

Guldberg, Cato Maximilian

(b. Christiania [now Oslo], Norway, 11 August 1836; d. Christiania, 14 January 1902)

chemistry, physics.

Guldberg was the eldest of the nine children of Carl August Guldberg, a minister and owner of a bookshop and printing office, and Hanna Sophie Theresia Bull. When Guldberg was eleven years old, his father was appointed minister at Nannestad, about fifty miles north of Christiania. Although the foundation for Guldberg's later delight in outdoor life, hunting, and fishing was laid in his father's remote parish, he could not get a satisfactory education there, and at the age of thirteen he was sent to live with his maternal grandmother at Fredrikstad. There he entered [secondary school](#), where he excelled in mathematics.

Because the school in Fredrikstad could not grant admission certificates for the university, in 1853 Guldberg went to Christiania, where he spent his last school year in a private Latin school; he then matriculated at the University of Christiania in 1854, the same year as his friend Peter Waage. At the university Guldberg majored in mathematics and studied physics and chemistry. While still a student, he worked independently on advanced mathematical problems, and his first published scientific paper, "On the Contact of Circles" (University of Christiania publication [Christiania, 1861]), won the crown prince's gold medal.

In 1859 he graduated in science and obtained a modest position as teacher at Nissen's [secondary school](#) in Christiania. In 1860 he was appointed teacher of mathematics at the Royal Military Academy. The next year, by means of a scholarship, he made a one-year study tour of France, Switzerland, and Germany. In 1862 he qualified for a position in applied mechanics at the Royal Military College,

and in 1863 he was appointed a teacher of advanced mechanics at the same school. He held these two positions until his death. He was awarded a scholarship in 1867 at the University of Christiania, where he became professor of applied mathematics in 1869.

Guldberg and Waage, whose names are linked for their joint discovery of the law of mass action, were also closely related through marriage. Guldberg married his cousin Bodil Mathea Riddervold, the daughter of cabinet minister Hans Riddervold; the couple had three daughters. Waage married her sister. The collaboration between the two friends and brothers-in-law on the studies of chemical affinity that were to lead to the law of mass action began immediately after Guldberg's return from abroad in 1862. The first report of their results was presented by Waage on 14 March 1864 before the Norwegian Academy of Sciences and published the following year in the Academy's proceedings. But the report remained almost completely unknown to scientists, a fate also suffered by a more detailed description of their theory published in French in 1867. The theory did not become generally known until [Wilhelm Ostwald](#), in a paper published in 1877, adopted the law of mass action and proved its validity by new experiments. Although the law had had several forerunners, the combined efforts of the theorist Guldberg and the empiricist Waage led to the first general mathematical and exact formulation of the role of the amounts of reactants in [chemical equilibrium](#) systems. In 1878 Jacobus Henricus van't Hoff, apparently without any knowledge of Guldberg and Waage's work, derived the law from reaction kinetics.

Although the law of mass action is Guldberg's greatest contribution to [physical chemistry](#), it is not his only one. Some of his early work published in Norwegian did not get the publicity it deserved. He devoted much time to a search for a general equation of state for gases, liquids, and solids from a kinetic molecular approach. In 1867, nineteen years before

van't Hoff, he introduced the ideal gas equation in the form $p^v = 2 T$. In 1869 he developed the concept of "corresponding temperatures" and deduced an equation of state valid for all liquids of certain types. In 1890 he formulated the rule that the reduced boiling temperatures of most liquids are close to 2/3, a relationship discovered independently by P. A. Guye. In addition, Guldberg made valuable contributions to the thermodynamics of solution and of dissociation, and he discovered and correctly explained cryohydrates. He wrote many articles on various practical problems and a number of textbooks on mathematics and mechanics. He was editor of the *Polyteknisk tidsskrift*, an active member and officer of scientific societies, and the recipient of many honors.

BIBLIOGRAPHY

I. Original Works. Guldberg and Waage's various papers on the law of mass action have been abridged and translated into German by Richard Abegg as *Untersuchungen über die chemischen Affinitäten*, in [Wilhelm Ostwald](#), *Klassiker der exakten Wissenschaften*, CIV (Leipzig, 1899). Their first paper, "Studier over Affiniteten," published in Norwegian in *Forhandlinger i Videnskabs-selskabet i Christiania*, (1865), 35-45, appears in facsimile, along with a number of articles on the law, in Haakon Haraldsen, ed., *The Law of Mass Action: A Centenary Volume 1864-1964* (Oslo, 1964).

II. Secondary Literature. A biography of Guldberg and a discussion of his work by Haakon Haraldsen appears on pp. 19-26 and 32-35 of the centenary volume cited above and on pp. 172-174 of Abegg's trans. Also see J. B. Halvorsen, "C. M. Guldberg," in *Norsk ForfatterLexikon*, II (Christiania, 1888), 447; Elling Holst, "C. M. Guldberg," in *Nordisk Universitetstidsskrift*, 2 (1902), 321; H. Goldschmidt, "C. M. Guldberg," in *Fordhandlinger Videnskabs-Selskabet Christiania*, no. 1 (1903), 1; Sophus Torup, "C. M. Guldberg,"

in *Norsk biografisk leksikon*, V (Oslo, 1931), 76; T. Hiortdahl, "Den Fysisk-Kemiske Forening, Tidsskr. Kemi, Farmaci og Terapi," in *Pharmacia*, **14** (1917), 240; Kåre Fasting, "Teknikk og Samfunn," in *Den Polytekniske Forening 1852-1952* (Oslo, 1952); and Gunnar Oxaal, *Teknisk Ukeblad* (1954), pp. 306, 308.

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