

# wiley encyclopedia of Chemical Biology







Volume 1

TADHG P. BEGLEY
Chief Advisor



# Wiley Encyclopedia of Chemical Biology

### Volume 1

ADME Properties of Drugs to Essential Fatty Acids: Physiology and Clinical Significance

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## **Preface**

Chemical biology is a cross-disciplinary science at the interface of chemistry, biology, and medicine. It may be viewed as subsuming important aspects of the traditional disciplines of bioorganic chemistry, bioinorganic chemistry, medicinal chemistry, biophysical chemistry, and biochemistry, with a special emphasis on rigorous application of the principles, tools, and language of chemistry to important topics in biology. Chemical biology aims at the elucidation of the chemical mechanisms of living systems and is the fundamental science of drug discovery, playing a key role in the development of novel agents for the prevention, diagnosis, and treatment of disease. Research in chemical biology is therefore of huge commercial importance because of its central role in drug discovery and design; this discipline is the scientific engine of a pharmaceutical market that is currently worth hundreds of billions of dollars per annum.

To best serve the needs of this cross-disciplinary field, the *Wiley Encyclopedia of Chemical Biology* is designed to present information to students and researchers of varying backgrounds and levels of experience. Three article types have been included, each targeted towards a different level of readership. Overview articles are written at a level suitable for students or scientists entering the field, and may serve as teaching materials for undergraduates. Advanced articles will be read by advanced students and researchers looking for an authoritative review of a topic in the field. Case studies cover topics that demonstrate the use of chemical biology concepts and methods to address specific questions in biology. All articles are written by

prominent scholars from academia, research institutions, and industry, carefully selected by the Encyclopedia's distinguished advisory board. Together, their contributions provide an unparalleled resource for authoritative, up-to-date, and accurate information in the field of chemical biology.

The scope of the Encyclopedia is broad and highly interdisciplinary. It brings together information on the chemistry and biology of biomolecules, cellular compartments, biological processes and systems, as well as the methods, technologies and techniques that are important for chemical biology research, and applications of this research. The reader is encouraged to explore the interconnectivity of topics, concepts, and methods in this field.

The Wiley Encyclopedia of Chemical Biology has been made possible by the hard work of hundreds of individuals, including contributors, reviewers and advisors, who dedicated their precious time and expertise to this publication. We wish to acknowledge and thank all those who took part in this important project.

