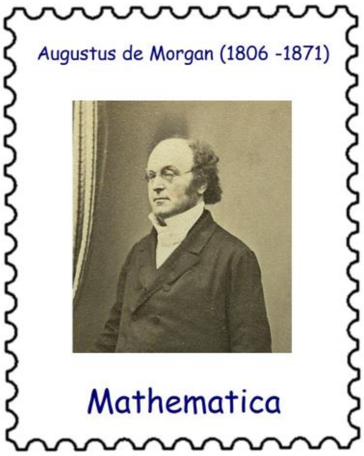
AUGUSTUS DE MORGAN (June 27, 1806 – March 18, 1871)

by HEINZ KLAUS STRICK, Germany



(Photo by DR. SIDNEY J. KOLPAS)

AUGUSTUS DE MORGAN was born the fifth child of JOHN DE MORGAN, a lieutenant colonel at the East India Company, in India. His mother's ancestors include JAMES DODSON, who in 1742 published a table with 11-digit anti-logarithms.

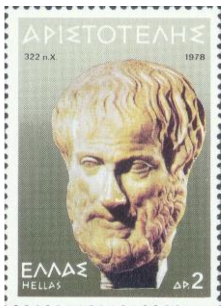
When AUGUSTUS was seven months old, the father brought his family to England. He himself had to continue to serve in India, and when he finally wanted to return to his family ten years later, he died during the sea voyage.

AUGUSTUS had lost the sight of the right eye in the first months of his life, and this excluded him from sporting activities during his school days and often gave his comrades the opportunity to perform cruel pranks.

AUGUSTUS attended various private schools in the south of England. At the age of 16 he moved to *Trinity College* in Cambridge; he graduated with a *Bachelor of Arts*. Although he was the fourth best in his class, he did not stay to complete a *Master of Arts*, for such a degree in Cambridge included a theological exam, and for fundamental reasons he refused to do so – although he was a member of the Church of England. (This regulation of the Universities of Cambridge and Oxford was only abolished in 1875.)

He began studying law in London. When the newly founded *London University* (later: *University College London*) advertised a position in mathematics in 1826, he applied and was appointed as a professor of mathematics at the age of only 21 based on the recommendation of his former professors and without any publications. He held this chair with a 5-year gap until 1866.
(The gap was because, when one of the professors was unjustly dismissed by the university, he demonstrated his disapproval by resigning from his office. He resumed teaching at *University College* in 1836 after his successor was killed in an accident.)

At the beginning of the 19th century, mathematical research in Great Britain was still suffering from the fact that the priority dispute between ISAAC NEWTON and GOTTFRIED WILHELM LEIBNIZ had brought an end to collaboration between mathematicians on the continental Europe and those in the British Isles. In contrast to the situation in analysis, British mathematicians have taken on a pioneering role in algebra: GEORGE PEACOCK, one of the teachers of AUGUSTUS DE MORGAN in Cambridge, had taken the first steps towards abstract algebra as a science of symbols that are multiplied according to certain rules. However, he could only give his critics the usual arithmetic ("symbol calculation") as an example of such an algebra. Examination of structures in which, for example, the commutative law did not apply were still beyond his imagination.



DE MORGAN recognized the need to examine the laws of logical reasoning in parallel with the further development of algebra. So he dealt intensively with the logic of ARISTOTLE and critically examined its syllogisms (proof and concluding doctrine): A logical conclusion included two statements (premises), from which a third statement (the conclusion) was concluded according to a logical scheme. ARISTOTLE distinguished between *deduction* (conclusion from the general to the individual case), *induction* (obtaining a general statement from individual cases) and *abduction* (classification of individual cases under a general rule still to be discovered).

In 1838, De Morgan was the first to provide a clear and strict definition of the concept of mathematical induction, in the popular science encyclopedia *Penny Cyclopedia*, published by the *Society for the Diffusion of Useful Knowledge*. Over the years, he wrote a total of 712 articles for these publishers, about one sixth of all articles in the encyclopedia.

Above all, De Morgan developed the predicate logic and invented his own notation.

The terms used by Aristotle A: "All X are Ys" he replaced with "X)Y"; E: "No X is a Y" by "X.Y" ;

I: "Some X are Ys" by "XY"; O: "Some X are not Ys" by "X:Y",

so that the Aristotelian syllogism: From "All X are Ys" and "All Y are Zs" follows:
"All X are Zs" can be written as "X)Y + Y)Z = X)Z" and so on.

