Encyclopedia of Signaling Molecules

Sangdun Choi
Editor

# Encyclopedia of Signaling Molecules

Second Edition

With 1893 Figures and 247 Tables

Springer

*Editor*
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# Preface to Second Edition

Cellular physiology is controlled by the interaction of thousands of molecules that work either autonomously or in a complex form to bring about the desired cellular processes. Current research should focus on comprehensively documenting the vital roles of these molecules. With this in mind, the first edition of the *Encyclopedia of Signaling Molecules* was compiled, and now, the updated and revised second edition is in your hands. This edition of the *Encyclopedia of Signaling Molecules* is a Springer Major Reference Work that contains information spanning 766 chapters. Each chapter addresses an individual molecule or molecular family found in humans and other animals. The second edition has incorporated molecules that could not be included in the first edition. The original authors of the first edition have also updated and revised entries for molecules that were previously described. This monumental effort is truly inspiring, and this text has been brought into existence by the efforts of qualified scientists from around the globe.

This encyclopedia has been a long-standing dream for many years. While there have been some attempts to build comprehensive gene databases, these have been very partial and brief. Amid the excitement of recent discoveries of new genes and their novel functions, one of the greatest scientific tasks of this century will be to compile all the useful information on human and animal genes in one place. This may be arduous, but, in the end, it will fill many gaps in our knowledge and foster a deeper understanding of the vibrant biological systems around us. Improving our understanding of genes will significantly aid disease-oriented research, and this will be instrumental in the development of new therapeutic approaches.

There are multiple Internet sites containing gene information, such as Wikipedia, GenBank, and UniProt. However, these sites lack proper peer review. They are not comprehensive and are difficult to cite in scientific journals. Therefore, we need to accurately collect gene data, explain them appropriately, and suggest prospective areas of research regarding particular genes to better suit scientists' needs. These factors have been the motivation for creating this encyclopedia.

This encyclopedia is published in both print and online formats. It is indexed in all major databases, and searches performed in the Springer database and other reputable international databases/search engines will display results from this encyclopedia. This second edition will be an improved version of the first edition of the *Encyclopedia of Signaling Molecules*,

which was published in September 2012. The text focuses on the core aspects of each gene's function, along with early historical findings that will help readers understand the astonishing progress we have achieved in this field.

The editing of this encyclopedia was a tedious job, and the invitation and recruitment of renowned scientists were challenging. However, the purpose of serving the scientific community kept me motivated and enthusiastic about this project. Now that it has been compiled, I am relieved and excited to have fulfilled my dream in the best possible way. This project has taken a significant amount of time; nonetheless, it has been well worth the effort. My excitement has been shared by many scientists. In this regard, I would like to share the feedback of some accomplished scientists regarding the organization and usefulness of this encyclopedia.

I'm really impressed with the efforts made and dedication shown by my fellow scientists and clinicians to compile the *Encyclopedia of Signaling Molecules* (2nd Edition). This is an inspiring work that will undoubtedly serve a wide audience as a sophisticated reference and trusted guide for the coming years.

Roswell Park Cancer Institute
United States of America
Samar Masoumi-Moghaddam

It is always difficult to find an appropriate review when looking for information on a new protein. In that sense, the *Encyclopedia of Signaling Molecules* is particularly adapted, on the one hand by its exhaustiveness, and also because of simple and explicit figures found in each of its chapters.

Normandie University, France
Romain Guinamard

I am impressed by the work done by many researchers in compiling this valuable compendium on signaling molecules. Now, this synopsis offers a unique opportunity for advanced students, researchers, and teachers to utilize this updated collection of genes as a reference guide.

RWTH University Hospital Aachen, Germany
Ralf Weiskirchen

This encyclopedia provides its readership with a comprehensive, high-quality overview of signaling molecules. Each chapter is compiled by authors who devote their scientific research to shedding light on each specific gene and protein, thus offering the reader the most updated and timely information.

Federico II University, Italy
Maria Fiammetta Romano

The *Encyclopedia of Signaling Molecules* (2nd Edition) is an astonishing achievement, which discusses multiple aspects of biological macromolecules in a comprehensive way to facilitate the readers' interest in understanding the signaling mechanisms of a particular molecule or its entire family.

Swansea University, United Kingdom
Venkateswarlu Kanamarlapudi

The *Encyclopedia of Signaling Molecules* (2nd Edition) is an excellent collection. It includes the review of most of the important cell signaling molecules, and discusses our current understanding in a comprehensive way. The book aids advanced readers interested in understanding the signaling mechanisms of a particular protein.

