



Roland Schauer – Obituary

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Professor Dr. med. Dipl.-Biochem. Roland Walter Schauer was born at Stuttgart-Bad Cannstatt, Germany, on 8 April 1936 as the son of Walter Schauer, an electrotechnical engineer at the Bosch company in Stuttgart, and Gertrud Uetz. Due to bombing raids on Stuttgart during World War II, in 1942 he was evacuated with his parents to Schorndorf, a city about 30 km east of Stuttgart, where he went to primary school and gymnasium.

Roland was a remarkable person and scientist. His individual passion for science and the focus of his research, the sialic acids were a constant feature throughout his life.

After starting his studies in Chemistry in 1955 at the University of Stuttgart, he switched to Medicine in the same year and moved to the Eberhard Karls University in Tübingen, Baden-Württemberg, one of the oldest and most reputable of German Universities, where he completed courses in medicine and biochemistry in 1966. Just to state, he was one of the first five students who followed the Biochemistry curriculum, which in those days had been introduced as a new field of study at the university. He then moved to the Ruhr University Bochum, a new University founded in 1962, which was still being built when he joined the group of Prof. Hans Faillard as a postdoctoral fellow and initiated his lifetime work on the sialic acids. At this time, the sialic acids were relatively unknown, initially being discovered by Gunnar Blix at the University of Uppsala, Sweden in 1936. Blix, together with Ernst Klenk, at Cologne, Germany, and Alfred Gottschalk, at Melbourne, Australia (later Tübingen), proposed the names neuraminic and sialic acid in 1957. However, it should be

noted that the structural identification of the mother 9-carbon monosaccharide N-acetylneuraminic acid, including its anomeric configuration in bound form, was not completed before 1969. For an overview of the first creation of chemical structures and the battle for the stereochemistry, including the major scientific players, see R. Schauer and J.P. Kamerling, Exploration of the Sialic Acid World, Adv. Carbohydr. Chem. Biochem., 75, 2018, 1–213. Roland took advantage of his scientific meeting trips to engage with the dominant researchers in the field of carbohydrate chemistry and biology before it was named Glycobiology by Raymond Dwek at Oxford in 1995. These included, amongst others, Jean Montreuil, André Verbert and Michel Monsigny in France, Saul Roseman, Len Warren, Abraham Rosenberg, Roger Jeanloz, Frederic Troy, Eric Vimr, and after 1983 Ajit Varki in the USA, Nathan Sharon and David Danon in Israel, Lars Svennerholm in Sweden, Guido Tettamanti in Italy, José Cabezas in Spain, and Tamio Yamakawa and Kyoko Hotta in Japan. At this time only a limited knowledge of the structural diversity of sialic acid chemistry was available and an understanding of their biological function and metabolism was non-existent.

Roland established a systematic and thorough approach for the study of the sialic acids. He followed their chemical identification using the techniques available at the time and set up collaborations with the scientific groups of Hans Vliegthart and Hans Kamerling at Utrecht University in The Netherlands (mass spectrometry) and Pierre Sinay at the University of Orleans in France (synthesis), together with contact with the groups of Richard Kuhn, Reinhard Brossmer, Fritz Zilliken and Werner Reutter in Germany. In addition, he maintained a strong interest in the chemical synthesis of the sialic acids which provided a vital link to the biochemical approaches to metabolic studies.

He initiated work on the metabolism of the sialic acids and within a few years was able to demonstrate existence of enzyme activities involved in the biosynthesis of N-glycolyl neuraminic acid and several O-acetylated sialic acids. These fundamental discoveries formed a solid basis for his future work. After only 3 years in Bochum, he received his *venia legendi* (Habilitation) with a thesis entitled “Acylneuraminic

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Acids: Properties, Synthesis and Biosynthesis” and became a docent and later an associate professor. A few years later, in 1976, Roland was offered the chair at Kiel, where he became Full Professor of Biochemistry and Director of the Institute of Biochemistry at the Christian-Albrechts University of Kiel. He headed this institute until his retirement in 2001, where he extended his research on the O-acetylation of sialic acids, demonstrated the occurrence of N-glycolylneuraminic acid in avian species, lectured on the biochemistry/molecular biology syllabus, drawing on his experience established in Tübingen.

