
Methods in Cell Biology

VOLUME 76

The Zebrafish: Cellular and Developmental Biology

Edited by

H. William Detrich, III

Department of Biology
Northeastern University
Boston, Massachusetts

Monte Westerfield

Institute of Neuroscience
University of Oregon
Eugene, Oregon

Leonard I. Zon

Division of Hematology/Oncology
Children's Hospital of Boston
Department of Pediatrics and Howard Hughes Medical Institute
Boston, Massachusetts



ELSEVIER
ACADEMIC
PRESS

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

F 3c/01



Elsevier Academic Press
525 B Street, Suite 1900, San Diego, California 92101-4495, USA
84 Theobald's Road, London WC1X 8RR, UK

This book is printed on acid-free paper. ∞

Copyright © 2004, Elsevier Inc. All Rights Reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the Publisher.

The appearance of the code at the bottom of the first page of a chapter in this book indicates the Publisher's consent that copies of the chapter may be made for personal or internal use of specific clients. This consent is given on the condition, however, that the copier pay the stated per copy fee through the Copyright Clearance Center, Inc. (www.copyright.com), for copying beyond that permitted by Sections 107 or 108 of the U.S. Copyright Law. This consent does not extend to other kinds of copying, such as copying for general distribution, for advertising or promotional purposes, for creating new collective works, or for resale. Copy fees for pre-2004 chapters are as shown on the title pages. If no fee code appears on the title page, the copy fee is the same as for current chapters. 0091-679X/2004 \$35.00

Permissions may be sought directly from Elsevier's Science & Technology Rights Department in Oxford, UK: phone: (+44) 1865 843830, fax: (+44) 1865 853333, E-mail: permissions@elsevier.com.uk. You may also complete your request on-line via the Elsevier homepage (<http://elsevier.com>), by selecting "Customer Support" and then "Obtaining Permissions."

For all information on all Academic Press publications visit our Web site at www.books.elsevier.com

ISBN: 0-12-564171-0

PRINTED IN THE UNITED STATES OF AMERICA
04 05 06 07 08 9 8 7 6 5 4 3 2 1

CONTENTS

Contributors	xiii
Preface	xix
Dedication	xxi

PART I Cell Biology

1. Use of the DsRed Fluorescent Reporter in Zebrafish	
<i>Hao Zhu and Leonard I. Zon</i>	
I. Introduction	3
II. DsRed: History and Properties	4
III. DsRed in Transgenic Zebrafish	5
IV. Use of Multiple Fluorescent Reporters in Transplantation Assays	7
V. Fusion Protein Reporters	10
VI. Conclusion	11
References	11
2. Analyzing Axon Guidance in the Zebrafish Retinotectal System	
<i>Lara D. Hutson, Douglas S. Campbell, and Chi-Bin Chien</i>	
I. Introduction	13
II. Retinotectal Mutants	14
III. Labeling the Retinotectal System	16
IV. Perturbing the Retinotectal System	27
V. Future Directions	31
References	32
3. Optical Projection Tomography for Spatio-Temporal Analysis in the Zebrafish	
<i>Robert J. Bryson-Richardson and Peter D. Currie</i>	
I. Introduction	38
II. The Principle of Tomography	39
III. Problems for OPT in Zebrafish	41

IV. Materials	42
V. Methods	42
VI. Sample Preparation	43
VII. Scanning	44
VIII. Reconstruction	45
IX. Presentation of Reconstructions	46
X. Discussion	49
XI. The Future of OPT	49
XII. OPT Equipment	50
References	50
4. Imaging Blood Vessels in the Zebrafish	
<i>Makoto Kamei, Sumio Isogai, and Brant M. Weinstein</i>	
I. Introduction	51
II. Imaging Vascular Gene Expression	53
III. Nonvital Blood Vessel Imaging	54
IV. Vital Imaging of Blood Vessels	63
V. Conclusion	73
References	73
5. Zebrafish Apoptosis Assays for Drug Discovery	
<i>Chuenlei Parng, Nate Anderson, Christopher Ton, and Patricia McGrath</i>	
I. Introduction	75
II. Zebrafish Apoptosis Genes	76
III. Caspase Substrate Recognition in Zebrafish	77
IV. Detection of Apoptosis <i>In Situ</i>	77
V. Perspectives	82
References	83
6. Lipid Metabolism in Zebrafish	
<i>Shiu-Ying Ho, Juanita L. Thorpe, Yun Deng, Evelyn Santana, Robert A. DeRose, and Steven A. Farber</i>	
I. Introduction	87
II. Genetic Screen—Forward, Reverse, and Targeted-Mutagenesis	88
III. Pharmacological Studies Using Zebrafish	93
IV. Mechanism of Action Studies Using Zebrafish: The Annexin2-Caveolin1 Complex	99
V. Gene-Specific Studies: The Acyl-CoA Synthetase Enzymes	102