Lund University, Sweden — Julhash U. Kazi

A remarkable collection of book chapters organized by gene name, this encyclopedia is particularly relevant for biologists, systems biologists, biochemists, and molecular biologists interested in some aspects of those genes; namely, their physiological and pathological roles in humans.

Universidade de Aveiro, Portugal — Sandra Rebelo

The *Encyclopedia of Signaling Molecules* (2nd Edition) can be recommended for all biologists, biochemists, molecular biologists, and geneticists. The book offers a comprehensive coverage of human genes and signaling pathways. It is very fun and useful to read this book.

Tokyo Medical and Dental University, Japan — Yutaka Hata

The second edition of the *Encyclopedia of Signaling Molecules* provides a wealth of information on a collection of genes, their backgrounds, and functions. This will undoubtedly constitute an important and useful reference guide for life science and medical professionals studying existing and new genes and their physiological roles in humans.

Texas Tech University Health Sciences Center
United States of America — Jorge L. Cervantes

The collection of genes, their backgrounds, and functions under one heading/title is an inspiring work that can be used as a reference, as well as a standard guide for new genes and their physiological and pathological roles in humans.

National Cancer Center, Japan — Masaru Katoh

The *Encyclopedia of Signaling Molecules* (2nd Edition) offers a comprehensive compendium of human genes, making it a pulsating inscription for the scientific community.

All India Institute of Medical Sciences, India — Samapika Routray

This book provides students and researchers with a comprehensive overview of genes, their backgrounds, signaling pathways, and functions. All readers will appreciate its comprehensive scope and depth.

Osaka University Graduate School of Dentistry, Japan — Hiroki Toyoda

This book represents a unique collection of genes, their molecular functions, and biological roles that can be of great use as a reference text by researchers and teachers around the world.

Mayo Clinic, United States of America Martin E. Fernandez-Zapico

The second edition presents the most advanced and up-to-date information about these signaling molecules in a format that is easily correlated with the functions of other genes. Moreover, the therapeutic potential of many of these genes becomes evident from the available data presented in the text. As a result, this updated edition is valuable in all areas of the biological sciences. It is particularly suitable for graduate students actively involved in designing and executing their dissertation projects, researchers wanting to advance current knowledge, and teachers and professors providing advanced knowledge to their students and working on scientific projects and manuscripts.

The second edition of the encyclopedia consists of essays organized in an easily accessible A-Z format. Each chapter is divided into three main parts, including a brief description of the historical background for each gene, its physiological roles inside cells, and a short summary. The historical background familiarizes the reader with the discovery and early studies of the gene. Next, the reader can learn about the current literature regarding that gene and its function. Finally, the summary includes possible future research directions with regard to each gene. Each chapter has color illustrations to highlight key concepts, in addition to tables that summarize information not supplied in the text. Lists of gene synonyms have also been provided for the reader. Every chapter was intentionally kept brief to efficiently provide the most current and relevant knowledge to the reader.

The genes included here have been described by recognized scientific leaders in their respective areas of expertise, and the interactions of these genes in biological networks have also been explored. Additionally, genes related to certain diseases are highlighted, and possible therapeutic targets are also suggested. This encyclopedia will be an essential resource for those who want to review a particular gene in connection with interaction networks in order to solve new biological puzzles related to health and disease.

The success of this project is the result of the efforts of many contributing scientists. Therefore, it would be unjust if I did not give credit to their efforts. I am happy to be part of an amazing and wonderful research community that enthusiastically serves science through any means available. These scientists are the real assets of our community, and they are passionate about spreading knowledge and sharing ideas. The intellectual insights they convey here will positively affect future scientific endeavors. There were many individuals who regretted not being able to participate in this effort due to their busy schedule. I duly acknowledge their feelings and hope to work with them in the next scientific endeavor.

Finally, my job has been to compile, organize, and present these recent scientific advances to the community. Now, it is the community's duty to benefit from this work, convey it to others, and contribute positively to humanity.

Happy signaling!

Suwon, South Korea Sangdun Choi

# Preface to First Edition

Biological processes are driven by a complex system of functionally interacting signaling components within the cell. These signaling processes are initiated when a class of cell surface proteins, called receptors, receives information from the surrounding environment. This information is then routed through complex signaling pathways and decoded in the nucleus and other areas of the cell. In order to fully understand cell signaling, we must first appreciate the spatial and temporal dynamics of cell surface receptors as well as the downstream components of signaling pathways. The functional states and downstream interactions of cell signaling components are critical to the understanding of both normal and pathologic biological processes. In recent years, a steady increase in both clinical and experimental data on cell signaling has emerged. As we progress through the twenty-first century, it is clear that a systems biology approach, concomitant with the understanding of individual cell signaling components, is needed to delineate biologically relevant signaling networks. Furthermore, it is well understood that almost all diseases exhibit signaling pathway dysfunction. As a result, there has been a profound interest in identifying novel drug targets that regulate key signaling components in disease states.

