doing. I believe higher education will flourish as more professionals from physics bring their talents to serve as leaders. The dynamic and quantitative focus in those roles makes me grateful for the preparation I received in physics.

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LETTERS

Reflections from gems in the old literature

A graduate school adviser, Christopher Shera, recently brought to my attention Ray Goldstein's article "Coffee stains, cell receptors, and time crystals: Lessons from the old literature" (Physics Today, September 2018, page 32). The author, as it happens, was a key undergraduate mentor to me. I recall, during a summer at the Santa Fe Institute, helping Professor Goldstein set up a loudspeaker with a water-filled petri dish on top to produce Faraday instability patterns such as those shown in the article's figure 3b. Even more remarkable was the article's figure 1, which reminded me of making a movie of coffee-ring formation for Greg Huber in the summer of 2000. The video aired that evening on the nightly news in connection with a now highly cited paper.[1]

The main thread of Goldstein's article—the joy and value of reading "widely"—is important and deserves voicing. The task gets harder daily as the body of scientific literature keeps growing at an extraordinary rate. The article reminded me, an auditory scientist, of a once-forgotten 1948 paper by Thomas Gold that suggested the notion of an "active ear."[2] David Kemp's discovery of otoacoustic emissions 30 years later[3] reignited the idea, and it now lies at the foundation of modern cochlear mechanics. Gold's paper is acknowledged, cited, and widely celebrated.

My recollection of that paper reminded me of a quote by Werner Heisenberg: "What we observe is not nature in itself but nature exposed to our method of questioning." Beyond Goldstein's narrative, I'd suggest that seeing a wider context for the convoluted and technical details of our field is crucial. Making the broad connections helps us enormously.

Consider diffusion, a central heuristic in Goldstein's narrative. I like to pose simple yet intuitive scientific questions for my students. For example, How does one's brain work? The short answer is that we don't really know. The longer and better answer is that we have many of what we believe are essential bits and pieces, such as spiking neurons, excitatory and inhibitory interactions, and network plasticity. And at the core of those are key concepts learned in freshman physics: oscillations, electric potentials, capacitance, and others.

Diffusion, though, is only rarely found in first-year physics materials, yet it is essential to spiking neurons. Electrodiffusion lies at the heart of the Hodgkin–Huxley model, which was laid out in a classic set of papers.[4] It also is vital to interneuron communication and plastic changes such as connection weights in Hebbian theory. Although the role of diffusion is central to many of Goldstein's scientific examples, it is also important in everyday phenomena, which include the sensory and neural processes involved in reading this letter. Incidentally, diffusion can serve as a wonderful pedagogical means to introduce undergraduates to more sophisticated concepts—for example, multivariable functions, differential equations, probability, and bridging micro- and macroscopic domains.

Budding scientists may hear the term "diffusion," hit that Google Search button, and immediately find themselves at a Wikipedia page. A somewhat useful general resource, it is unlikely to have any clear indications that diffusion is "a

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process foundational to how your brain works." No, you need the "serendipitous kind of rediscovery" Goldstein mentions to find such connections yourself. That continual process of renewal is what keeps us going when we hit those inevitable dead ends. And the combination of reading widely and making broad connections is a fruitful form of renewal. (See, for example, Douglas Hofstadter's 1979 classic *Gödel, Escher, Bach: An Eternal Golden Braid*.)

References

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4. See A. L. Hodgkin, A. F. Huxley, *J. Physiol.* **117**, 500 (1952) and references therein.

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One of the papers chosen by Ray Goldstein in his survey of gems in the old literature (PHYSICS TODAY, September 2018, page 32) is by Theodor Engelmann, who used oxygen-sensitive putrefying bacteria to determine the wavelength dependence of photosynthesis. Engelmann (1843–1909) made important contributions to physiology, botany, and photosynthesis; less well known is that he was an excellent cellist and a close friend of Johannes Brahms, who dedicated his String Quartet no. 3 to him. Engelmann, in turn, sent Brahms his scientific papers. When in Utrecht, the Netherlands, Brahms often stayed with Engelmann and his wife Emma, herself an eminent pianist, and played chamber music with them.

Known for the brevity and haste of his correspondence, Brahms wrote an unusually long, light-hearted, rambling letter to Emma after he received her husband's papers. In his letter, Brahms whimsically links the dissolved O (oxygen) that attracts the bacteria (aerotaxis) to the ohs and ahs that art evokes in sensitive persons and he wonders what music would be without these. Styra Avins included and discussed the letter in *Johannes Brahms: Life and Letters* (1997; letter number 403).

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Bhabha's legacy: Atoms for peace and war

The article by Stuart Leslie and Indira Chowdhury on Homi Bhabha's many accomplishments to advance science and technology in India (PHYSICS TODAY, September 2018, page 48) made only a few oblique references to that country's nuclear weapons program. India's speed in achieving the successful detonation of a 12-kiloton device in 1974 was clearly due to the infrastructure that Bhabha initiated and guided.

Although the explosion, carried out by the Indian Army, was termed "Smiling Buddha," then prime minister Indira Gandhi called it a "peaceful test." Nonetheless, it initiated a nuclear arms race with Pakistan (see Stuart Leslie's article "Pakistan's nuclear Taj Mahal," PHYSICS TODAY, February 2015, page 40). Thus Bhabha could be called the father of Indian nuclear weaponry. One wonders whether nuclear weapons development was his main justification for establishing the Trombay complex.

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▶ **Leslie and Chowdhury reply:** Homi Bhabha clearly designed Trombay with nuclear weapons as more than an afterthought, though Bhabha himself remained ambivalent about a nuclear-armed India. The CIRUS heavy-water reactor and its successors produced weapons-grade plutonium that supplied the material for India's first atomic bomb, and the plutonium itself was extracted in the facility designed by Edward Durell Stone for the Trombay campus. In India—as in France, Israel, and every other member of the nuclear fraternity—atoms for peace could never be entirely separated from atoms for war.

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