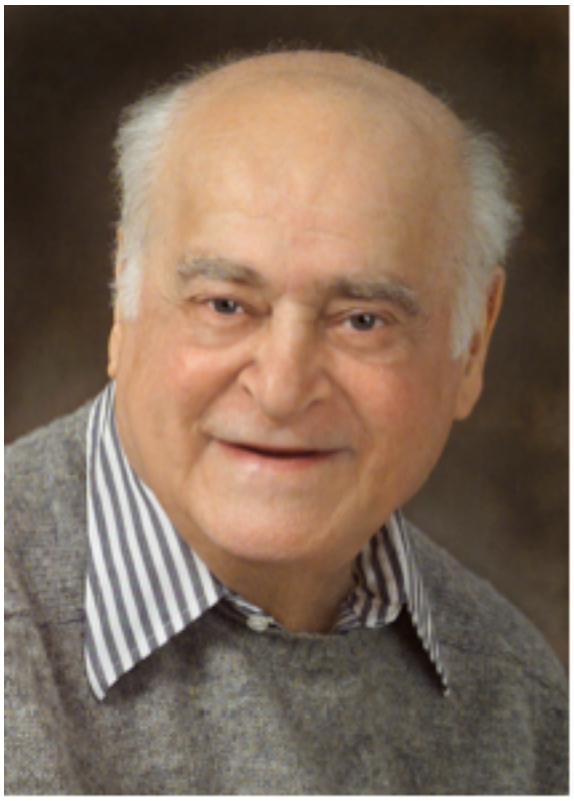
Eli Ruckenstein Interview for AIChE Mini History Project

Interview conducted Thursday, May 4, by Leslie Graff



Eli Ruckenstein's office at the State University of New York at Buffalo is lined with his numerous awards, including the 2004 Founders Award from the National Academy of Engineering and the 1998 National Medal of Science, which is bestowed on individuals who have made outstanding contributions to knowledge in the chemical, physical, biological, mathematical, engineering, or social sciences. Ruckenstein holds the title of Distinguished Professor, and at almost 81 years of age he still energetically and passionately pursues his research, developing new interests and actively contributing to cutting-edge research.

Over many years, Ruckenstein's prolific and imaginative research has advanced theories in transport phenomena, interfacial phenomena, catalysis, colloidal forces, polymers, surfactants, materials, and countless other diverse areas of chemical engineering and science. His inspirational story is one of great difficulties but also of great satisfaction. In fact, Ruckenstein believes that joy and pain are mixed not only in life but also in scientific research, because you cannot come to the joy of rewarding new research without the painful process of discovering new questions and developing ideas in order to solve them.

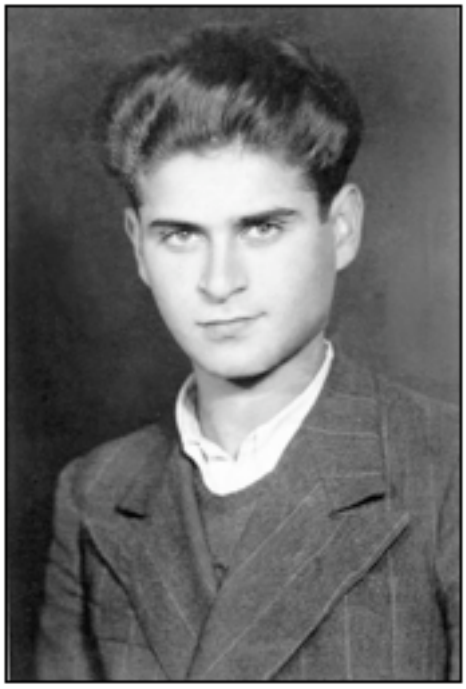
## Biography

Eli Ruckenstein was born in Botosani, a small agricultural town in northern Romania. His family was well off until they lost everything in the Great Depression. This meant that in his formative years he had to struggle and fight poverty.

He began school at seven but at fourteen he was expelled due to racial laws. The Jewish community responded by organizing a private high school where the teachers were intellectuals who loved their jobs and, although without the necessary credentials, made schooling interesting and exciting.

In his last two years of high school, he was taken into forced labor six days a week from 5 a.m. to 5 p.m. His task was to carry bricks on a scaffold all day. Although he was out

of school, he studied by himself and took exams at the end of each of these two years. At this time he fell in love with mathematics, which he learned by himself, and in this way he laid the educational foundation for the rest of his future studies.



Eli at 19 years of age

In 1944, the year when the Russian troops entered Romania and when the fascist government was replaced by a communist regime, Ruckenstein arrived in Bucharest in order to enter the University. He imagined this institution as a temple of learning, but when he reached the Polytechnic Institute, which was the School of Engineering, he was disappointed to find military types of buildings. He was also disoriented in choosing a profession. His interests were in mathematics, chemistry and physics. A family friend guided him towards chemical engineering as a way to bring all these fields together. In order to enter the Polytechnic Institute he had to take competitive exams because there were 400 candidates vying for 20 places. He was among the successful ones, and he received his degree in 1949. Although the education was free in Romania, even at the University level, Ruckenstein suffered hunger through all his student years, and many times he didn't have money for a street car ticket, so he had to walk long distances.

