Emanuel Merck-Lectureship (2019 – 1993)

Short profiles of Awardees

2019

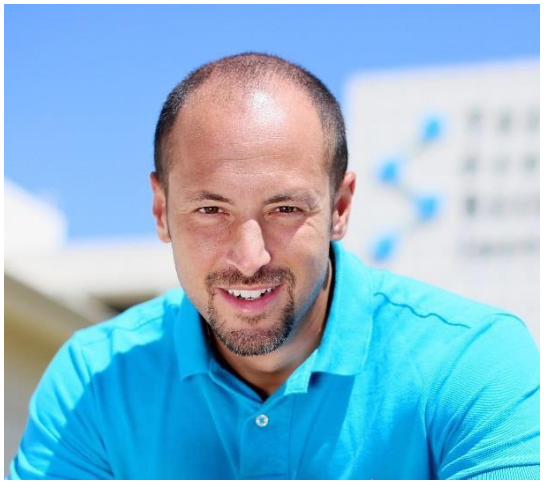
Susumu Kitagawa is a Japanese chemist working in the field of coordination chemistry, with specific focus on the chemistry of organic–inorganic hybrid compounds, as well as chemical and physical properties of porous coordination polymers and metal-organic frameworks in particular. He is currently Distinguished Professor at Kyoto University, in the Institute for Integrated Cell–Material Sciences, of which he is co-founder and current director.

His fundamental contributions to the development of this innovative class of nanoporous materials could lead to new ways of capturing, storing and releasing gases. Broadly speaking, MOFs could contribute to improving the state of our planet. Capturing and re-using gases in these “cages” could help develop sustainable technologies to tackle climate change and open up new possibilities in energy storage.

His development of nanoporous materials could lead to new ways of capturing, storing and releasing gases. Think of a cage whose bars are so small you could lock gas molecules in it. That, in essence, is what “Metal Organic Frameworks” (MOFs) are. They combine metallic knots and organic ligands that hold them together. By combining different types of metals and ligands, the size and shapes of the pores can be controlled, which means MOFs can be used to capture or release gases at a molecular scale.

His distinctions include the Humboldt Research Prize in 2008, the Chemical Society of Japan Award in 2009 and the Creative Society of Japan (CSJ) Prize for Creative Work in 2003.

2017



Phil Baran is Professor of Chemistry at the Scripps Research Institute (La Jolla, CA), and member of the Skaggs Institute for Chemical Biology, and Darlene Shiley Chair in Chemistry.

Baran's work has dismantled the myth that the synthesis of large and complex molecules is a matter of mere academic interest. His aim is to develop useful reactions and methods that make it easier to synthesize complex molecules. Baran's elegant syntheses are extremely efficient, and he always has the requirements of industrial production in mind when developing them. His objective is to produce natural substances on gram scale. He made some decisive contribution to solving some of society's problems – for example, by developing new drugs or materials. Therefore, he focuses on the total synthesis of natural products that show medical potential – for example, cyanobacterial compounds with antimycotic or antibacterial properties.

Another example is Ingenol – a natural substance derived from garden spurge. Baran managed the two-phase total synthesis in just 14 steps, using delta- 3-carene – a commercially available chemical. Previous Ingenol syntheses required between 37 and 45 steps.

His lab produces enantiomerically pure natural marine substances on gram scale, such as the steroid Cortistatin A, which has promising characteristics for the prevention of angiogenesis, or Haouamine A, an active substance that is used to treat cancer.

Baran is also interested, however, in syntheses that may not necessarily deliver biologically active natural substances but which will permit the development of new methods and strategies. A recent example is the total synthesis of Pallambin A and C originally isolated from liverwort. The simple and reliable method for incorporating tri- or difluoromethyl groups into an aromatic ring with the aid of sulfinates was also the product of his laboratory.

His distinctions include the 2013 MacArthur Fellowship, for example, and the 2016 Elias J. Corey Award. One can only echo the words of Corey himself, who describes Baran as "an incredibly bright, creative, and productive synthetic organic chemist who is destined to lead his generation to new heights of achievement."

2015

Prof. Dr. Paul T. Anastas, Yale University, New Haven

Paul Anastas is the Teresa and H. John Heinz III Professor in the Practice of Chemistry for the Environment Department of Chemistry at Yale University, New Haven and Director of the Center for Green Chemistry and Green Engineering.

