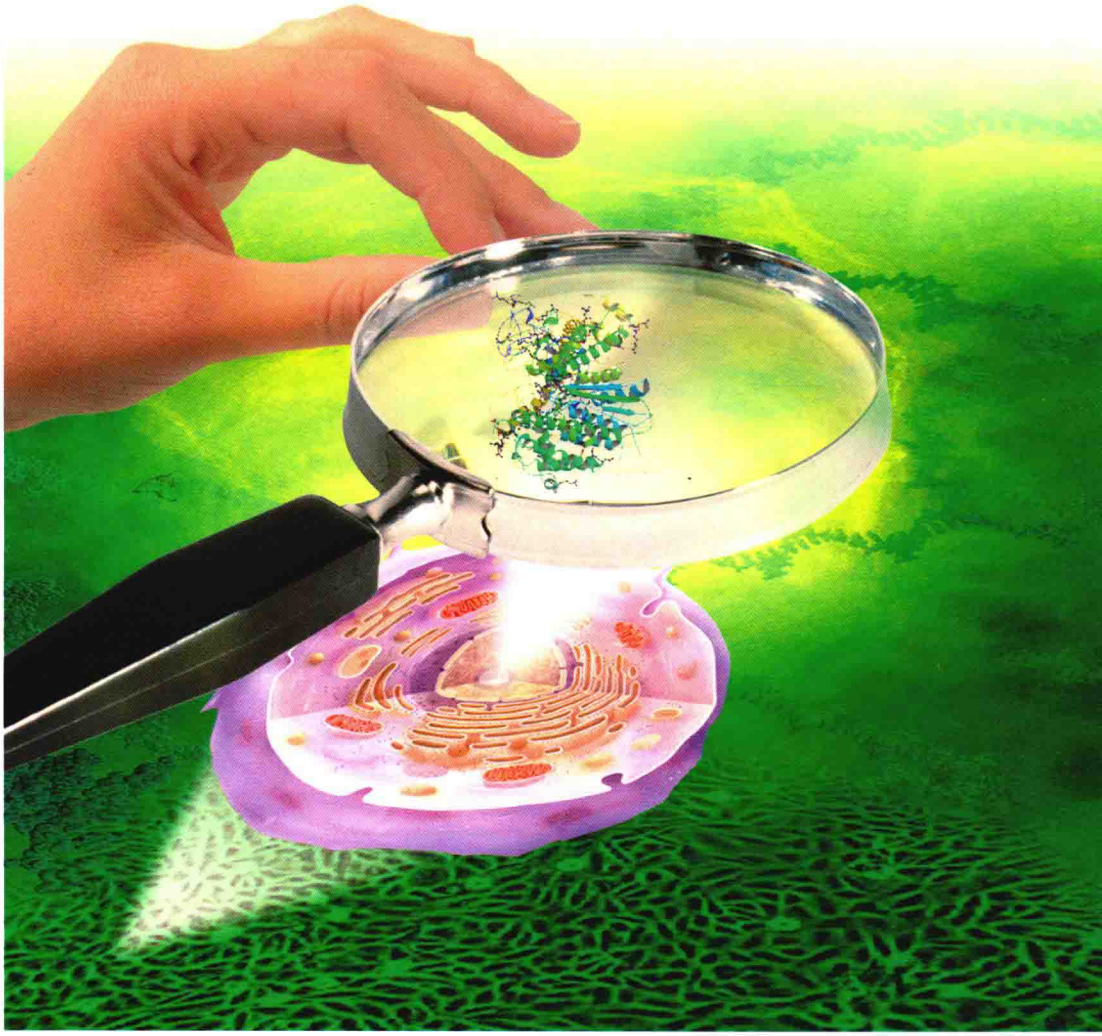
Edited by
Toshio Yanagida and Yoshiharu Ishii

WILEY-VCH

Single Molecule Dynamics in Life Science



Single Molecule Dynamics in Life Science

Edited by
Toshio Yanagida and Yoshiharu Ishii

WILEY-VCH Verlag GmbH & Co. KGaA

The Editors

Prof. Dr. Toshio Yanagida
Osaka University
Laboratory for Nanobiology
1-3 Yamada-oka, Suita
Osaka 562-0871
Japan

Dr. Yoshiharu Ishii
CREST
Soft nano-machine Project JST
1-3 Yamada-oka, Suita
Osaka 562-0871
Japan

Library of Congress Card No.: applied for

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

Bibliographic information published by the Deutsche Nationalbibliothek
Die Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available on the Internet at http://dnb.d-nb.de.

