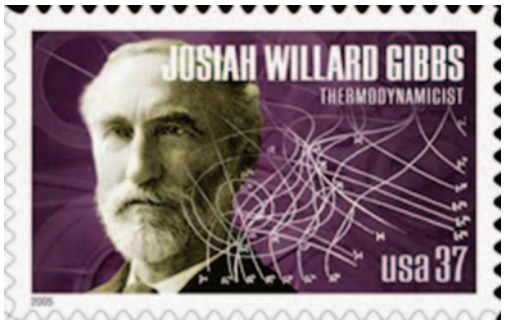
THANKS, DR. GIBBS

Hap McSween



When I was first exposed to thermodynamics as an undergraduate, I felt like the kid who opened the balloon to see how it works: I wasn't left with much. It seemed like smoke and mirrors. Why would anyone envision such an intangible and non-intuitive way to understand chemical reactions? And, who came up with this approach in the first place?

I've since learned to appreciate, even delight in, the elegance of thermodynamics. We all have J. Willard Gibbs to thank. Nowadays, his name is almost universally recognized by scientists and engineers. Even the first letter of his surname is forever memorialized as the symbol for Gibbs free energy (the U.S. National Bureau of Standards uses *F* rather than *G*, but the latter is recommended by the International Union of Pure and Applied Chemistry). His visage even graces a U.S. postage stamp, a rare honor for a scientist. During his lifetime, though, Gibbs's genius mostly went unacknowledged, especially in his native America.

Thermodynamics is manifestly one of those areas where we stand on the shoulders of a giant. Thanks Dr. Gibbs, on behalf of geoscientists everywhere.

Gibbs was educated at Yale University, and in 1863 received the first PhD in engineering awarded in the United States. After spending a year each in Paris, Berlin, and Heidelberg, he returned to Yale as Professor of Mathematical Physics, a position that initially carried no salary. In 1880 Johns Hopkins University offered Gibbs a faculty position paying $3000. Yale countered with a $2000 salary, which proved to be enough to retain him.

Several years before he started getting a regular paycheck, Gibbs wrote a series of papers that were eventually published together in a monograph entitled *On the Equilibrium of Heterogeneous Substances*. In hindsight, this work is viewed as one of the greatest scientific achievements of the nineteenth century, and it has garnered Gibbs the title of founder of chemical thermodynamics. Despite publication of this book, some time elapsed before the significance of Gibbs's work was recognized, because its mathematical rigor made it difficult reading for experimental chemists, who could most readily use its approach. A few leading European chemists noticed, notably James Clerk Maxwell, Wilhelm Ostwald, and Henry Louis le Chatelier, but Gibbs's revolutionary contribution was not widely appreciated until two decades after his death, with the 1923 publication of Lewis and Randall's classic chemistry text, *Thermodynamics and the Free Energy of Chemical Substances*.

Gibbs' thermodynamics first found application in physics, then chemistry, and later engineering. Its utility in geology had to wait until enough data on the thermodynamic properties of compositionally complex minerals, melts, and fluids became available. The phase equilibria experiments of Norman Bowen, carried out between 1912 and 1956, constituted an important part of that data set. Bowen was educated in both geology and chemistry, and he surely was familiar with Gibbs's work. Surprisingly, though, in leafing through Bowen's *The Evolution of the Igneous Rocks* (1928), I could find no mention of Gibbs or even of any thermodynamic functions. Victor Goldschmidt's *Geochemistry*, published posthumously in 1956, explains the chemical affinities of elements for oxide, silicate, sulfide, and metal phases in terms of their free energies of formation, but again Gibbs's name is nowhere to be found. The first textbooks that really showed mineralogists, petrologists, and geochemists how to apply thermodynamic principles were authored by Robert Garrels in 1960 (*Mineral Equilibria at Low Temperatures and Pressures*) and by Raymond Kern and Alain Weisbrod in 1964 (*Thermodynamique de Base pour Minéralogistes, Pétrographes et Géologues*). After a slow start, Gibbs's concepts have become indispensable parts of our science.

I've heard it said that the sincerest form of flattery for scientists is to have their contributions become so ingrained that they need no reference. Gibbs should truly be flattered. I looked through my extensive collection of modern mineralogy, petrology, and geochemistry texts, and not a single one references his published work. Any reference to him (if there is one at all) only acknowledges his derivation of the phase rule, although our community did christen a mineral (gibbsite) in his honor. Thermodynamics is manifestly one of those areas where we stand on the shoulders of a giant. Thanks, Dr. Gibbs, on behalf of geoscientists everywhere.

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* Hap McSween was the principal editor in charge of this issue.