He invented the term “Green Chemistry” during the 1990s, triggered by a research contract from the US government. Ever since Paul T. Anastas is often referred to as “the father of Green Chemistry”. He is a creative, big-picture thinker. The basic idea was to look at the entire life cycle of chemicals and to make a design for the best, least harmful and most secure handling throughout the manufacturing process and the chemical products themselves. In 1994 the fundamental idea of Green Chemistry, was laid down in the book "Benign by Design" and then 1998 - along with John Warner - in the standard reference work “Green Chemistry – Theory and Practice”.

What are these principles about? They are balanced, specific enough for research, but also more generally for transposition in the economy. The desire for "Green Chemistry" is rational and pragmatic. The bottom line is: Customize reaction processes and products, so that in the end as little as possible waste is generated during production, use and disposal. These wastes should also be as harmless as possible. Prevention is better than cure. Aiming at increased efficiency by using catalysts and preventing intermediate steps in the synthesis. Using as little solvent and other adjuvants as possible. Making reactions at low temperature and low pressure; so the energy demand decreases. Using renewable resources. And above all: Devise processes so to avoid risks altogether. The amazing thing: This list is still valid today.

Barack Obama paid tribute to Anastas' pioneering role and appointed him as head of research at EPA in 2009, a position he held until 2012. Anastas has served as a staffer at the White House Office of Science and Technology Policy from 1999 to 2004, director of the Green Chemistry Institute at the American Chemical Society in Washington DC from 2004 to 2006 and since 2007 as a professor at Yale University.

Since 2012 Anastas has been director of the Center for Green Chemistry and Green Engineering at Yale University in New Haven, Connecticut/USA.

2013

Prof. Frances H. Arnold,

California Institute of Technology, Pasadena

Frances Arnold is the Dickinson Professor of Chemical Engineering and Biochemistry at the California Institute of Technology, Pasadena, USA. She is one of only 11 living scientists, and the only woman, to be elected to all three National Academies in the US – the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine.

In the early 1990s, Frances Arnold set off to develop methods to evolve proteins for properties not found in nature. She started by mutating DNA, the genetic blueprint for building proteins, by mixing it with compounds that cause it to copy itself with mistakes. The DNA is inserted into living organisms that translate the genes into proteins. Cells are then sorted for protein variants that confer the most promising properties. This process is repeated over and over – sometimes up to 50 times – to get the desired characteristics. Arnold's so called "directed evolution" radically transformed the science of protein engineering and its applications, by harnessing the power of natural selection in a test tube to evolve proteins, ultimately creating desirable properties. Her research requires contributions from many disciplines including Chemistry, Bioengineering, Biochemistry, Molecular Biology, Microbiology, Chemical Engineering, Chemistry and Applied Physics. In fact, Arnold "breads" not plants or animals but molecules. She initiated methods of directed evolution to create useful biological systems, including enzymes, metabolic pathways, genetic regulatory circuits, and entire organisms. The technology can be applied in various fields, such as medicine, renewable energy and agriculture.

2011

Prof. Carolyn R. Bertozzi, University of California, Berkeley

Carolyn Bertozzi is the T.Z. and Irmgard Chu Distinguished Professor of Chemistry and Professor of Molecular and Cell Biology at the University of California, Berkeley. Carolyn R. Bertozzi research interests span the disciplines of chemistry and biology with an emphasis on studies on cellular communication. She wants to understand how sugars mediate cell-to-cell communication and how changes in cell surface glycosylation are related to disease states. She's exploring ways to re-engineer cell surfaces with the goal of controlling cells' social interactions.

She studied the relationship between glycosylation, the addition of sugar groups to a molecule, and disease – specifically how glycans contribute to bacterial infections and the changes in glycosylation that accompany cancer onset and progression.

Exploiting the information how the changes are associated with cancer, inflammation and bacterial infection her lab developed new diagnostic and therapeutic approaches. She has pioneered tools for labelling molecules inside living cells and methods for protein engineering. Her biomedical inventions have contributed to the development of non-invasive methods for identifying disease tissue within the body - advances that could revolutionize both the diagnosis and the treatment of diseases ranging from inflammatory disorders such as arthritis to cancer and infectious diseases like tuberculosis.

Bertozzi is a chemist who is interested in developing technologies to help advance biomedical research. She herself calls her concept "bio-orthogonal chemistry", because the kinds of reactions among chemical functionalities she tries to understand neither interfere with nor interact with biological molecules.