Typesetting Thomson Digital, Noida, India
Printing Strauss Gmbh, Mörlenbach
Bookbinding Litges & Dopf GmbH, Heppenheim-

Printed in the Federal Republic of Germany
Printed on acid-free paper

ISBN: 978-3-527-31288-7

Single Molecule Dynamics in Life Science

Edited by
Toshio Yanagida and Yoshiharu Ishii

Further Reading

Feringa, B. L. (Ed.)

Molecular Switches

Second Edition
2 volumes
2009
ISBN: 978-3-527-31365-5

Anselmetti, D. (Ed.)

Single Cell Analysis

Technologies and Applications

2008
ISBN: 978-3-527-31864-3

Miller, L. W. (Ed.)

Probes and Tags to Study Biomolecular Function

for Proteins, RNA, and Membranes

2008
ISBN: 978-3-527-31566-6

Mirkin, C. A., Niemeyer, C. M. (Eds.)

Nanobiotechnology II

More Concepts and Applications

2007
ISBN: 978-3-527-31673-1

Daunert, S., Deo, S. K. (Eds.)

Photoproteins in Bioanalysis

2006
ISBN: 978-3-527-31016-6

Goeldner, M., Givens, R. (Eds.)

Dynamic Studies in Biology

Phototriggers, Photoswitches and Caged Biomolecules

2005
ISBN: 978-3-527-30783-8

Preface

Biomolecules are responsible for various dynamic biological functions ranging from the intracellular to the whole body and brain. Recently developed molecular and cellular biology techniques have allowed biomolecules involved and their roles to be identified. Snapshots of atomic structures and molecular organization of these identified biomoledules, which have been determined using structural biology techniques, have been foundation for understanding the mechanism of their functions. The dynamic behavior of biomolecules, which is essential for the functios, is often inferred from static and average data.

Alternatively, single molecule measurements have been developed to directly measure the dynamic behavior of single biomolecules, which is hidden in average signals that originate from a large number of molecules, which is the case for previous ensemble measurements. Single molecules can be traced while they are working in biological environments. Furthermore, high resolution, reaching the scale of nm, msec and pN, has enabled the unitary events within a molecular function to be measured. For example, the step movement of molecular motors was observed while the motors hydrolyzed single ATP molecules. Single molecule imaging has been used to monitor the dynamic changes in location, structure and interactions of biomolecules in several complicated systems such as molecular machines, organelles and cells leading to significant progress in clarifying the fundamental principles driving cellular functions. With continued progress, we believe that single molecule measurements offer the promise of disclosing the fundamental principles behind biological dynamics.

It has been more than a decade since both single fluorophores attached to biomolecules were detected in aqueous solution and single biomolecules were manipulated. Since then, single molecule measurements have become common tools in a large number of laboratories. However, there is still much that needs to be accomplished. The technology is still immature as new techniques, such as new probes, are needed. Forging single molecule measurements with other fields like nanotechnology will be instrumental to further develop single molecule detection and potentially enable single molecule detection to be applied throughout the whole body. We hope that this book serves as a steppingstone for the next generation of

Single Molecule Dynamics in Life Science. Edited by T. Yanagida and Y. Ishii

ISBN: 978-3-527-31288-7

single molecules measurements, as readers will find information that will guide them to developing future techniques, subjects, strategies and goals.

Finally, we would like to thank all the authors for their valuable contributions to this book. Each is a pioneer for single molecule measurements in their respective biological field. We would also like to thank the staff of Wiley-VCH, in particular Dr. Rainer Muenz, for their help and encouragement.

August 2008

Toshio Yanagida
Yoshiharu Ishii

List of Contributors

Toshio Ando
Kanazawa University
Department of Physics
Kanazawa 920-1192
Japan

and

CREST
JST
Sanban-cho
Chiyoda-ku
Tokyo 102-0075
Japan

Donna J. Arndt-Jovin
Max Planck Institute for Biophysical Chemistry
Laboratory of Cellular Dynamics
Am Faßberg 11
37077 Göttingen
Germany

Jasha Brujic
New York University
Department of Physics
New York, NY 10003
USA

Wouter Caarls
Max Planck Institute for Biophysical Chemistry
Laboratory of Cellular Dynamics
Am Faßberg 11
37077 Göttingen
Germany

Christophe Danelon
Ecole Polytechnique Fédérale de Lausanne (EPFL)
Laboratoire de Chimie Physique des Polymères et Membranes
1015 Lausanne
Switzerland

Lorna Dougan
Columbia University
Department of Biological Science
New York, NY 100027
USA

Julio M. Fernandez
Columbia University
Department of Biological Science
New York, NY 100027
USA

