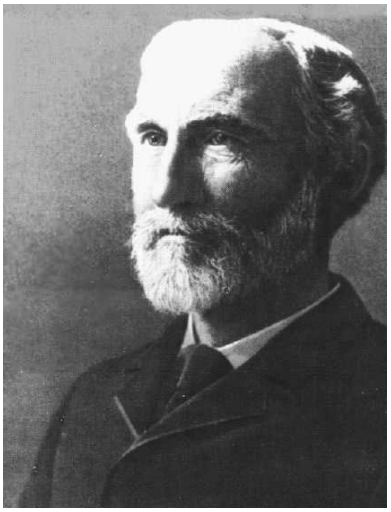
JOSIAH WILLARD GIBBS

American mathematical physicist **Josiah Willard Gibbs** (February 11, 1839 – April 28, 1903) greatly extended the field of thermodynamics, which originally comprised only the relations between heat and mechanical work. Gibbs was instrumental in broadening the field to embrace transformations of energy between all the forms in which it may be manifested, be they thermal, mechanical, electrical, chemical, or radiant. He is considered to be the founder of chemical thermodynamics. In mathematics he wrote on quaternions and was influential in developing vector analysis.



Gibbs was born and died in New Haven, Connecticut, where he attended Hopkins Grammar School and Yale University. To distinguish himself from his father, also named Josiah Willard Gibbs, a professor of sacred literature and linguistics at Yale, and not be referred to as 'junior," the younger man went by the name J. Willard Gibbs. At Yale the younger Gibbs received prizes in mathematics and Latin, and in 1863 he became the first person to be awarded a doctorate in engineering from a United States university. In his thesis he used geometrical methods to study the design of gears. For the next three years he tutored in Latin and Natural Philosophy at Yale. From 1866 to 1869, he studied at universities in Paris, Berlin, and Heidelberg. Except for this period, Gibbs, who remained a bachelor, spent his whole life living with his sisters in the same house his father built, only a short walking distance from Yale.

In 1869, Gibbs was appointed professor of mathematical physics at Yale without pay, partly because he had not published anything. This was the first professorship in mathematical physics in the United States. It wasn't until 1880 when he was offered a $3000 salary from the newly established Johns

Hopkins University that Yale kept Gibbs by agreeing to pay him $2000 per year. Gibbs was reluctant to make his ideas known until he had thoroughly substantiated them. His works were long, with little wording, most of his presentations being formulas and calculations. It wasn't until he was 34 that he published his first papers "Graphical Methods in the Thermodynamics of Fluids" and "A Method of Geometrical Representation of the Thermodynamic Properties of Substances by Means of Surfaces." The first described diagrams in thermodynamics and the second extended the diagrams to three dimensions. His third paper "On the Equilibrium of Heterogeneous Substances" (1878) established Gibbs' reputation. It is considered a groundbreaking work in the field of physical chemistry. French physical chemist Henry Châtelier compared it in importance with the work of Antoine Lavoisier.

Gibbs published in a relatively obscure journal, *Transactions of the Connecticut Academy of Arts and Sciences*. The articles were expensive to set in type because of their length and large numbers of mathematical formulas. Funds to pay for the printing were raised by subscription from Yale professors and New Haven businessmen, most of whom were unable to understand them. As this journal was not well known in Europe, prominent European scientists were unaware of Gibb's contributions. It wasn't until his work was translated into German by physical chemist Friedrich Wilhelm Ostwald in 1892 and French by Châtelier in 1899 that he was recognized as the greatest American theoretical scientist up to his time.

Gibbs' work in statistical mechanics made contributions to crystallography and the determination of planetary and comet orbits, as well as providing a mathematical framework for quantum theory. Marcel Brillouin, who wrote a commentary on Gibbs' *Elementary Principles in Statistical Mechanics* (1902), compared it for its genius with the analytical mechanics of Lagrange. Gibbs and Oliver Heaviside independently made the formal mathematical break with quaternions and the introduction of a new independent subject, three-dimensional vector analysis. Gibbs prepared a pamphlet *Elements of Vector*

Analysis that was privately circulated among his students. The material was finally incorporated in a book *Vector Analysis* (1901) written by E.B. Watson and based on Gibb's lectures. Gibb's viewpoint is expressed in an introductory note to his pamphlet:

> "The fundamental principles of the following analysis are such as are familiar under a slightly different form to students of quaternions. The manner in which the subject is developed is somewhat different from that followed in treatises on quaternions, being simply to give a suitable notation for those relations between vectors, or between vectors and scalars, which seem most important, and which lend themselves most readily to analytical transformations, and to explain some of these transformations."

When he died Gibbs was buried in Grove Street Cemetery, New Haven, on the edge of the Yale campus. Yale University honored him by establishing the *J. Willard Gibbs Professorship in Theoretical Chemistry,* a chair long occupied by Nobel Prize winning physical chemist Lars Onsager, who like Gibbs was primarily interested in applying new mathematical ideas to problems in physical chemistry, especially statistical mechanics. Gibbs died prior to the establishment of the Nobel Prize or he might have been awarded one. As it is he received the Copley Medal of the Royal Society of the United Kingdom, at the time considered the highest available honor.

Quotation of the Day: "A mathematician may say anything he pleases, but a physicist must be at least partially sane." – J. Willard Gibbs