Bertozzi's multi-disciplinary approach, her ability to identify unmet needs and craft innovative solutions has led to scientific advances with a broad range of applications. Bertozzi has utilized bio-orthogonal chemical reactions for non-invasive imaging of sugar molecules in living animals, which can potentially lead to applications for cancer detection.

2009

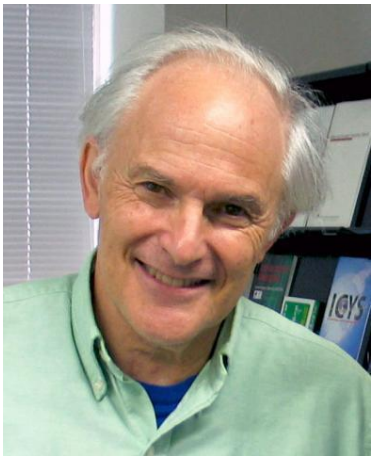
Prof. Axel Ullrich, Max-Planck-Institut für Biochemie, Martinsried

Axel Ullrich's work in the field of signal transduction research has elucidated major fundamental molecular mechanisms that govern the physiology of normal cells and allowed insights into pathophysiological mechanisms of major human diseases.

For over 25 years Prof. Ullrich has been a leader in gene technology, translating basic science discoveries into medical applications. This led in the eighties to the development of Humulin (human Insulin for the treatment of diabetes; Lilly), the first therapeutic agent to be developed through gene-based technology and the first biotechnology product ever. Another biotechnology product that is based on Prof. Ullrich's work is Herceptin, the first target-directed, gene-based cancer therapy for the treatment of metastatic breast carcinoma (Genentech/Roche). Prof. Ullrich's work has also led to the development of the multi-targeted drug SU11248/SUTENT which has successfully passed Phase III clinical trials and in August 2005 was submitted to the FDA for approval (Pfizer) as a cancer therapeutic.

Since 1988, Prof. Ullrich has been Director of the Department of Molecular Biology at the Max-Planck-Institute of Biochemistry in Martinsried (Germany) and currently he is a visiting scientist at the Institute of Molecular and Cell Biology in Singapore and Research Director of the Singapore Onco Genome Project. He is an Honorary Professor of the Second Military Medical University (Shanghai, China) and the University of Tübingen and elected member of the European Molecular Biology Organization, the German Academy of Natural Scientists "Leopoldina" and the American Academy of Arts and Sciences.

2007



Prof. Sir Harold W. Kroto, University of Sussex, Brighton

Harold Kroto is one of the pioneers on the journey to new dimensions in physics, astrophysics, spectroscopy and chemistry. His original aim was simply to find out how large chain-like carbon molecules form in space. What he discovered in 1985, however, was a previously unknown form of carbon – a carbon nanocluster C_{60}. The door to new research fields was now open. For this discovery he and his twocolleagues Richard Smalley and Robert Curl in 1996 were jointly awarded the Nobel Prize for Chemistry.

As a chemist, Professor Kroto was primarily involved at the start of his academic career with the electron spectroscopy of free radicals and unstable intermediates, before turning his attention to the chemistry of multiply-bound carbon-phosphorus compounds and initiating a new research field surrounding phosphaalkenes and alkynes.

Professor Kroto's research work since the 1970s has been devoted to chain-like carbon molecules and their occurrence in space and, from the 1980s, to the origin of these structures and hence to the chemistry of fullerenes, and to nanotechnology.

C_{60} is a fascinating compound, which was named after the American architect and designer Richard Buckminster Fuller. The discovery of the fullerenes reveals just some of the many talents of this year's prize winner. It exemplifies Harold Kroto's talent for creatively combining design, architecture and technology.

His research has led to a new branch of carbon chemistry: the chemistry of the fullerenes and of carbon nanotubes based on this science. Professor Kroto's work on the self-organisation of molecules on surfaces has provided new and important insights into the structures and properties of nanomaterials. The application of self-organisation principles has opened up interesting new ways of using fullerenes in superconducting materials and of employing nanotubes as molecular wires or electronic semiconductors. These are just a few examples of technical applications for which the work of this year's prize winner has provided the impetus.

Since 2004 he has taught in the Department of Chemistry and Biochemistry at Florida State University, Tallahassee, Florida.

