wide range of disciplines and by the public.

Concerning the potential of scientific study into anomalous phenomena, Holden asserts that certain topics are "completely unsusceptible to research." In fact, both examples cited by Holden are being investigated by competent scientists. Extraterrestrial intelligence is the focus of the SETI (Search for Extraterrestrial Intelligence) program, which is the search for radio signals from other stars. Ian Stephenson, of the University of Virginia, has published several compilations of evidence suggestive of reincarnation.

The study of anomalous phenomena requires caution, thoroughness, and objectivity. So does the reporting of this study.

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Origin of the Theory of Solutions

I first heard this story from W. J. V. Osterhout (1871–1964), by then a member-emeritus of what was still the Rockefeller Institute. Thinking that it was too interesting to be lost, I begged him to write it out, but he never did. I'll tell it first as he told it to me; then I'll authenticate it.

One day in Amsterdam Jacobus Henricus van't Hoff (1852–1911), the "father of physical chemistry," was walking down the street when he encountered his fellow professor, the botanist Hugo de Vries, one of the trio that in 1900 rediscovered Mendel's Laws, out walking with his wife. Having met, the three went on together; but what had they to say to each other? Finally de Vries ventured, "The other day I had a letter from Pfeffer." (Wilhelm Pfeffer, 1845–1920, another botanist, pioneer in using semipermeable membranes to measure osmotic pressures.) To the desultory Dutch equivalent of "Oh yeah? What's he up to?" de Vries replied, "He says he's measuring the effect of temperature on osmotic pressure." "What does he get?" asked van't Hoff. "Well," said de Vries, "he writes that for each degree rise in temperature the osmotic pressure goes up by about 1/270."

By that night van't Hoff was well launched on the theory of ideal solutions, with its fundamental equation, the exact equivalent of the ideal gas law $pv = RT$, becoming in dilute solutions $p/c = RT$, in which p is now the osmotic

pressure, c the concentration, R the Rydberg constant, and T the absolute temperature.

I was happy to find mention of this story in Ernst Cohen's monumental biography of van't Hoff (1). That, in turn, led me to van't Hoff's own telling of the story, in a lecture on "How the theory of solutions arose," given to the German Chemical Society on 8 January 1894, with Emil Fischer, president of the society, in the chair (2).

van't Hoff explains that he had come across a measurement by Eilhard Mitscherlich (1794–1863) that troubled him (3). Mitscherlich had tried to measure the strength of binding of water of hydration in salts by noting the lowering of the vapor pressure of water in their crystals. He put crystals of Glauber's salt ($Na_2SO_4 \cdot 10 \ H_2O$) into the vacuum space of a barometer and saw that the mercury sank 5.45 millimeters (mm), whereas water would have made it sink 8.72 mm. He concluded that the difference, 3.27 mm, measures the affinity of Na_2SO_4 for its water of hydration. This would amount to a binding force of about 1/32 kilogram per 2.615 square centimeters (about 12 grams per square centimeter). Having quoted Mitscherlich to this effect, van't Hoff goes on to say, "This value, 1/200 atm[osphere], seems to me unprecedentedly low, since I have the impression that even the weakest chemical forces are very large, as seems to me also to be concluded from Helmholtz's Faraday lecture." Wouldn't aqueous solutions offer a much simpler way to make such measurements than dealing with the state of water in crystals?

"Leaving the laboratory with this question on my lips, I encountered my colleague de Vries and his wife, who was just then busy with osmosis experiments and acquainted me with Pfeffer's measurements." van't Hoff then goes into a discussion reconciling Mitscherlich's measurements with Pfeffer's, ending with the words:

"So it occurred to me that with the semipermeable barrier all the reversible transformations that so materially ease the application of thermodynamics to gases, become equally available for solutions. . . .

"That was a ray of light; and led at once to the inescapable conclusion that the osmotic pressure of dilute solutions must vary with temperature entirely as does gas pressure, that is, in accord with Gay-Lussac's Law"—that is, $p \propto T$.

"There followed at once, however, a second relationship, which Pfeffer had already drawn close to: the osmotic pres-

sure of dilute solutions is proportional also to concentration, i.e., alongside Gay-Lussac's Law, that of Boyle applies. Without doubt the famous mathematical expression $pv = RT$ holds for both. With that in hand I could demonstrate my [further thermodynamic formulation], and had achieved my goal."

So the essential story is authentic. How about Osterhout's circumstantial details? Here I have recourse to Lawrence Blinks' biographical memoir on Osterhout, his former teacher (4). Osterhout taught at the University of California in Berkeley from 1896 to 1909 in the company of "sophisticated colleagues who remembered Pfeffer's laboratory." Benjamin Ide Wheeler, president of the university and eager to build up its intellectual status, took to bringing over European scholars, each for a year. Among them were de Vries, Arrhenius, and Ostwald. "There exists a photograph taken in 1905 showing de Vries beside an *Oenothera* plant in the botanic garden, flanked with the portly Arrhenius [Svante Arrhenius, 1859–1927, who propounded the theories of ionization and energy of activation for chemical reaction, and was the prototype of Sondelius in Sinclair Lewis's *Arrowsmith*] . . . with [Jacques] Loeb smiling beside them, and Osterhout [in bowler hat] in the back row." So Osterhout got to know de Vries, and I think had the story, trimmings and all, directly from him.

Osterhout died at 92, de Vries at 87, Pfeffer at 75; but van't Hoff at 59. Is botany that much more preservative than physical chemistry? To be sure, van't Hoff drove himself hard, and to the very end; but it was not physical chemistry that killed him. "Something seems to have altered in my constitution," he wrote on 1 August 1906 (1, p. 548); and on 1 March 1911 he died of tuberculosis. Even an enforced stay in a sanatorium led to a paper, "Sanatoriums-Betrachtung," on heat and work relationships in active life and in the bedridden (5).

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