His move to Bochum was at a time when the University was still under construction and the first months were spent in laboratories at “Im Lottental”, before moving into the main University buildings. At this time he worked with Ferdinand Wirtz-Peitz, Hans Schoop, Monika Blohm (Graessmann), Hans-Peter Buscher, Jorge Casals-Stenzel, Clarice Ferreira do Amaral, Stephan Nees, Jürgen Jancik, Rüdiger Veh, Gerd Reuter, Anthony Corfield, Johan Haverkamp and Margret Wember.

Together with Hans Faillard he started to develop isolation protocols based on anion-exchange and cellulose column chromatography, and 1D and 2D thin-layer chromatography for O-acetylation identification purposes. In the following years he developed the necessary tools, such as synthetic precursors for metabolic labelling, chemical, biochemical and histochemical/immunochemical analytical assays and procedures, and the use of cell culture and surviving tissue slices to address the biological aspects of the sialic acids.

Following on from the early discoveries of the metabolic pathways, he embarked on the demanding project of purifying and characterizing the enzymes involved. This proved to be a very difficult task due to low enzymatic abundance, poor stability or complex enzymatic mechanisms. His laboratory developed novel procedures based on affinity chromatography, well characterised substrates and a range of inhibitors. A notable discovery was that the formation of N-glycolylneuraminic acid occurred at the level of the CMP-glycoside, CMP-Neu5Ac (L. Shaw and R. Schauer, The Biosynthesis of N-Glycolylneuraminic Acid Occurs by Hydroxylation of the CMP-Glycoside of N-Acetylneuraminic Acid, *Biol. Chem. Hoppe-Seyler*, 369, 1988, 477–486). Work on the metabolism of the sialic acids, including both N-acetyl- and N-glycolyl-neuraminic acid was carried out by Ulrich Nöhle. These studies generated a sound basis for following work on the biological relevance of N-glycolylneuraminic acid and in particular the pathological aspects of N-glycolylneuraminic acid in man.

Relevant enzymes, especially the sialidases, the CMP-Neu5Ac hydroxylase making N-glycolylneuraminic acid, and the sialate 8-O-methyltransferase, were purified to apparent homogeneity by conventional protein purification

techniques. He pushed this work forward through gene cloning. Peter and Telse Roggentin cloned several bacterial sialidase genes and were the first to point out characteristic sequence motifs found in these enzymes which have been invaluable for the identification of genes coding for sialidases and trans-sialidases. In addition, sialate lyase and the CMP-Neu5Ac hydroxylase were also cloned in his group. After many years of study, the enzymes responsible for the 4-O- and 9-O-acetylation of the sialic acids were identified and specific esterases removing these acetyl esters were demonstrated. Collaboration with Reinhard Vlasak (Salzburg, Austria) and Chitra Mandal (Kolkata, India) formed an essential part of this work. A significant amount of research on the CMP-Neu5Ac hydroxylase was achieved by Lee Shaw and Yanina Malykh.

The biological roles of the sialic acids were a constant feature of research, and Roland published regular reviews drawing attention to the physiological relevance of the sialic acid family. These observations included consideration of their expression in relation to evolution, their normal function in a wide range of organisms and aberrations leading to pathology. Of particular importance was the demonstration of the half-life of erythrocytes in the human circulation, work completed by Jürgen Jancik in Roland’s Lab. (Jancik, J.; Schauer, R.; Streicher, H.-J. Influence of Membrane-Bound N-Acetylneuraminic Acid on the Survival of Erythrocytes in Man. *Hoppe-Seyler’s Z. Physiol. Chem.* 1975, 356, 1329–1331).

Important discoveries included the demonstration that sialic acids protect cells from phagocytosis by masking the galactose recognition sites and the identification of a macrophage receptor responsible for the recognition of desialylated cells, work carried out in Roland’s Lab by Sørge Kelm. Further demonstration of the conformation and intermolecular interactions of the different sialic acids using high resolution techniques were the work of Hans-Christian Siebert in Roland’s group. In addition, ab initio calculations were performed by Diet den Boer and Joop van Lenthe at Utrecht University (J.H. van Lenthe, D.H.W. den Boer, R.W.A. Havenith, R. Schauer and H.-C. Siebert, Ab Initio Calculations on Various Sialic Acids Provide Valuable Information About Sialic Acid-Specific Enzymes, *J. Mol. Struct. (Theochem)*, 677, 2004, 29–37).