2005

Prof. George M. Whitesides, Harvard University, Cambridge

George Whitesides is currently the Woodford L. and Ann A. Flowers University Professor at Harvard. Prof. Whitesides research interests are extremely broad, and he has made significant scientific contributions to many of these fields including physical and organic chemistry, materials science, biophysics, complexity, surface science, microfluidics, optics, self-assembly, micro- and nanotechnology, catalysis, energy production, rational drug design, cell-surface biochemistry and several other subjects.

He is best known for his insights to surface chemistry, understanding how molecules arrange themselves on a surface. The discovery laid the groundwork for advances in nanoscience that led to new technologies in electronics, pharmaceutical science and medical diagnostics. His recent research interests include energy, the origin of life, and science for developing economics.

Given this broad range of research, he is active in several enabling technology platforms at Harvard's Wyss Institute: adaptive material technologies, bioinspired robotics, biomimetic microsystems, and programmable nanomaterials. Much of his work involves developing diagnostic tools that are low cost, simple to use, and durable enough to withstand conditions in rural areas and in the developing world. Whitesides has incorporated advanced microfluidics into paper-based devices that are about the size of a postage stamp. These low-cost devices use polymers that repel water to steer blood or urine along tiny channels. There, the fluids interact with chemicals that change color if they detect disease indicators, such as the signature high-glucose levels of diabetes. Results could be read by a layperson.

He is a member of the National Academy of Sciences and has been appointed a Fellow of numerous societies. Whitesides is the author of more than 950 research papers and holds over 50 patents.

2003

Prof. Samuel J. Danishefsky, Columbia University, New York

Samuel Danishefsky has received world-wide acclaim for his work in organic total synthesis of some of the most complex natural products, most of which are known to have significant physiological activity. Most of the syntheses require numerous stereoselective steps in order to obtain the desired stereospecificty.

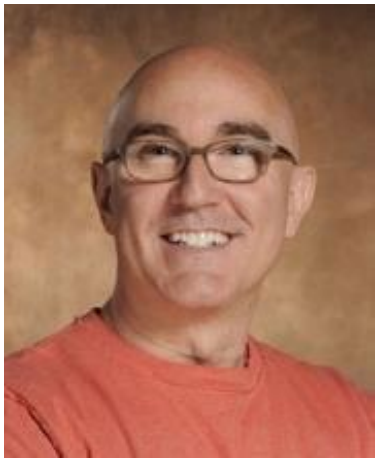
There are very few areas involving the synthesis of physiologically-active organic molecules that have not come under attack by Dr. Danishefsky at some time during his long and productive career: anti-tumor carbohydrate vaccines, several classes of anti-tumor chemotherapeutic agents, antibiotics, antivirals, angiogenesis agents, anti-immune agents, and on and on. In general, he is at the forefront of those approaches that blend the best chemical and biological science to obtain solutions to some of the most pressing problems of our time that involve disease treatment and prevention.

An important achievement also is the Danishefsky Taxol total synthesis, which his group published in 1996 shortly after the first two total synthesis efforts described by the Holton and the Nicolaou groups. Combined this collection provides a good insight in the application of organic chemistry methods to the total synthesis of bioactive natural products.

Danishefsky is a member of the National Academy of Sciences, the American Academy of Arts and Sciences and a Fellow of numerous foreign academies.

By 1991 he was sharing his time with Memorial Sloan-Kettering Cancer Center as director of the Laboratory for Cancer Research Bioorganic Chemistry, becoming chair in 1993. He accepted an appointment as professor at Columbia University in 1993, and now splits his time between Columbia and Sloan-Kettering.

2000



Prof. Stuart Schreiber, Harvard University, Cambridge

Stuart Schreiber is the Morris Loeb Professor in the Department of Chemistry and Chemical Biology at Harvard University and a Howard Hughes Medical Institute investigator.

Schreiber is a world leader in chemical biology, using small molecules as probes in uncovering biological functions, an approach he termed “chemical genetics”. He has provided some of the most significant small-molecule-based advances, includingsmall-molecule probes of extremely difficult targets and processes (e.g., transcription factors, oncogenes, protein/protein interactions, transdifferentiation of cells) that are atthe root of human disease.

His development of diversity-oriented synthesis, discovery-based small-molecule screening in an open data-sharing environment, and ChemBank, among others, have dramatically advanced chemical biology and contributed to its becoming a vibrant area of life science research. Numerous new drugs for various indications (organ transplantation, dendritic cell vaccination, leukemia, multiple myeloma, and solid tumors, including carcinomas and sarcomas) have been approved and are being developed in which therapeutic effects are the direct consequence of proteins and/or cellular control mechanisms revealed by Schreiber’s research.

