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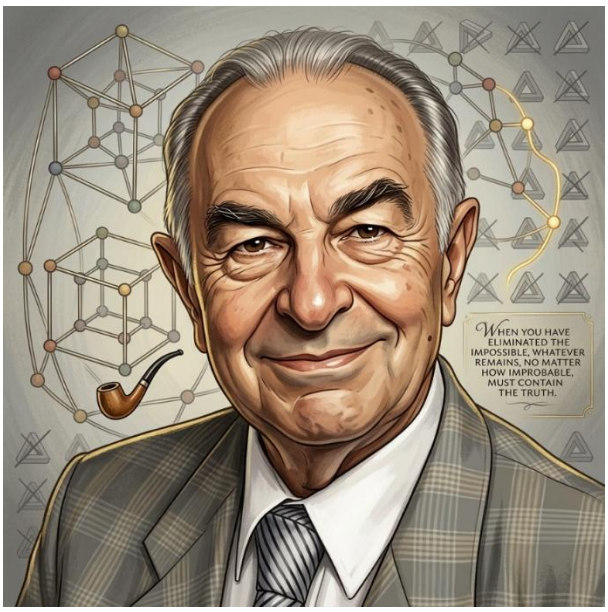
BRIDGING MOLECULES, MATHEMATICS AND GENERATIONS: CELEBRATING PROFESSOR ALEXANDRU T. BALABAN AT HIS 95th ANNIVERSARY



Academician Alexandru T. BALABAN
(photo generated with Adobe Firefly AI)

The history of science is often told through discoveries, reactions, and equations. Yet the true measure of a scientist lies not only in what they discover, but also in how they change the way others think. Prof. Alexandru T. Balaban belongs to that rare category of scholars whose influence extends far beyond the boundaries of a single discipline. His career illustrates how curiosity, hard work, intellectual courage, and interdisciplinary thinking can reshape entire fields of research and inspire generations of scientists.

Having witnessed nearly a century of chemical progress and maintained an active scientific career for more than seven decades, Prof. Balaban has not only observed many of the most important developments in modern chemistry but has also played a significant role in shaping them. Few scientists can claim to have contributed to the discipline across such a broad historical period, spanning the post-war expansion of organic chemistry as an experimental science focused on synthesis and structural elucidation, the rise of physical organic chemistry and molecular orbital theory, the advent of modern spectroscopic methods, the emergence of supramolecular chemistry, and ultimately the development of computational chemistry and cheminformatics.

Trained as an organic chemist under the legendary Prof. Costin D. Nenitzescu, Prof. Balaban made landmark contributions to experimental chemistry, including the discovery of the Balaban-Nenitzescu-Praill reaction, a valuable alternative synthetic route to pyrylium salts, compounds that became central to his research and to the broader understanding of aromatic and heteroaromatic systems. He also had important contributions in the synthesis of oxazoles, indolizines, naphthalene derivatives, and hydrazyl radicals, while also contributing to the development of isotopic labeling methods which provided chemists with powerful tools for elucidating reaction mechanisms and molecular structures.

Yet it is perhaps his ability to transcend traditional disciplinary boundaries that most clearly defines his scientific legacy. At a time when chemistry and mathematics were often viewed as separate worlds, Prof. Balaban

recognized that molecules could be understood not only as collections of atoms but also as mathematical objects. This insight led him to become one of the founders of modern chemical graph theory, a field that transformed the representation and analysis of molecular structures. His *Chemical Applications of Graph Theory* with a forefront written by Vladimir Prelog, published in 1976, was the first book dedicated to this emerging discipline and helped establish a new scientific language that is now fundamental to cheminformatics.

The impact of these ideas reaches far beyond theoretical elegance. Today, the mathematical descriptors and topological concepts pioneered by Prof. Balaban are used in modern drug discovery, quantitative structure-activity relationships, and the prediction of material properties. The famous Balaban index provides a powerful molecular descriptor capable of distinguishing chemical structures with unprecedented precision and remains widely cited decades after its introduction.

What makes Prof. Balaban's career particularly remarkable is the breadth of his intellectual vision. His work spans organic synthesis, physical chemistry, radical chemistry, carbon allotropes, aromaticity, molecular topology, scientometrics, and science philosophy. He contributed to the understanding of molecular symmetry, predicted novel chemical species later confirmed experimentally, explored alternative carbon networks long before nanotechnology became fashionable, and helped establish international standards for pharmaceutical quality control through his work with the International Atomic Energy Agency.

Prof. Balaban was a respected mentor for many generations of undergraduate, master, and PhD students (more than 40), to which he cultivated not only scientific expertise but also intellectual curiosity, academic rigor and perseverance. Moreover, he was a member of the editorial board of many leading scientific journals, and he played an important role in modernizing scientific evaluation and peer-review practices in Romania.

In numbers, the career of Professor Balaban is truly remarkable with over 800 published articles, 17 books, over 80 book chapters, 25 patents, and numerous invited conferences and seminars leading to an H-index of 62. He received numerous distinctions and awards including the Roumanian Academy Prize (1962), the Herman Skolnik Award of the Division of Chemical Information of the American Chemical Society (1994), Dr. Honoris Causa, University Timişoara, Roumania, (1997), National Order Star of Roumania with grade Faithful Service of the President of Roumania (2000), Roumanian Academy's Medal "Costin D. Nenitzescu" for distinguished chemical research results (2007), Distinguished Achievement Award for Research of the Association of Former Students, Texas A&M University (2007) and National Order Star of Roumania with grade Cavalier from the President of Roumania (2016). Beyond these distinctions, his contribution to science and humanity was also recognized through election to some of the most prestigious scientific academies, including the Roumanian Academy, where he served as Vice-President (1995-1998), the World Academy of Theoretical Organic Chemists Paris, the Roumanian Academy of Technical Sciences, the American-Roumanian Academy of Sciences, Arts and Letters, the Hungarian Academy of Sciences, and the International Academy of Mathematical Chemistry, of which he also served as President (2005–2008).

For society, the significance of Professor Balaban's work lies in a lesson that extends beyond chemistry. He demonstrated that major advances often occur at the intersections of disciplines. Long before terms such as "interdisciplinary research", "data science", or "artificial intelligence" became commonplace, he understood that solving complex problems requires connecting ideas across fields. His scientific journey serves as a reminder that creativity is often born when seemingly unrelated concepts are brought together.

In times increasingly defined by specialization, Prof. Balaban stands as an example of the universal scholar: a scientist equally comfortable discussing organic reactions, mathematical structures, history of science, or philosophy. His legacy is not merely a collection of publications, patents, awards, or scientific indices, it is a way of thinking, one that embraces curiosity without boundaries and seeks unity within complexity.

As Prof. Balaban marks his 95th year, we celebrate a scientist who has lived and breathed the spirit of *labor omnia vincit* transforming decades of tireless dedication into a scientific legacy that will endure long beyond our time. May he continue to inspire us with his wisdom and curiosity for many years to come.

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