These hardships did not diminish his perseverance. Finding the classes boring, he spent his time in the library reading at random. He read every journal in his field, understanding some of the papers and not understanding others (he wouldn't recommend this way of studying to anyone). When he took his final exams in Chemical Engineering, he met Professor Emil Bratu, who became his mentor and of whom he keeps fond memories.

In 1948 Ruckenstein married Velina Rothstein, an event he describes as the best thing he has ever done. He credits his wife with having a tremendous influence on his career by offering unflinching support for his academic goals. By profession a chemist, she worked in a research institute and most of the time she earned more money than he did as an academic.

In 1949 Ruckenstein secured a position of Assistant Professor at the Polytechnic Institute in the Department of Chemical Engineering, which was quite a miraculous occurrence considering that he was not a member of the Communist party. Still, because he was not part of the ruling party it took him 15 years to be promoted to associate professor.

Before 1958 Romanian scientists were not allowed to send papers to the West for publication. When this rule was changed Ruckenstein's work reached an international audi-

ence, and as a result he became known outside Romania. In 1969 he was invited to spend six weeks in London at the University College and Imperial College.

Eli at 42

When he returned home, there were letters from the University of Minnesota and Clarkson University inviting him to the U.S. The University of Minnesota wanted him to make arrangements through the Romanian Academy of Science. This suggestion was not viable because of the policy of the Romania government which controlled all institutions, including the Academy, and which was discriminating against persons who were not members of the Communist Party.

Clarkson University had received a grant from the National Science Foundation for a visiting European scientist. This allowed Ruckenstein to bypass the Romanian Academy, and consequently he spent one academic year at Clarkson. Subsequently, in 1970, he received a permanent position as Full Professor with tenure at the University of Delaware.

It was not easy for Ruckenstein to acclimate to new ways and a new atmosphere, but his American colleagues were very friendly and helpful. Beside the need to accommodate to new ways, he had to deal with an extremely difficult family problem. While his wife was allowed to accompany him to the United States, his two children were not allowed to leave Romania, in order to compel him to come back. In a way it was like keeping these two minor children (ages 12 and 14) as hostages. It took two years of effort to get the children out from behind the Iron Curtain, and in this process, his colleagues at the University of Delaware, particularly Art Metzner, were of the greatest help. Their son, Andrei, is now a professor of physics at Rutgers University and their daughter, Lelia, is a literary critic and a writer.

In 1971 Professor William Gill, Ruckenstein's former chair at Clarkson, moved to the University of Buffalo as Dean of the Engineering School. He encouraged Ruckenstein to move to Buffalo as well, and from 1973 to the present he has been a faculty member in the Department of Chemical Engineering (now Chemical and Biological Engineering), SUNY at Buffalo.

## Career Accomplishments

Ruckenstein conducts both theoretical and experimental research that not only has increased scientists' understanding of the fundamental phenomena of chemical processes, but has led to the development of enhanced research methods and new materials.

His initial interests were in transport phenomena, and two of his more important contributions have been "A generalized penetration theory" and "Scaling and physical models in transport phenomena." In the first, he developed a new similarity transformation on the basis of which numerous unsolved transport equations could be solved, such as mass transfer in wave motion and mass transfer under pulsating flows. In the second, he showed how numerous complex problems could be solved by coupling simple solutions valid in extreme cases. An example is the "Heat transfer under combined forced and free convection." He also suggested a physical model for turbulence near a wall, which he applied to a solid surface and to boiling heat transfer; he developed a theory of thixotropy, theories for foams, a unitary theory of phoretic motions, theories for electrokinetic phenomena involving osmosis and anomalous osmosis, and he extended the simple approach of Prandtl for Newtonian fluids to viscoelastic fluids.

After arriving in U.S. his research diversified widely, encompassing the areas of catalysis, colloids, phase transformations, thermodynamics, and materials. In catalysis he pioneered the areas of stability of supported metal catalysts and catalytic combustion, and he suggested solid solution catalysts for $CO_2$ reforming of $CH_4$. He developed also a theory for the mechanism of oxidation by mixed oxides, proposed a kinetics for the selectivity of the catalytic processes and was the first to use quantum mechanics in the interpretation of catalytic reactions.

In the area of colloids and interfaces, he has introduced the concept of interaction force boundary layer in the examination of the deposition of particles on surfaces, he performed simulations to understand the collective behavior of a large number of charged colloidal particles, and he developed a theory for hydration forces, theories for specific ion effects, for steric repulsion, and for bridging forces. He has shown that hydration and double layer forces should be coupled in an unitary treatment and he changed the traditional treatment of double layers. He developed a thermodynamics of surfactant aggregation and a new kind of thermodynamics for microemulsions, lamellar liquid crystals, and phospholipids monolayers. He was concerned with the phospholipid bilayer and examined the interactions between them. He developed theories for wetting and for the stability of both Newtonian and non-Newtonian thin films.