Single Molecule Dynamics in Life Science. Edited by T. Yanagida and Y. Ishii

ISBN: 978-3-527-31288-7

Yale E. Goldman
University of Pennsylvania
Pennsylvania Muscle Institute
School of Medicine
Philadelphia, PA 19104-6083
USA

Taekjip Ha
University of Illinois
Urbana-Champaign and Howard
Hughes Medical Institute
Department of Physics
Urbana, Il 61801
USA

Guy M. Hagen
Department of Cell Biology
Charles University Medical School
Albertor 4
12800 Prague
Czech Republic

Minako Hirano
Osaka University, 1-3
Graduate School of Frontier Biosciences
Laboratories for Nanobiology
Soft Biosystem Group
Yamadaoka
Suita
Osaka 565-0871
Japan

Toru Ide
Osaka University, 1-3
Graduate School of Frontier Biosciences
Laboratories for Nanobiology
Soft Biosystem Group
Yamadaoka
Suita
Osaka 565-0871
Japan

Ryota Iino
Osaka University
The Institute of Scientific and Industrial
Research
Mihogaoka 8-1
Ibaraki 567-0047
Osaka
Japan

Noriyuki Kodera
Kanazawa University
Department of Physics
Kanazawa 920-1192
Japan

and

CREST
JST
Sanban-cho
Chiyoda-ku
Tokyo 102-0075
Japan

Yoshiharu Ishii
CREST
Soft nano-machine Project JST
1-3 Yamada-oka, Suita
Osaka 562-0871
Japan

Thomas M. Jovin
Max Planck Institute for Biophysical
Chemistry.
Laboratory of Cellular Dynamics
Am Faßberg 11
37077 Göttingen
Germany

Ted A. Laurence
University of California
Department of Chemistry and
Biochemistry
Los Angeles, CA 90095
USA

Keith A. Lidke
University of New Mexico
Department of Physics
Albuquerque, NM 87131
USA

Diane S. Lidke
University of New Mexico
Department of Pathology
Albuquerque, NM 87131
USA

Atsushi Miyagi
Kanazawa University
Department of Physics
Kanazawa 920-1192
Japan

Hiroyuki Noji
Osaka University
The Institute of Scientific and Industrial Research
Mihogaoka 8-1
Ibaraki 567-0047
Osaka
Japan

Bernd Rieger
Delft University of Technology
Department of Imaging Science & Technology
Quantitative Imaging Group
Lorentzweg 1
2628 CJ Delft
The Netherlands

Yasushi Sako
Cellular Informatics Laboratory
RIKEN

Tatsuo Shibata
Hiroshima University
Department of Mathematical and Life Sciences
Higashi-Hiroshima
Hiroshima 739-8526
Japan

Robert H Singer
Albert Einstein College of Medicine
Gruss-Lipper Biophotonics Center
Department of Anatomy and Structural Biology
1300 Morris Park Avenue
Bronx, NY 10461
USA

Yuko Takeuchi
Osaka University, 1-3
Graduate School of Frontier Biosciences
Laboratories for Nanobiology
Soft Biosystem Group
Yamadaoka
Suita
Osaka 565-0871
Japan

Masaaki Taniguchi
Kanazawa University
Department of Physics
Kanazawa 920-1192
Japan

Valeria de Turris
Albert Einstein College of Medicine
Department of Anatomy and Structural Biology
1300 Morris Park Avenue
Bronx, NY 10461
USA

Takayuki Uchihashi
Kanazawa University
Department of Physics
Kanazawa 920-1192
Japan

and

CREST
JST
Sanban-cho
Chiyoda-ku
Tokyo 102-0075
Japan

Masahiro Ueda
Osaka University
Graduate School of Frontier Biosciences
Laboratories for Nanobiology
Suita
Osaka 565-0671
Japan

Horst Vogel
Ecole Polytechnique Fédérale de Lausanne (EPFL)
Laboratoire de Chimie Physique des Polymères et Membranes
1015 Lausanne
Switzerland

Shimon Weiss
University of California
Department of Chemistry and Biochemistry
Los Angeles, CA 90095
USA

Daisuke Yamamoto
Kanazawa University
Department of Physics
Kanazawa 920-1192
Japan

and

CREST
JST
Sanban-cho
Chiyoda-ku
Tokyo 102-0075
Japan

Hayato Yamashita
Kanazawa University
Department of Physics
Kanazawa 920-1192
Japan

Toshio Yanagida
Osaka University
Graduate School of Frontier Bioscience and Graduate School of Medicine
1-3 Yamada-oka
Suita
Osaka 562-0871
Japan

Contents

Single Molecule Dynamics in Life Science. Edited by T. Yanagida and Y. Ishii

ISBN: 978-3-527-31288-7