) second was *Our Invisible Culture* (Allen L. Hammond, 1978) about the elusive human face of mathematics. I think that more than three decades later, developments in mathematics and its applications to biology in particular may render some aspects of this entry dated, but then that is to be expected in a volume spanning 500 years of mathematical writing!

The final Chapter ("The Mathematicians Who Never Were: Fiction and Humor") contains several amusing items, but I gravitated immediately to an extract from Edwin Abbott's celebrated 1884 classic, *Flatland* (here subtitled *A Sight of Thine Interior*). The joys of "dimensional interface phenomena" are many and varied! In fact, several times in his Scientific American essays Martin Gardner (1914–2010) discussed the dimensional analogy, so I am astonished that there is no mention of him in this book (at least, I could find none). He was a well-known and highly regarded popular mathematics and science writer, specializing in recreational mathematics. His obituary in the NY Times described him as "puzzler and polymath," and the tribute to him in the Scientific American noted that "For 25 years, he wrote *Scientific American*'s Mathematical Games column, educating and entertaining minds and launching the careers of generations of mathematicians." In my opinion this certainly qualifies him for inclusion in this eclectic survey of popular mathematics writing.

In summary, this book contains much hard-to-find material that will be of particular interest to those who teach the history of mathematics, but also to those who wish to broaden their mathematical horizons in time (and space!), despite the significant omission of some of Gardner's prolific writings. There is much here worth delving into, and that is probably the best way to approach the book, rather than reading it through directly.

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A First Course in Loop Quantum Gravity. Rodolfo Gambini and Jorge Pullin. 191 pp. Oxford U.P., New York, 2011. Price: \$62.95 (hardcover) ISBN 978-0-19-959075-9. (Seth Major, Reviewer.)

Once we have it, quantum gravity will explain the microstructure of space-time. Is space continuous? What about time? Does space-time geometry make sense near the initial singularity? What is the description of physics deep inside a black hole? What is the dimension of space-time on the smallest length scales? These are the sort of questions, the theory of quantum gravity is expected to answer. The essence of our search for the theory is an exploration of the quantum foundations of space-time.

The theory of quantum gravity is a fascinating subject full of wonderful conceptual and technical challenges. It is no wonder that Rodolfo Gambini and Jorge Pullin wish to introduce it to undergraduates with a "light and nimble" (p. iv) presentation in **A First Course in Loop Quantum Gravity.**

General relativity makes a strong statement: geometry is physical, rather than a mere array of background coordinates over which field and particle dynamics unfolds. At times called general coordinate invariance, or diffeomorphism invariance, the background independence of general relativity makes sense for the theory of the space-time geometry with which and on which stuff happens. It is also radically different from other well-tested physical theories that typically assume a great deal of background structure.

Loop quantum gravity is an attempt, as yet incomplete, to quantize Einstein's theory of general relativity in four space-time dimensions while retaining its background independence. In the Hamiltonian approach taken, the kinematics (the quantum geometry of space) is quantized before the dynamics (the evolution of spatial geometry). To date, loop quantum gravity has succeeded at the first step. Building on methods from field theory, an essentially unique quantum theory of spatial geometry emerges. Loop quantum gravity predicts discrete spectra of familiar geometric quantities such as length, area, volume, and angle. Acting like quantum mechanical angular momentum operators, these operators give the physical geometry. The scale of the granularity in geometry is set by the fantastically remote Planck length, or about 10^{-35} m.

As one would expect from a quantum theory of geometry, the state space is suitably weird. For instance, there exist states for which surfaces have area, but every closed surface encloses vanishing volume. The state space is also suitably familiar. The space contains states that closely approximate our apparent Euclidean geometry of daily life.

Loop quantum gravity has also achieved success in applications to cosmology, black holes, and even the nascent field of quantum gravity phenomenology. However, before the dynamics is complete, the theory must be regarded as tentative.

In presenting this fascinating but incomplete theory, there are two immediate issues to settle—the reader's background knowledge and the expected depth of understanding. Wisely choosing not to include general relativity in the required background, the authors state that they assume electrodynamics, Lagrangian and Hamiltonian mechanics, special relativity, and quantum mechanics. In fact, the requirements go a bit beyond this with such topics as index notation and complex analysis. But the gaps between core subjects in the undergraduate physics major and the book could be bridged in a class setting. As to the expected depth of understanding, the authors announce their modest goal of hoping that readers "get some minimal grasp of the subject in a relatively short amount of time" (p. iii). Their nuts and bolts approach is light and breezy. Anyone who recalls the heady days of the early development of loop quantum gravity, and the 1993 paper "Knot theory and quantum gravity in loop space: a primer" by Pullin, will recognize his flowing style and drive in the text. It is particularly apparent in the "Further Developments" chapter, where readers new to the field will be carried along, assuming they are not looking for details.