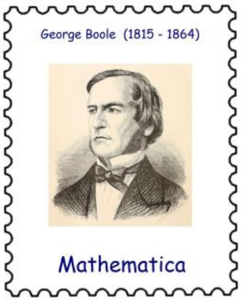
In 1847, De Morgan published *Formal Logic: or, The Calculus of Inference, Necessary and Probable*, which among other things also contains the laws for the negation of linked statements. These rules are known today as De Morgan's laws. (William of Ockham (1288 – 1347) had already formulated them, but they had been forgotten).

In mathematical propositional logic, the laws today are in the form

$\neg(a \vee b) = (\neg a) \wedge (\neg b)$ and $\neg(a \wedge b) = (\neg a) \vee (\neg b)$,

in set theory as

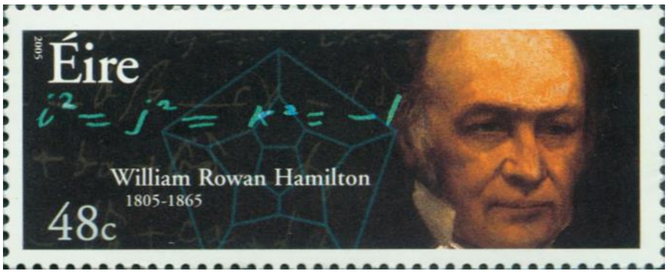
$\overline{A \cup B} = \overline{A} \cap \overline{B}$ and $\overline{A \cap B} = \overline{A} \cup \overline{B}$.

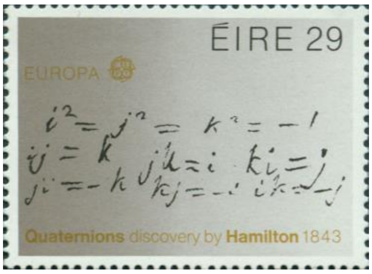


The time was ripe for the development of a formal language:

George Boole's epochal work *The Mathematical Analysis of Logic* also appeared in 1847; in the foreword, he expressly thanked De Morgan for his various suggestions.

In his lectures and in numerous scientific treatises (including the books: *Elements of Trigonometry*, *The Elements of Algebra*, *The Elements of Arithmetic*, *The Differential and Integral Calculus*), De Morgan endeavoured to provide more precise wording and reasoning than was previously the case. In the *Cambridge Philosophical Transactions*, he published several articles on the fundamentals of algebra.





William Rowan Hamilton discovered in 1832 that complex numbers could be understood as pairs of numbers. In 1843 he found the laws of multiplication for four-dimensional objects, the *quaternions*. In his *Lectures on Quaternions* (1853), the Irish mathematician stated several times that De Morgan's publications encouraged him to investigate this area.

In 1849, De Morgan's *Trigonometry and Double Algebra* appeared. The first part of the book dealt with trigonometric functions, including complex ones, which had only recently been used for geometric calculations. In the second part of the book he reflected on the symbols and rules used in algebra. This single algebra deals with the multiplication of symbols – no matter what their meaning.

Solving quadratic equations could lead to terms of the form $a + b \cdot \sqrt{-1}$, which were interpreted as two-dimensional objects; he described the operations with these as *double algebra*. After HAMILTON succeeded in finding a quadruple algebra, DE MORGAN still hoped to develop a triple algebra himself, a three-dimensional system of objects with a suitable multiplication.

In 1866 he founded the *London Mathematical Society* together with his son GEORGE and other supporters and became the company's first president; in contrast to the *Royal Society*, whose membership he refused throughout his life, it was to be a discussion forum for new ideas.

Shortly thereafter, a chair for philosophy at *University College* became vacant and the most capable applicant was rejected by the University Council because of his membership of the Unitarian Church.

DE MORGAN protested against this violation of the principle of religious neutrality of the university and resigned - this time permanently.

His seven children ensured that he has enough to live on, but when his son GEORGE, in whom he had hopes of a career as a mathematician, and then one of the daughters died, he lost his will to live. Five years after leaving the university, it was said that he died of a nervous disorder.

His wife posthumously published *Budget of Paradoxes*, a compilation of comments on books and writings that he had diligently collected: It contained articles about circle squarers, angle trisectors, cube doublers, designers of a perpetual motion machine, inventions that cancel gravity or stop the earth's rotation and many more curiosities.

DE MORGAN loved number games throughout his life. Regarding his age, he used to refer to the fact that he differed from many people in that he was able to celebrate his xth birthday in the year x^2 ($x = 43$; $x^2 = 1849$).

First published 2016 by Spektrum der Wissenschaft Verlagsgesellschaft Heidelberg

https://www.spektrum.de/wissen/augustus-de-morgan-1806-1871/1413631

Translated 2020 by John O’Connor, University of St Andrews

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