In the area of molecular thermodynamics, he developed theories for the solubility of gases and pharmaceutics in binary and multi-component solvents and for the solubility of proteins. He developed also theories for salting in and out, and for the local composition in liquid mixtures.

In the area of kinetics of phase transformation he developed theories for nucleation for unary and binary mixtures, free of macroscopic thermodynamic concepts, based on a first passage time. He also developed unitary theories for nucleation and growth.

In the areas of polymers and materials, he suggested and implemented numerous technological approaches to prepare composites, conductive polymers, membranes for separation processes, polymers with unusual properties, pastes with high thermal conductivity, and more recently, materials for $H_2$ storage.

In addition to the 2004 National Academy of Engineering Founders Award and the 1998 National Medal of Science, Ruckenstein has been honored by the American Institute of Chemical Engineers with its most prestigious awards: the Founders Award in 2002 for outstanding contributions to the field of chemical engineering; the Alpha Chi Sigma Award in 1977 for excellence in chemical engineering research; and the Walker Award for excellence in contributions to chemical-engineering literature in 1988. He received the 1986 Kendall Award of the American Chemical Society for creative theories and experiments in colloid and surface science and, in 1994, the society's Langmuir Lecture Award. In 1996, he was awarded the American Chemical Society's E.V. Murphree Award in Industrial and Engineering Chemistry. He received the Senior Humboldt Award of the Alexander von Humboldt Foundation in West Germany in 1985 for his work related to detergents, and the Creativity Award from the National Science Foundation for his work on protein separation. The Hauptman-Woodward Medical Research Institute honored him in 2003 with inclusion in their Pioneers of Science Award. He became in 1990 a member of the National Academy of Engineering.

**Ruckenstein receiving the National Medal of Science from President Clinton**

Ruckenstein is a voracious reader and a true intellectual. He converses easily on world history, politics, and the history of science and engineering. He has deep knowledge of the course that scientific progress has taken, and he is well versed in the lives and the specific contributions made by many of the great minds that preceded us. He has a bibliographic memory, and is often able to cite his own and others' contributions to a specific area made as long as fifty years ago, specifying the both year and the journal of publication!

## Outlook

Now, at nearly 81 years of age, Ruckenstein still works full time, he is still active and finds his work in the department to be extremely satisfying. One source of satisfaction is his interaction with his younger colleagues, who he finds to be very talented and dedicated and who are doing meaningful research. Ruckenstein feels that it is very important to have flexibility in his own work, and he is even now expanding his research in a variety of new areas. Recently he has acquired interest in areas related to proteins and the

thermodynamics of complex systems. Even though he has made his mark with more than 800 publications, he has no intention in slowing down.


**Special issue *Chem. Eng. Comm.* devoted to Eli Ruckenstein.**

When asked about his concerns and hope for the future of chemical engineering, Ruckenstein sees great promise. As the world changes, so too must engineering research. In the past, the goal of Chemical Engineering was to design equipment, but now he sees the mission as designing technology. There is a tremendous need for chemistry, biochemistry, and physics to answer modern questions in a variety of fields such as pharmaceutics, medicine, chemicals for industry or agriculture, and to provide solutions to problems that we may not even be familiar with yet. In this way the field will be able to provide enough flexibility to withstand the changes in industry and in the public sector and to offer opportunities to improve the quality of life for everyone.

Looking back at his long career and at his long life, he is grateful for the opportunities as well as for the hardships which he encountered; and he considers himself a very lucky man. As he comes into his office every morning, he is still excited by the challenge of a new problem to address, by a new theory to explore and by the anticipation of the joy of quest.

SUMMARY

Eli Ruckenstein's inspirational life story is one of great difficulties but also of great satisfaction. In fact, Ruckenstein believes that joy and pain are mixed not only in life but also in scientific research, because you cannot come to the joy of discovery without the painful process of formulating the right questions and developing ideas in order to solve them.

Ruckenstein was born in a small agricultural town in northern Romania. In his formative years he suffered great hardships of poverty, forced labor, and political oppression. Nevertheless, his insatiable curiosity and his intellectual passion led him to persist in his studies, and to pursue knowledge wherever he could find it. His drive led him to succeed against great odds. His contributions were hidden behind the Iron Curtain for more than two decades, but when he eventually became known to the West his talent was immediately recognized, and he was invited to several universities. He visited Clarkson for a year, obtained a permanent position at Delaware, and then was lured to Buffalo where he is presently Distinguished Professor of Chemical and Biological Engineering.

As of this writing Eli Ruckenstein is 81 years of age, and yet his productivity has been steadily increasing for at least the past 20 years. His lifetime contributions touch an astonishing variety of areas, including fundamental topics in transport phenomena, thermodynamics, and kinetics, as well as specific topics in catalysis, colloids, polymers, and proteins. As the author of more than 800 publications and several patents, he has received almost all of the major awards for which he is eligible, culminating in the National Medal of Science in 1999 and the Founder's Award of the National Academy of Engineering in 2004. Eli Ruckenstein's life story is a profile in courage and dedication, and a demonstration that hardship can temper one's being.