The loss of sialic acid O-acetylation in colorectal cancer was featured in a number of papers with Anthony Corfield, Joe Tiralongo and Christoph Hanski, while the presence of O-lactyl and O-acetyl sialic acids in normal gastric tissue and a depletion of sialic acids with age was reported by Anthony Corfield. Additional studies of 9-O-acetyl-N-acetylneuraminic acid showed its presence in the precocular tear film of canine mucins and depletion in Keratoconjunctivitis sicca, its presence in normal human skin and basalomas, and the differential regulation of its expression

in the ganglioside GD3 during the differentiation and maturation of human T and B lymphocytes.

Further analysis of the sialate lyase continued with Reinhard Kleineidam and Erich Zbiral combining chemical synthesis with enzymatic testing in biological systems.

Work on the viral sialidases was a major part of Roland's research, in particular the influenza virus, and this was carried out with Reinhard Vlasak and Anthony Corfield. A series of papers focussed on the Trypanosoma sialic acids and trans-sialidases of both African and American origin. Further significant progress on the role of sialic acids in Leishmania and Childhood Acute Lymphoblastic Leukemia was established through a productive collaboration with Chitra Mandal from Kolkata, India.

Immunological studies included analysis of T-lymphocyte clones in the Tn-Syndrome and detailed work on CD22 and siglecs, moderated by Sørge Kelm with links to Paul Crocker and his group in Dundee, Scotland and Reinhard Brossmer in Heidelberg, Germany.

Demonstration and structure of the sialic acids in the Lipopolysaccharides of purple nonsulfur bacteria was established by J. Krauss in H. Mayer's group in Freiburg, Germany, while microbiological work included the adhesion of *Helicobacter pylori* strains to α -2,3-linked sialic Acids (Siiri Hirno, Torkel Wadström) and sialylglycoconjugates and sialyltransferase activity in the fungus *Cryptococcus neoformans* (Luiz Travassos).

More information about the sialic acids in Drosophila and Starfish was presented, and a sialic acid binding lectin from the Chinese bird-hunting spider was analysed. Furthermore, observations of a low incidence of N-glycolylneuraminic acid in birds and reptiles and its absence in the Platypus, which together with Echidna are the only egg laying mammals (monotremes unique to Australasia), were reported. The trisaccharide 4-O-acetyl-N-acetylneuraminic acid-(α 2-3)-lactose was detected in Echidna, provided by Michael Messer, Sydney, Australia, through the links with Hans Kamerling and Hans Vliegthart in Utrecht. Studies confirming the nature of sialic acids in insects was reported by Yanina Malykh for the Cicada, meadow froghopper, *Philaenus spumarius* and work with Jürgen Roth confirmed the presence of sialic acids in the fruit fly, *Drosophila melanogaster*. An important series of papers with Russel J. Howard established the nature of sialic acids in malaria parasites and the biological effects in the surface sialo glycoproteins of erythrocytes from malaria patients. Characterization of trans-sialidases in African and American Trypanosomes and their importance in parasitology was reported in several publications by M. Engstler in Roland's group (see R. Schauer and J.P. Kamerling, The Chemistry and Biology of Trypanosomal *trans*-Sialidases: Virulence Factors in Chagas Disease and Sleeping Sickness, ChemBioChem 12, 2011, 2246–2264).

All of these studies emphasise the broad range of interest linked to Roland's laboratory

Roland always had an appreciation for research workers in other countries. In 2004 he reported the influence of Victor Ginsberg on his understanding of the biological roles of the sialic acids and he had a long-standing association with Japanese scientists. These included Tamio Yamakawa from the University of Tokyo, one of the pioneers in the field of glycoscience, who discovered a sialic acid containing glycolipid from blood clots, and Teruo Yoshino, who worked in Roland's laboratory. In 2016, Roland published an overview of sialic acid links with Japanese scientists.

