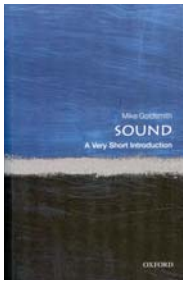
company Virgin Galactic and who wrote the foreword for *How to Make a Spaceship*. However, Virgin Galactic only recently resumed test flights and may soon be surpassed by its rival Blue Origin, owned by Amazon billionaire Jeff Bezos. Blue Origin's automated, vertically launched *New Shepard* rocket includes a booster that can be recovered and reused and a crew capsule for a parachute landing. It has already flown without passengers; Blue Origin plans to launch employees this year and tourists next year. Bezos and Elon Musk of SpaceX, who appear briefly in *How to Make a Spaceship*, have displaced Guthrie's main actors to become the new faces of New Space. Perhaps the next few years will produce the space-tourism breakthrough that Diamandis has long tried to facilitate.

Michael J. Neufeld
Smithsonian National Air and Space Museum
Washington, DC

Sound

A Very Short Introduction



Mike Goldsmith

Oxford U. Press, 2016. $11.95 paper (144 pp.). ISBN 978-0-19-870844-5

Sound helps shape how we experience the world, and an understanding of sound is critical in domains as diverse as psychology, linguistics, architecture, animal behavior and evolution, oceanography, and, of course, music. Thus the physics and technology of acoustics are inherently of interest to a great many people, scientists and the lay public alike.

The special place of sound in science and culture, and a general fascination with the topic, inspired physicist and science writer Mike Goldsmith to write *Sound: A Very Short Introduction*. At 144 pages, the book, part of Oxford University Press's Very Short Introductions series, lives up to its title. Within its eight brief chapters, *Sound* covers the diverse fields noted above and more, and it includes some basic physics. The author has written other popular and children's books on science, and his experience comes through in the engaging, easy-to-read style of *Sound*. Equations are kept to a bare minimum, and most phenomena are explained with familiar examples. Goldsmith has worked at the National Physical Laboratory in Teddington, UK, and his specific background in the measurement of sound, notably its speed in various media, is conspicuous in several chapters.

The book opens at the absolute beginning, the Big Bang, and progresses through acoustic landmarks in biological and human history toward the present. Following a basic treatment of acoustics that focuses on measurements and on the wave nature of sound, there are chapters on music, hearing and speech, technologically produced sound, sounds we cannot hear (infrasound and ultrasound), sounds in liquids and solids, and noise.

For readers who are not physicists or engineers, however, some fundamental issues should have been clarified early in the book. For example, although Goldsmith extensively discusses the wave aspect of sound, he does not mention the particle velocity aspect—longitudinal movement of molecules in the fluid medium that carries a sound wave—despite noting in a later section on microphones how some instruments respond to that velocity.

For readers who are biologists, some of the evolutionary and physiological explanations are certain to raise eyebrows. The book's introduction rather glibly states that the main impetus to the evolution of animal hearing was communication. Most current analyses, however, indicate that hearing evolved for defense, as predators inevitably make some noise when moving. Additionally, hearing generally precedes sound communication in the evolutionary tree; many animal groups hear but do not use sound for communication.

A fair amount of discussion is devoted to echolocation in bats via ultrasound signals, an excellent example of acoustic autocommunication. Indeed, those signals, not studied until the late 1930s, inspired much of the development

of radar during World War II. The author describes the lengthy constant frequency and the short frequency sweep emissions that bats use as echolocation signals, but he misses the main points regarding their pulsed nature and the particular abilities that the pulses afford: Bats do not hear effectively during their own broadcasts, and pulses allow them to listen to and analyze the returning echoes during the interpulse intervals. Constant frequency signals enable bats to estimate the velocity of flying prey; sweep signals give extremely precise information on how far away they are. Those issues could have been resolved with a close peer review, and such missed opportunities render the book less valuable for nonbiologists, who would benefit most from accurate descriptions.

Goldsmith carefully distinguishes longitudinal sound waves from various transverse mechanical waves, such as those that occur in earthquakes, but he does not relate the distinction to animal communication signals. Because the types of mechanical waves are often muddled in the biological literature, biologists would have benefited from the author's physical perspective, which could highlight why the distinction is critical for understanding how different types of signals disperse in the environment. The book includes a number of line illustrations, and many of them are quite helpful for depicting complex acoustic phenomena. But the book's compact size and small print is best suited to schematic diagrams, and the several drawings that attempt to depict biological and instrumentation details are not particularly effective.

Despite those shortcomings, *Sound: A Very Short Introduction* is an enjoyable read. I learned quite a lot about many topics in the process of my review. The book has something for everyone, and the author has done a remarkable job in assembling so much information and condensing it into a truly pocket-size edition. I do not know of another title that covers so much about sound in a nontechnical yet scientific manner.

Michael D. Greenfield
CNRS
Tours, France

Quantitative Viral Ecology

Dynamics of Viruses and Their Microbial Hosts

Joshua S. Weitz

Princeton U. Press, 2016. $69.95 (360 pp.). ISBN 978-0-691-16154-9

Quantitative Viral Ecology: Dynamics of Viruses and Their Microbial Hosts takes on a topic of vast scientific and societal importance. Consider, for example, the ocean's surface, where microbes constitute most of the biomass. Viruses control the microbe population through infection and release organic carbon and other nutrients back into the environment. That has big effects on ecosystem function, since without the turnover of biomass, many sources of food would not be available to other organisms.

The same scenario plays out in many locations. Indeed, microbes, and consequently microbial viruses, inhabit essentially every natural niche on Earth, including waters, soils, sediments, higher organisms, and air. They also live in artificial environments such as homes, waste reactors, and city streets.

The book's topic is not something a traditional physicist would study. However, physical ways of thinking permeate every chapter. Author Joshua Weitz, whose research is in ecology but who holds a PhD in physics, takes a theoretical, model-building viewpoint as the key to interpreting classic and state-of-the art experiments. Modeling is a central and defining feature of physics, and oftentimes simple models—of springs, beads, liquid droplets, and so forth—are immensely useful for conceptualizing problems and identifying main drivers of observed behavior.

The book is aimed at a scientifically educated audience ranging from students to researchers. Each chapter ends with a concise, point-by-point summary that I found useful for quick reference. The chapters contain tutorials on important modeling tools such as mean-field