IV. Lateral Inhibition and the Neurogenesis Cascade	174
V. Establishment of Neuronal Identity	176
VI. Aspects of Neuronal Differentiation	179
VII. Useful Tools for the Study of Zebrafish Neurogenesis	181
VIII. Conclusion	190
References	190
11. Time-Lapse Microscopy of Brain Development	
<i>Reinhard W. Köster and Scott E. Fraser</i>	
I. Introduction—Why and When to Use Intravital Imaging	208
II. Techniques for Vital Staining of the Nervous System	209
III. Preparation of the Zebrafish Specimen	218
IV. The Microscopic System	221
V. Data Recording	222
VI. Data Analysis	225
VII. Pitfalls to Avoid	229
VIII. Summary	231
References	232
Further Reading	235
12. Development of the Peripheral Sympathetic Nervous System in Zebrafish	
<i>Rodney A. Stewart, A. Thomas Look, John P. Kanki, and Paul D. Henion</i>	
I. Introduction	237
II. The Peripheral Autonomic Nervous System	238
III. The Zebrafish as a Model System for Studying PSNS Development	242
IV. Zebrafish as a Novel Model for Studying Neuroblastoma	254
V. Conclusion and Future Directions	255
References	256
13. Optical Physiology and Locomotor Behaviors of Wild-Type and <i>Nacre</i> Zebrafish	
<i>Donald M. O'Malley, Nagarajan S. Sankrithi, Melissa A. Borla, Sandra Parker, Serena Banden, Ethan Gahtan, and H. William Detrich III</i>	
I. Introduction	262
II. Optical Physiology—Basics	263
III. Optical Physiology—Alternative Approaches	267
IV. Options for Improving the Transparency of Larval Zebrafish	272
V. Behavioral Perturbation Studies	276
VI. Conclusions	280
References	280

174	14. Computer-Aided Screening for Zebrafish Embryonic Motility Mutants	
176	<i>Charles A. Lessman</i>	
179	I. Introduction	286
181	II. Flatbed Transparency Scanners and Computers	288
190	III. Software	290
190	IV. Embryos and Larva: Physiological Considerations	291
	V. Data Acquisition	294
	VI. Data Analysis	294
	VII. Potential Problems and Remedies	305
	VIII. Conclusions	311
	References	312
208		
209		
218		
221	15. Photoreceptor Structure and Development: Analyses Using GFP Transgenes	
222	<i>Brian D. Perkins, James M. Fadool, and John E. Dowling</i>	
225	I. Introduction	316
229	II. Photoreceptor Development	318
231	III. Transgenic Zebrafish Expressing Photoreceptor-Specific Reporter Genes	320
232	IV. Developmental Studies of Photoreceptors Using Transgenic Zebrafish	322
235	V. Conclusions	327
	References	328
237		
238		
242		
254	16. Approaches to Study Neurogenesis in the Zebrafish Retina	
255	<i>Andrei Avanesov and Jarema Malicki</i>	
256	I. Introduction	333
	II. Development of the Zebrafish Retina	335
	III. Analysis of Wild-Type and Mutant Zebrafish Visual Systems	341
	IV. Genetic Analysis of the Zebrafish Retina	359
	V. Summary	374
	References	375
262		
263		
267		
272	17. Instrumentation for Measuring Oculomotor Performance and Plasticity in Larval Organisms	
276	<i>James C. Beck, Edwin Gilland, Robert Baker, and David W. Tank</i>	
280	I. Introduction	386
280	II. Methods	389
	III. Results and Discussion	395
	IV. Conclusion	407
	V. Supplemental Movie Descriptions	407
	References	411