Currently, there are more than 20,000 genes reported in the human genome; however, not all of the encoded proteins work equally to maintain homeostasis. Achieving a thorough understanding of the most potent signaling components and their associated signaling pathways will significantly improve our knowledge of the molecular mechanisms that regulate disease. Moreover, this insight will lead to the development of novel therapeutics. In recent years, there were multiple attempts to build molecule databases, which were still very partial and brief. Amid the excitement over the recent discoveries of new functional molecules, one of this century's greatest scientific tasks is to compile all information pertaining to signaling components into a single resource. Such an attempt may be arduous but, at the end, will fill the intellectual voids of the field and drastically streamline the understanding of critical signaling networks.

The Encyclopedia of Signaling Molecules is a testament to how far we have come in terms of identifying the function of and the interconnection between signaling molecules. This book represents biologically important signaling components from the level of a single gene, to that of gene families. The contents of this encyclopedia are built on the core concepts of the function of

signaling components along with the early historical findings to show readers the progress the field has achieved. The encyclopedia not only focuses on individual and groups of signaling components, but also explores the interactions between these groups of signaling components within signal transduction networks. Additionally, it also provides an abundance of information on the conversion of external signals generated by growth factors, hormones, neurotransmitters, chemokines, cytokines, etc., to the resultant cellular response. Applications of these data to disease and drug discovery efforts have also been discussed. Overall, the encyclopedia is designed to aid those who wish to investigate the function of specific signaling molecules and its role in signaling networks.

The encyclopedia is a Springer Major Reference Work, published in print and online. It consists of entries organized alphabetically. Each entry is concise, clearly written, and contains references to the literature for readers who wish to study each topic in depth. The broad coverage is expected to make the encyclopedia an indispensable reference tool in the field of biomedical research. The online version features colored illustrations and is fully searchable. In addition, cross-references are listed as hyperlinks to easily access related topics in the book.

There are many people to thank and whose help was critical for completing the Encyclopedia of Signaling Molecules. This encyclopedia is based on the expertise of hundreds of biomedical professionals who must receive my sincere gratitude for their dedication, efforts, and polite responsiveness to the continuous inquiries. Most importantly, the chapter authors have written outstanding pieces that provide the latest information in their respective field of research. I am grateful to the editors and staffs of Springer: Ann H. Avouris, Anil Chandy, Meetu Lall, Mansi Seth, and Rajneesh Roy for their outstanding help and assistance. Special thanks go to Mrs. Melanie Tucker who made certain that all the molecules were included for the final draft of the encyclopedia.

I hope that the information presented in the Encyclopedia of Signaling Molecules will not only aid in understanding the subject matter but also in using the biological information for the benefit of humankind.

Sangdun Choi

# List of Topics

# About the Editor

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Sangdun Choi is currently the Director of the Molecular Science and Technology Research Center (Priority Research Center) and a Professor in the Department of Molecular Science and Technology at Ajou University, Korea. He joined the faculty of the Department of Molecular Science and Technology, Ajou University, as an Associate Professor in 2006. His research interests include Toll-like receptor signaling, innate immunity, induced pluripotent stem cells, and systems biology. He earned his Ph.D. at the Texas A&M University, USA. He was one of the pioneers in the development of Bacterial Artificial Chromosomes (BACs) and was instrumental in the construction of a complete human BAC library for the Human Genome Project. He was also involved in a second consortium, the Alliance for Cellular Signaling. Furthermore, he served as the Director of the Transcription Analysis Laboratory at the California Institute of Technology, USA, for 10 years. He has published more than 250 scientific articles in international journals, including *Nature*, *Science*, *Nature Biotechnology*, *Blood*, *ACS Nano*, and *Proceedings of the National Academy of Sciences*. He has edited eight books, including the *Encyclopedia of Signaling Molecules*, *Systems Biology for Signaling Networks*, and

*Introduction to Systems Biology*. He is currently on the editorial board of *Scientific Reports*, an academic editor of *PLoS ONE*, and an associate editor of *Experimental & Molecular Medicine*, as well as an active editor for several other international journals.

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