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- **Richard B. Silverman**, Northwestern University, Evanston, Illinois, Enzyme Inhibition
- Scott K. Silverman, University of Illinois at Urbana-Champaign, Urbana, Illinois, Nucleic Acid Enzymes (Ribozymes and Deoxyribozymes): In Vitro Selection and Application
- S. Stoney Simons, Jr., Steroid Hormones Section, NIDDK/CEB, NIH, Bethesda, Maryland, Steroid Hormones
- Thomas J. Simpson, School of Chemistry, University of Bristol, Bristol, United Kingdom, Polyketide Biosynthesis: Fungi
- Pratibha Singh, Research Center for Advanced Science and Technology, University of Tokyo, Tokyo, Japan, Quorum Sensing
- Sheo B. Singh, Merck Research Laboratories, Rahway, New Jersey, Pharmaceuticals: Natural Products and Natural Product Models
- Yashveer Singh, Department of Pharmaceutics, Rutgers University, New Brunswick, New Jersey, Synthetic Peptide Templates for Molecular Recognition
- Spiros S. Skourtis, University of Cyprus, Nicosia, Cyprus, Electron Transfer: Chemical Roles of Water
- Jan A.M. Smeitink, Nijmegen Center for Mitochondrial Disorders, Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands, Mitochondrial Medicine
- Youhei Sohma, Department of Physical Chemistry, Kyoto Pharmaceutical University, Yamashina-ku, Kyoto, Japan, Click Peptides: Design and Applications
- **Ariel Solomon**, *The Weizmann Institute of Science, Rehovot, Israel,* Metalloproteinases, Biophysics and Chemistry of
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- Maria Spies, Department of Biochemistry, Center for Biophysics and Computational Biology at the University of Illinois at Urbana-Champaign, Urbana-Champaign, Illinois, DNA Helicases: Chemistry and Mechanisms
- Max Stadler, Institute for Organic Chemistry and Chemical Biology, Center for Biomolecular Magnetic Resonance, Frankfurt, Germany, NMR: Applications in Chemical Biology
- **Frauke Stähler**, Department of Molecular Genetics, German Institute of Human Nutrition Potsdam-Rehbruecke, Nuthetal, Germany, Taste, Chemical Biology of
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- Rhys G. Stoneman, Department of Chemistry, University College London, London, United Kingdom, Neocarzinostatin: Protein-Small Molecule Interactions
- Zenia M. Størling, Santaris Pharma A/S, Hørsholm, Denmark, Locked Nucleic Acids
- **Hiroaki Suga**, Research Center for Advanced Science and Technology, University of Tokyo, Tokyo, Japan, Quorum Sensing
- Eric J. Sundberg, Boston Biomedical Research Institute, Watertown, Massachusetts, Protein–Protein Interactions
- Jeffrey K. Takimoto, The Jack H. Skirball Center for Chemical Biology and Proteomics, The Salk Institute for Biological Studies, La Jolla, California, Unnatural Amino Acids to Investigate Biological
- **Nellie Taleux**, Cellular Energy Metabolism and Integrated Oxidative Phosphorylation
- **Lukas K. Tamm**, *University of Virginia, Charlottesville, Virginia*, Supported Lipid Bilayers
- **Guiliang Tang,** Department of Plant and Soil Sciences and KTRDC, University of Kentucky, Lexington, Kentucky, RNA Interference: Mechanisms and Proteins Involved
- Atsuhiko Taniguchi, Department of Medicinal Chemistry, Kyoto Pharmaceutical University, Yamashina-ku, Kyoto, Japan, Click Peptides: Design and Applications

- Tohru Taniguchi, Columbia University, New York, New York, Circular Dichroism (CD) for Natural Products
- **Boris Tenchov**, *Northwestern University, Evanston, Illinois*, Lipids: Phase Transitions
- Daniel S. Terry, Tri-Institutional Training Program in Computational Biology and Medicine, Weill Cornell Medical College of Cornell University, New York, New York, Single-Molecule Studies of Biomolecules
- **David Y. Thomas,** *McGill University, Quebec, Canada,* Protein Trafficking Diseases: Small Molecule Approaches
- S. David Tilley, Department of Chemistry, University of California, Berkeley, Berkeley, California, Proteins: Chemistry and Chemical Reactivity
- Jonathan T. Ting, Duke University Medical Center, Durham, North Carolina, Neurotransmitter Release
- Brian A. Todd, NICHD, NIH, Bethesda, Maryland, Hydration Forces Monika Tokmina-Lukaszewska, University of Texas Health Science Center at San Antonio, San Antonio, Texas, Proteasome, Chemistry of
- Clifford A. Toleman, University of Alabama at Birmingham, Birmingham, Alabama, Cytosolic Glycosylated Proteins, Chemistry of
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- Melissa V. Turman, A.B. Hancock Jr. Memorial Laboratory for Cancer Research, Vanderbilt University School of Medicine, Nashville, Tennessee, Cyclooxygenase Inhibition Mechanisms: Recent Advances
- Nicholas John Turner, Manchester University—Chemistry, Manchester, United Kingdom, Biocatalysis and Biotransformation
- Benjamin S. Twining, University of South Carolina, Columbia, South Carolina, Metal Homeostasis
- Scott M. Ulrich, Chemistry Department, Ithaca College, Ithaca, New York, Kinases and Dephosphorylases: Chemistry and Roles
- Michael D. Urbaniak, School of Life Science, University of Dundee, Dundee, United Kingdom, Neocarzinostatin: Protein-Small Molecule Interactions
- Kenji Usui, Graduate School of Bioscience and Biotechnology, Tokyo Institute of Technology, Yokohama, Japan, Proteins: Array-Based Techniques
- Joseph P. Vacca, Merck Research Laboratories, West Point, Pensylvania, HIV: Small Molecule Approaches
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- Wilfred A. van der Donk, University of Illinois at Urbana-Champaign, Urbana-Champaign, Illinois, Lantibiotics: Biosynthesis and Modes of Action
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- Peter Vandenabeele, Department of Molecular Biology, Ghent University, Ghent, Belgium, Apoptosome and Caspase Activation