18. Development of Cartilage and Bone	
<i>Yashar Javidan and Thomas F. Schilling</i>	
I. Introduction	415
II. Cartilage Visualization Techniques	419
III. Bone Visualization Techniques	427
IV. Molecular Markers of Skeletal Precursors	431
V. Strategy and Potential of Future Screens for Skeletal Mutants	431
References	433
19. Morphogenesis of the Jaw: Development Beyond the Embryo	
<i>R. Craig Albertson and Pamela C. Yelick</i>	
I. Larval Zebrafish Craniofacial Cartilage Development	437
II. Analysis of Craniofacial Skeletal and Replacement Tooth Development	439
III. Conclusion	451
References	451
20. Cardiac Development	
<i>Le A. Trinh and Didier Y. R. Staimier</i>	
I. Introduction	455
II. Stages of Heart Tube Morphogenesis	456
III. Gene Expression	465
IV. Conclusion and Future Directions	469
References	470
21. Chemical Approaches to Angiogenesis	
<i>Joanne Chan and Fabrizio C. Serluca</i>	
I. Introduction	475
II. Screening Tools	479
III. Chemical Screening	482
IV. Sensitized Screens	485
References	485
22. Vascular Occlusion and Thrombosis in Zebrafish	
<i>Pudur Jagadeeswaran, Matthew Cykowski, and Bijoy Thattaliyath</i>	
I. Introduction	489
II. Vascular Occlusion	491

III. Methods	493
IV. Future Perspectives	496
References	498

23. Zebrafish Kidney Development

Iain A. Drummond

I. Introduction	501
II. Pronephric Structure and Function	502
III. Pronephric Development	504
IV. The Zebrafish Pronephros as a Model of Human Disease	521
V. Conclusions	524
References	525

24. Pancreas Development in Zebrafish

Lara Gnügge, Dirk Meyer, and Wolfgang Driever

I. Pancreas Organogenesis	531
II. Morphology of the Mature Pancreas	532
III. Physiology of the Endocrine Pancreatic Tissues	533
IV. Pancreas Development	533
V. Formation and Patterning of the Zebrafish Endoderm	533
VI. Formation of the Pancreatic Primordium	537
VII. Cell Type Specification and Differentiation of the Endocrine Pancreas	542
VIII. Formation of the Exocrine Pancreas	544
IX. Perspectives	546
References	547

PART III Disease Models

25. Mosaic Eyes, Genomic Instability Mutants, and Cancer Susceptibility

Jessica L. Moore, Erin E. Gestl, and Keith C. Cheng

I. Introduction	556
II. Mutagenesis and Screening for Mosaic Eyes	558
III. Mosaic Eyes: Genomic Instability or Retinal Mutations?	561
IV. Studying Cancer Susceptibility in Adult Zebrafish	562
V. Transgenic Analysis of Genomic Instability	564
VI. Summary	566
References	566

26. Discovery and Use of Small Molecules for Probing Biological Processes
in Zebrafish

Randall T. Peterson and Mark C. Fishman

I. Rationale for Small Molecule Screens in Zebrafish	570
II. Assay Development	575
III. Chemical Suppressor and Enhancer Screens	577
IV. Selection of Small Molecule Libraries	579
V. Screening Methods	582
VI. Follow-Up Studies for Active Small Molecules	584
VII. Conclusions	588
References	588

27. Modeling Human Disease by Gene Targeting

Andrew Dodd, Stephen P. Chambers, Peter E. Nielsen, and Donald R. Love

I. Introduction	594
II. DNA Repair Processes	595
III. Transient Means to Effect Altered Gene Expression in the Zebrafish	600
IV. Heritable Means to Effect Altered Gene Expression in the Zebrafish	607
V. Discussion	608
References	609

Index	613
Volumes in Series	625