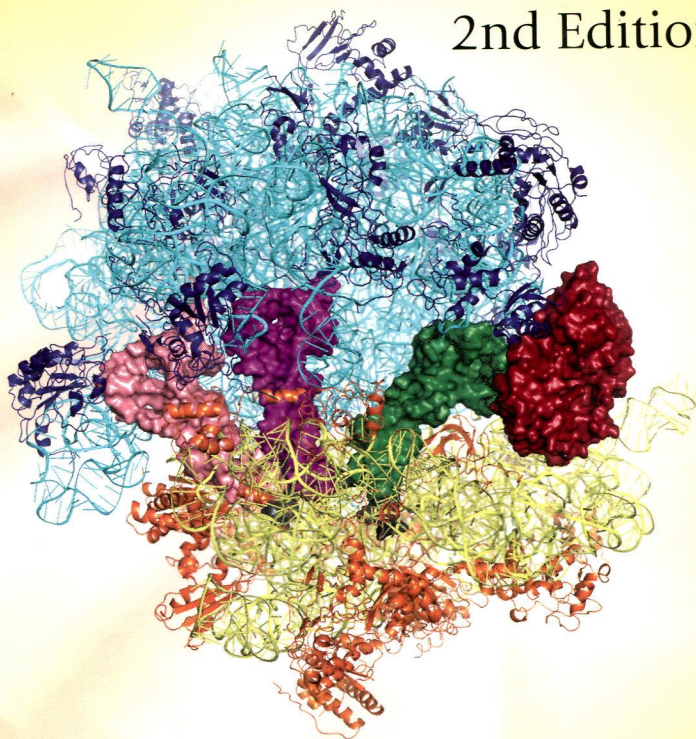


Series in Structural Biology – Vol. 1

STRUCTURAL ASPECTS OF
PROTEIN
SYNTHESIS

2nd Edition



Anders Liljas • Måns Ehrenberg

Series in Structural Biology – Vol. 1

STRUCTURAL ASPECTS OF
PROTEIN
SYNTHESIS

2nd Edition



Anders Liljas

Lund University, Sweden

Måns Ehrenberg

Uppsala University, Sweden

 **World Scientific**

NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

Library of Congress Cataloging-in-Publication Data

Liljas, Anders.

Structural aspects of protein synthesis. -- 2nd edition / Anders Liljas, Lund University, Sweden, Måns Ehrenberg, Uppsala University, Sweden.

pages cm

Includes bibliographical references and index.

ISBN 978-9814313209 (hardcover : alk. paper) -- ISBN 978-9814313216 (pbk. : alk. paper)

I. Proteins--Synthesis. I. Ehrenberg, Måns. II. Title.

QP551.L4685 2013

572'.6--dc23

2013018180

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Copyright © 2013 by World Scientific Publishing Co. Pte. Ltd.

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

Typeset by Stallion Press

Email: enquiries@stallionpress.com

Printed in Singapore by Mainland Press Pte I

Contents

<i>Preface</i>	vii
Chapter 1: The Basics of Translation	1
Chapter 2: Historical Milestones	5
Chapter 3: Methods of Studying Structure	15
3.1 Low-Resolution Methods	16
3.2 High-Resolution Methods	23
3.3 Computational Methods	29
Chapter 4: The Message — mRNA	33
4.1 The Genetic Code	33
4.2 Transcription	35
4.3 Processing of the Transcribed RNA	36
4.4 Translational Regulation, Reading Frame and Usage of the Genetic Code	37
Chapter 5: The Adaptor — tRNA	41
5.1 The tRNAs	42
5.2 tRNA Structures	42
5.3 Charging — the tRNA Synthetases	46
5.4 Recognition of Amino Acids and tRNAs by Aminoacyl-tRNA Synthetases	50
5.5 Deviations	58

Chapter 6:	The Workbench — Ribosomes	61
	6.1 The Composition of Ribosomes	61
	6.2 rRNA	62
	6.3 Ribosomal Proteins	66
	6.4 The Assembly of Ribosomes	69
Chapter 7:	The Structure of the Ribosome	71
	7.1 Early Studies of the Structure of Ribosomal Subunits and Ribosomes	71
	7.2 Crystal Structures of Ribosomes	74
	7.3 The Inter-Subunit Bridges	81
	7.4 The Structures of the Ribosomal RNA Molecules	86
	7.5 The Structures of Ribosomal Proteins	87
	7.6 The Structures of Eukaryotic and Mitochondrial Ribosomes	112
Chapter 8:	Ribosomal Sites and Ribosomal States	115
	8.1 The Binding of mRNA	116
	8.2 The tRNA Binding Sites	120
	8.3 The Peptidyl Transfer Center	131
	8.4 The Polypeptide Exit Tunnel	134
	8.5 The GTPase Binding Site	136
	8.6 The Ribosomal States	138
	Color Plates	P1
Chapter 9:	The Catalysts — Translation Factors	149
	9.1 The trGTPases	151
	9.2 Initiation Factors	168
	9.3 Elongation Factors	178
	9.4 Release Factors	207
	9.5 Ribosome-Recycling Factor	211
	9.6 tRNA Mimicry	212
	9.7 Ribosome Rescue Factors/Ribosomal Protection Proteins	214

Chapter 10:	Inhibitors of Protein Synthesis — Antibiotics, Resistance	229
	10.1 Inhibitors of Initiation	230
	10.2 Inhibitors of Aminoacyl-tRNA Binding	237
	10.3 Interference with Decoding; Distortion of Fidelity	238
	10.4 Inhibitors of Peptidyl Transfer	242
	10.5 Inhibitors of the Exit Tunnel	247
	10.6 Inhibitors of Transslocation	252
	10.7 Inhibitors of Translation Factors	255
Chapter 11:	The Process — Translation	261
	11.1 The Dynamics of Translation and the Ribosome	261
	11.2 Central Assays	262
	11.3 Initiation	263
	11.4 Elongation	267
	11.5 Termination	292
	11.6 Ribosome Recycling	299
Chapter 12:	Protein Processing, Folding and Targeting	303
	12.1 Processing of the Nascent Peptide	303
	12.2 Folding of the Nascent Chain	304
	12.3 Transport of the Nascent Polypeptide	310
Chapter 13:	Evolution of the Translation Apparatus	319
	13.1 Evolution of the Genetic Code, tRNAs and tRNA Synthetases	321
	13.2 The Evolution of Ribosomal RNAs	324
	13.3 Evolution of Proteins in Translation	328
	13.4 The RNA World or RNA-Dominated World	331
Appendix I		333
Appendix II		339
References		347
Index		431