Professor Schreiber and his group members have discovered principles that underlie information transfer and storage in cells, specifically discoveries relating to signaling by the phosphatase calcineurin and kinase mTOR (demonstrating for the first time that drugs can result from the targeting of protein kinases and protein phosphatases), gene regulation by chromatin-modifying histone deacetylases, small-molecule dimerizers that activate cellular processes by enforced proximity, and small-molecule probes of challenging targets and processes (e.g., transcription factors, oncogenes, protein/protein interactions, transdifferentiation) that relate to human disease.

Schreiber is an elected member of the National Academy of Sciences and theAmerican Academy of Arts and Sciences.

1998

Prof. Jean-Pierre Changeux, Institut Pasteur, Paris

Jean-Pierre Changeux is professor at the Collège de France, and at the Institut Pasteur, where he has directed, since 1967, a laboratory of Molecular Neurobiology. His main contributions and discoveries in the course of the past 37 years are centered on the general theme of the molecular and cellular mechanisms of signal recognition and transduction, also referred to as receptor mechanisms, primarily in the nervous system.

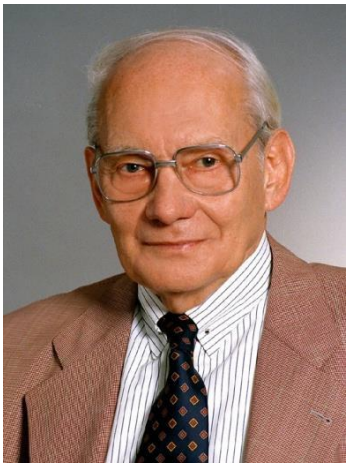
Together with his group, he made the decisive steps in the identification of the acetylcholine nicotinic receptor, the first neurotransmitter receptor linked to an ion channel, and unravelled the main features of its functional organization (in particular its active site and ion channel) as well as the mechanisms of its activation and short-term regulation, in particular by desensitization, thus substantiating its properties as “allosteric membrane protein”.

Furthermore, Changeux and his collaborators have proposed a model of epigenesis of neural networks by selective stabilization of synapses, and analyzed in these terms the molecular mechanisms involved in the regulation of acetylcholine receptor genes expression during the development of the motor endplate. These issues are of relevance for the understanding of long term synaptic plasticity.

His seminal work on the nicotinic receptor has pioneered new fields of research in signal transduction mechanisms, molecular pharmacology and pathology of chemical communications in the nervous system.

A highly creative scientist, whose eyes focus on the fundamental mechanisms that regulate the biology of any life form, Changeux soon extrapolated the allosteric protein model to neurotransmitter receptors. And it was to test this theoretical proposition that he reached his second considerable experimental achievement, the isolation of the acetylcholine receptor.

1996



Prof. Manfred Eigen, MPI Göttingen

In 1967, **Manfred Eigen** was awarded, along with Ronald George Wreyford Norrish and George Porter, the Nobel Prize in Chemistry. They were distinguished for their studies of extremely fast chemical reactions induced in response to very short pulses of energy.

During a rich and varied research career Manfred Eigen has been studying on countless different questions. Manfred Eigen has focused his attention not only on analyzing the finest chemical processes, but also on research into evolution. He has demonstrated technical competence and visionary farsightedness in both disciplines.

At the Max Planck Institute for Physical Chemistry in Göttingen the highly gifted inventor developed ingenious relaxation methods. All relaxation methods are based on the same fundamental principle: if you briefly disturb the equilibrium of a chemical system, ascertaining the time the system requires to return to equilibrium (relaxation time) allows you to measure the speed of chemical reactions. That was how Manfred Eigen was soon able to investigate reaction states that only lasted a billionth of a second. Relaxation methods became standard procedures and have made it possible to answer countless important biochemistry questions – for example, about metabolic processes.

His attention turned also to biochemical questions, which now claimed his chief interest. He focused his research on figuring out how molecules formed and evolved into the first forms of life on Earth. He built a theory on the idea that the first life forms evolved from a chance set of circumstances that all took place at the same time. He proposed that cycles of chemical reactions might have occurred, one reproducing nucleic acids and one reproducing proteins. The nucleic acids contained information to form life but had a limited chemical function, and the proteins ensured chemical function and reproduction of the information contained in the nucleic acids. And hence, life arose from these combinations. He also proposed that eventually a number of the nucleic acid cycles and proteins would have come to coexist and form a “hypercycle.” By natural selection, the best hypercycle would have eventually caused the first organism to evolve.