The authors' approach allows for views of the facades of the fields involved in constructing the city of quantum gravity. In just 90 pages, the books reviews special relativity, the 4-vector form of electrodynamics, general relativity, diffeomorphisms, the Hamiltonian formulation of general relativity, constraint analysis, quantum field theory, renormalization, and Yang-Mills theory. At this pace, the authors accurately describe their book as an introduction to "elements" of these subjects. The advantage is that readers have a full view of the scope of the background that underlies loop quantum gravity. But the approach leaves students little time to explore the intriguing interiors behind these facades and to build understanding of the city's structure.

As is clear from the above list, the topics immediately veer toward the graduate level. There are moments when the pace is breathtaking. For instance, when the definition of the Hamiltonian constraint is reviewed we are rushed through the streets, "Starting with the Poisson bracket, we see that the parallel transport within it goes to the identity plus a term proportional to the connection. The identity will have vanishing Poisson bracket with the volume, so the only contribution will come from the connection" (p. 119). This leads to the question of why one would present this subject, fundamentally built on graduate level material, to undergraduates. The best use I can see is for departments with sufficient depth and resources seeking to add variety for their advanced undergraduates. A course based on this book meets the genuine student interest for an introduction to this frontier of fundamental theoretical physics. Certainly the text fills a gap in the existing literature, because the two existing introductory texts by Carlo Rovelli (Quantum Gravity, Cambridge U.P., 2004) and Thomas Thiemann (Modern Canonical Quantum General Relativity, Cambridge U.P., 2007) are clearly at the graduate level. For such courses, the book provides a basis for a fast-paced introduction to loop quantum gravity as it stands today.

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Seven Tales of the Pendulum. Gregory L. Baker. 248 pp. Oxford U.P., New York, 2011. Price: $44.95 (hardcover) ISBN 978-0-199-58951-7. (Arnold Wolfendale, Reviewer.)

There are many reasons why a youngster should choose a particular profession. In my own case, remarkably, the pendulum played an important role. The reasons were several. One was the history of the pendulum's application as a timekeeper: Galileo's timing of the swings of the cathedral incense-pot using his own pulse as the datum clock. Here was a historical experiment that one could carry out by oneself. Another reason, which came later, was the knowledge that I could prove the equation for the period of a pendulum in terms of length and the acceleration due to gravity, myself, and understand it. Gosh!

Even including circular motion the pendulum is supreme. By its smooth transfer of potential energy into kinetic, and back, it seems to epitomize the behavior of so many systems in the physical universe. Even biological systems have their equivalent.

The book under review rests heavily on **The Pendulum: A Case Study in Physics** by Gregory L. Baker and James A. Blackburn, Oxford U.P. 2009. However, whereas the earlier book related to the pendulum's classical, chaotic and quantum behavior, the present one ventures into broader pastures: the historical development of science in the wider sense. Thus, to a significant extent the two books are complementary.

Seven Tales is intended for a wide audience and is largely non-technical, but it inevitably contains a modicum of mathematics. It succeeds in its purpose.

All the expected aspects of the pendulum are here: use in studies of the Earth, applications in horology, measurement of fundamental forces, large-amplitude swings (and their use in horror-fiction!), chaotic pendulums, Foucault, synchronized, and 'microscopic pendulums'—they are all here. All in all, the book is a fascinating mixture of applications, their backgrounds, and the personalities involved.

As a former UK Astronomer Royal, I was interested, but disappointed by its brevity, in the story about G. B. Airy (1801–1892) and his determination of the mean density of the Earth. Using pendulums at ground level and underground, initially in Cornwall, he managed to drop the apparatus down the shaft and also set fire to the pit! Later experiments near the Reviewer's home in Durham (UK) were more successful, although his claim to have measured the density of the Earth to within 2/3% turned out to be grossly in error. As Baker points out, the error was 20%.

Leon Foucault (1819–1868), a brilliant scientist, is given good coverage. His invention of the precision gyroscope and his contributions to astronomy by way of inventing techniques for manufacturing large mirrors are described. Particularly well covered are the events leading to the realization of the relationship of the swing of the pendulum to the rotation of the Earth. Foucault's personal interaction with Louis Napoléon Bonaparte, the future Emperor Napoleon III, led to the construction of the great 67 m, 28-kg pendulum in the Pantheon in Paris in March, 1851. What a story…and well told.

What, then, of this book? High marks for the mixture of sensible science and fascinating sociology. I wish it well.

Sir Arnold Wolfendale, FRS the 14th Astronomer Royal, is President of the Antiquarian Horological Society and Past-President of the European Physical Society. He initiated the Memorial to John Harrison in Westminster Abbey as well as the Harrison Medal of the Worshipful Company of Clockmakers.