Roland published over 400 original peer reviewed papers and reviews, ranging across the chemistry, metabolism and biological functions of the sialic acids. Particularly eminent are the book "Sialic acids – Chemistry, Metabolism and Function" that he edited and published as volume 10 in the Springer Verlag Cell Biology Monographs series in 1982, his review entitled "Chemistry, Metabolism, and Biological Functions of Sialic Acids", published in Adv. Carbohydr. Chem. Biochem. 40, 1982, 131–234, and the chapter "Chemistry, Biochemistry and Biology of Sialic Acids" that he published together with Hans Kamerling in 1997 in the Elsevier New Comprehensive Biochemistry series (29b, 1997, 243–402). He was invited to present over 200 lectures all-round the globe and was constantly involved in the organisation of international symposia. He supervised ten Sialic Acid Workshops in Kiel and chaired the Vth International Symposium on Glycoconjugates in Damp near Kiel in 1979 and the Japanese-German Symposium on Sialic Acids in Berlin in 1988 (together with Tamio Yamakawa). He served on the Editorial Board of Glycoconjugate Journal and Trends in Glycoscience and Glycotechnology. Funding for Roland's research was provided by the German Research Council (Deutsche Forschungsgemeinschaft—DFG) throughout his career. The Alexander von Humboldt Foundation acknowledged his work by granting fellowships and AvH-Professorships to Roger Jeanloz, Boston, USA and Mark von Itzstein, Gold Coast, Australia.

Roland was responsible for the training of more than 40 Diploma students, over 50 Doctoral students, and 5 Habilitation candidates. In addition, guest researchers from over 20 countries spent time in his labs. He was a strong supporter of female scientists, who were always part of his team. This was long before gender awareness became a big issue and emphasises his strong social awareness.

Promotion of science and especially the sialic acids featured throughout Roland's career. The Sialic Acid Society was inaugurated in April 1986, and the Roland and Elfriede Schauer Foundation was established in December 2008, both aimed to support research in the field of glycobiology. In keeping with his broad interests, he engaged the painter Carl Lambertz to design a motif for the Society, based on

his knowledge of these sugars. It features the carbohydrate ring of the sialic acids and a starfish, the earliest organism to possess sialic acids. A striking emblem well recognised by the scientific community (shown below).

Recognition of Roland's work came through a "Lifetime Achievements in Sialoglycosciences Award" from Griffith University, Australia in 2002, the Rosalind Kornfeld Award for Lifetime Achievements in Glycobiology from the American Society for Glycobiology in 2009 and the "Pro-Scientia-Förderpreis" from the Eckhart-Buddecke-Stiftung in Germany in 2012. In April 2016, the international sialic acid community celebrated Roland's eightieth birthday with a sialic acid symposium in Bad Lauterberg, Germany.

The scope of Roland's research was very wide and some of the topics and collaborators are not mentioned in this obituary. However, they are not forgotten and also form a significant and valuable part of the achievements detailed here.

Roland was also actively engaged in many other of his interests. Often these were directly linked to his science and the people he encountered throughout the World. Most of this interest and enthusiasm was shared with his wife Elfriede. This covered literature, music, theatre, art and botany. Art was also in the Schauer family, Otto Schauer (1923–1985) was a well-recognised painter, and provided a close and constant connection with the art world.

Roland linked his travels to scientific meetings with many visits to museums and galleries for exhibitions in Paris, Vienna, Cologne, Hamburg, Rome, Moscow and Tokyo among others. Both he and Elfriede were always fascinated to see and hear the latest events and to talk about them with their friends.

In his obituary, a citation from Max Planck summed up his achievements – "Those who are granted the privilege to work on building up the exact sciences will find their satisfaction and inner happiness in the awareness that they

have researched the researchable and calmly worship the unexplored (translated from the German text).

Roland Schauer, Japan 2004 at the chrysanthemum show



Roland Schauer, who passed away on October 24, 2019, was certainly a remarkable person and scientist. We have a valuable treasure-trove for the future when we look back on his lifetime achievements.

A survey of his scientific publications and reviews can be found on his website.



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