1995

Prof. Jean-Marie Lehn, University of Straßburg

Jean-Marie Lehn shares with Charles Pedersen the 1987 Nobel Prize in Chemistry for their research and development of host-guest chemistry. Host-guest chemistry is where two or more molecules/ions bond in unique ways due to their complementary structure by using other than covalent bonds. Lehn created molecules that acted as a cage molecule where a central molecule or atom would get trapped within a cavity created by the cage molecule.

Expanding on his pioneering work on molecular recognition, Lehn was led to the definition of a new field of the chemistry of molecular assemblies, which he has proposed calling “supramolecular chemistry” as it deals with the complex entities formed by the association of two or more chemical species held together by non-covalent intermolecular forces, whereas molecular chemistry concerns the entities constructed from atoms linked by covalent bonds. Subsequently, the area developed into the chemistry of "self-organization" processes and more recently into constitutional dynamic chemistry and towards "adaptive chemistry".

Supramolecular chemistry lies beyond molecular chemistry and aims at constructing highly complex chemical systems from components held together by non-covalent intermolecular forces.

Beyond pre-organization, supramolecular chemistry is actively exploring systems undergoing self-organization, i.e. systems capable of spontaneously generating well-defined functional supramolecular architectures by self-assembly from their components, on the basis of the molecular information stored in the covalent framework of the components.

This chemical basis of “molecular recognition” also plays a fundamental role in biological processes.

1994

Prof. Kenneth Wade, University of Durham

Ken Wade is one of the most illustrious former members of staff of Durham University and is an Emeritus Professor in Durham's Department of Chemistry.

During his first decade at Durham, Professor Wade set up a thriving research group probing covalent chemistry of main group metals and metalloids, and wrote or co-authored three books (on organometallic compounds, on principles of organometallic chemistry, and on electron deficient compounds), that charted and influenced global developments in these rapidly expanding fields. Interests in structural and bonding issues led him to devise simple electron-counting rules to explain or predict the polyhedral structures of so-called 'electron deficient' cluster compounds such as boron hydrides that had challenged earlier bonding descriptions, transforming these apparent rule-breakers into pattern-makers for a wide range of other compounds. These tools are well known as "Wade's Rules" around the world.

Refining and developing his rules, exploring various aspects of organometallic, cluster, polymer, materials and catalysis chemistry, and demonstrating the relevance of boron hydride chemistry to hydrocarbon chemistry, have occupied him fully subsequently.

Present research interests involve cluster, organometallic and polymer chemistry and heterogeneous catalysis, and include synthetic, spectroscopic and theoretical work on both fundamental and applied themes.

Since his retirement in 1997 Professor Wade continues to represent Durham University with extraordinary energy and zeal and is still actively engaged with the Department and its alumni.

1993

Prof. Albert Eschenmoser, ETH Zürich

Albert Eschenmoser has been Professor Emeritus at ETH Zurich since 1992.

In his research in organic and bioorganic chemistry, Eschenmoser has made lasting contributions to the theory of terpene biosynthesis, structure elucidation of natural products, stereochemistry and mechanism of organochemical and biochemical reactions, development of new methods for organic synthesis, total synthesis of complex natural products and chemical etiology of nucleic acid structure.

Eschenmoser is perhaps best known for his work in organic synthesis. The total synthesis of vitamin B_{12}, which he achieved in collaboration with Harvard University's Robert B. Woodward, is considered one of the most ambitious total syntheses ever undertaken. Powerful synthetic methods he developed include the Eschenmoser fragmention, the Eschenmoser versions of the Claisen rearrangement and the Mannich reaction, the sulfide contraction to convert an amide into a vinylogous amide, and the Eschenmoser α-chloronitrone/olefin cycloaddition.

However, Eschenmoser's crowning achievement may be his more recent work on the origin of life. His systematic investigations of potentially natural alternatives to the nucleic acid structure have shown that Watson-Crick pairing is not a specific property of the ribofuranosyl system and that nature did not select RNA according to the criterion of maximization of base-pairing strength. His studies of pyranose RNA have provided evidence for the mode in which the specific nature of the sugar governs the pairing behavior of oligonucleotides.