- **Ilpo Vattulainen**, Tampere University of Technology, Tampere, Finland and Helsinki University of Technology, Helsinki, Finland, Lipids: Organization and Aggregation
- Winchil L. C. Vaz, Departamento de Química, Universidade de Coimbra, Coimbra, Portugal, Lipid Bilayers: Properties, Stereochemistry of Biological Molecules
- B. Jill Venton, Department of Chemistry, University of Virginia, Charlottesville, Virginia, Neurotransmission: Measuring Chemical Events
- **Trisha L. Vickrey**, *Department of Chemistry*, *University of Virginia*, *Charlottesville*, *Virginia*, Neurotransmission: Measuring Chemical Events
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- Jens Völker, Department of Chemistry and Chemical Biology, Rutgers, The State University of New Jersey, Piscataway, New Jersey, Nucleic Acids: Hydration
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- Jill Wegrzyn, Skaggs School of Pharmacy, Pharmaceutical Sciences, University of California, San Diego, California, Neuropeptides: Chemical Activity Profiling and Proteomic Approaches
- Richard W. D. Welford, Departments of Chemistry and Molecular Cell Biology, University of California, Berkeley, California, Oxygen-Activating Enzymes, Chemistry of
- Fei Wen, Department of Chemical and Biomolecular Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, Directed Evolution: Novel and Improved Enzymes
- Paul Wentworth, Jr., University of Oxford, Oxford, United Kingdom and The Scripps Research Institute, La Jolla, California, Protein Misfolding and Disease

- Renee Whan, The Electron Microscopy Unit, University of Sydney, Sydney, Australia, Platinum Anticancer Drugs, Chemical Biology of
- Ronald E. White, Schering-Plough Research Institute, Kenilworth, New Jersey, Pharmacokinetics of Drug Candidates
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- Spencer J. Williams, Biotechnology Institute, University of Melbourne, Parkville, Victoria, Australia, Glycoconjugates: Structure and Biosynthesis
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- Thomas E. Wilson, University of Michigan Medical School, Ann Arbor, Michigan, Non-Homologous Recombination
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- Aislyn Wist, Department of Pharmacology and Systems Therapeutics, Mount Sinai School of Medicine, New York, New York, Signaling Networks in Biology
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- **Gerard D. Wright**, Antimicrobial Research Centre, Department of Biochemistry and Biomedical Sciences, McMaster University, Hamilton, Ontario, Canada, Antibiotics: Bacterial Resistance
- Xiaoyang Wu, Cornell University, Ithaca, New York, Integrin Signaling
- **Arthur Wuster**, MRC Laboratory of Molecular Biology, Cambridge, United Kingdom, Chemical Molecules that Regulate Transcription and Facilitate Cell-to-Cell Communication
- Jianfeng Xu, The Jack H. Skirball Center for Chemical Biology and Proteomics, The Salk Institute for Biological Studies, La Jolla, California, Unnatural Amino Acids to Investigate Biological Processes
- Yue Xu, The Scripps Research Institute, Department of Chemistry and the Skaggs Institute for Chemical Biology, La Jolla, California, Stem Cell Fates: Control by Small Molecules
- Xiaohong H. Yang, Massachusetts General Hospital Cancer Center and Harvard Medical School, Boston, Massachusetts, DNA Damage: Sensing
- Ioannis V. Yannas, Massachusettes Institute of Technology, Cambridge, Massachusetts, Tissues and Organs: Synthesis
- Kevin J. Yarema, Department of Biomedical Engineering, The Johns Hopkins University, Baltimore, Maryland, Glycan Biosynthesis in Mammals