

VOLUME XI

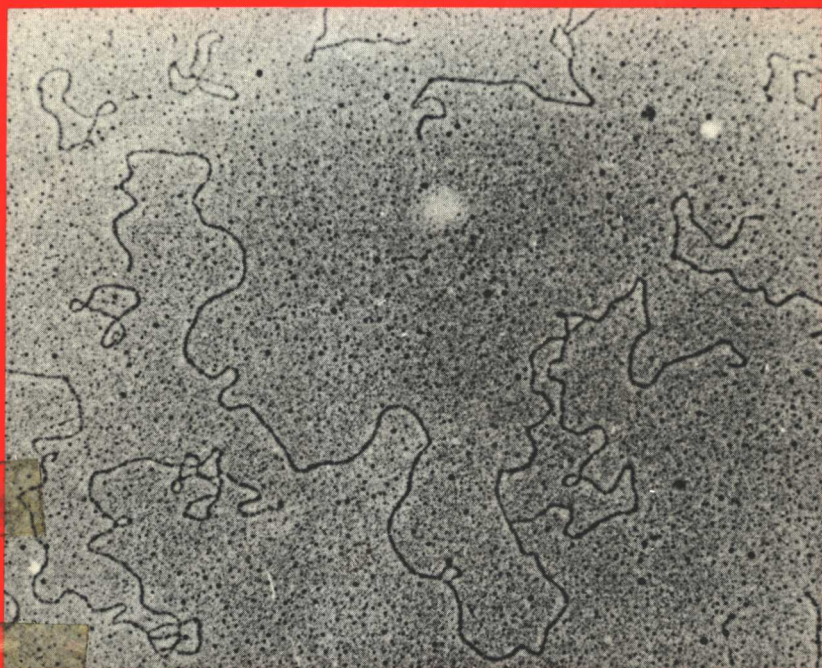
THE CELL NUCLEUS

rDNA PART B

Edited by

HARRIS BUSCH

LAWRENCE ROTHBLUM



ACADEMIC PRESS

A Subsidiary of Harcourt Brace Jovanovich, Publishers

THE CELL NUCLEUS

Volume XI

rDNA, Part B

EDITED BY

HARRIS BUSCH

Department of Pharmacology
Baylor College of Medicine
Texas Medical Center
Houston, Texas

LAWRENCE ROTHBLUM

Department of Pharmacology
Baylor College of Medicine
Texas Medical Center
Houston, Texas

1982



ACADEMIC PRESS

A Subsidiary of Harcourt Brace Jovanovich, Publishers

Paris San Diego San Francisco São Paulo New York London
Sydney Tokyo Toronto

COPYRIGHT © 1982, BY ACADEMIC PRESS, 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.

ACADEMIC PRESS, INC.
111 Fifth Avenue, New York, New York 10003

United Kingdom Edition published by
ACADEMIC PRESS, INC. (LONDON) LTD.
24/28 Oval Road, London NW1 7DX

Library of Congress Cataloging in Publication Data
Main entry under title:

The Cell nucleus.

Subtitle varies.

Includes bibliographies and indexes.

1. Cell nuclei. I. Busch, Harris. [DNLM:

1. Cell nucleus. QH 595 C392 1974j
QH595.C44 574.87'32 73-18944
ISBN 0-12-147611-1 (v. 11) AACR2

PRINTED IN THE UNITED STATES OF AMERICA

82 83 84 85 9 8 7 6 5 4 3 2 1

List of Contributors

Numbers in parentheses indicate the pages on which the authors' contributions begin.

L. S. BLOOMER (63), Department of Cellular Biology, Scripps Clinic and Research Foundation, La Jolla, California 92037

R. BRAUN (177), Department of General Microbiology, University of Bern, Bern, Switzerland

MARY COLAVITO-SHEPANSKI (193), Department of Biology, University of Rochester, Rochester, New York 14627

MARTIN A. GOROVSKY (193), Department of Biology, University of Rochester, Rochester, New York 14627

J. M. GOTTESFELD (63), Department of Cellular Biology, Scripps Clinic and Research Foundation, La Jolla, California 92037

VERA HEMLEBEN (225), Institut für Biologie II, Lehrstuhl für Genetik, Universität Tübingen, D-7400 Tübingen, Federal Republic of Germany

TORU HIGASHINAKAGAWA (255), Department of Molecular Biology, School of Medicine, University of Occupational and Environmental Health, Kitakyushu 807, Japan

W. MIKE HOWELL (89), Department of Biology, Samford University, Birmingham, Alabama 35209

BIRGIT LEWEKE (225), Institut für Biologie II, Lehrstuhl für Genetik, Universität Tübingen, D-7400 Tübingen, Federal Republic of Germany

A-LIEN LU (45), Department of Biochemistry, Duke University Medical Center, Durham, North Carolina 27710

ROSS N. NAZAR (1), Department of Botany and Genetics, College of Biological Sciences, University of Guelph, Guelph, Ontario N1G 2W1, Canada

VINCENZO PIRROTTA (29), European Molecular Biology Laboratory, 69 Heidelberg, Federal Republic of Germany

W. F. REYNOLDS (63), Department of Cellular Biology, Scripps Clinic and Research Foundation, La Jolla, California 92037

ULRICH SCHEER (143), Division of Membrane Biology and Biochemistry, Institute of Cell and Tumor Biology, German Cancer Research Center, D-6900 Heidelberg, Federal Republic of Germany

T. SEEBECK (177), Department of General Microbiology, University of Bern, Bern, Switzerland

R. D. SMITH (63), Department of Cellular Biology, Scripps Clinic and Research Foundation, La Jolla, California 92037

DARREL W. STAFFORD (45), Department of Zoology, University of North Carolina, Chapel Hill, North Carolina 27514

CHRISTIAN TSCHUDI¹ (29), European Molecular Biology Laboratory, 69 Heidelberg, Federal Republic of Germany

KAREN J. VAVRA (193), Department of Biology, University of Rochester, Rochester, New York 14627

HANSWALTER ZENTGRAF (143), Institute of Virus Research, German Cancer Research Center, D-6900 Heidelberg, Federal Republic of Germany

¹ Present address: Department of Internal Medicine, Yale University School of Medicine, New Haven, Connecticut 06510

Preface

The progress made on the description, sequences, and analysis of controls of the gene coding for ribosomal RNA and ribosomal proteins since the publication of "The Nucleolus" in 1970 is extensive. Volumes X through XII of "The Cell Nucleus" review the remarkable advances as of 1982 and point to the areas for research in the future.

The ribosomal RNA genes are among those most completely studied. They were the first eukaryotic genes purified and made available in sufficient quantity for detailed biochemical analysis and as molecular clones. Because of the large copy number per cell, these genes can be studied under both normal and amplified conditions.

Volume X deals first with the ribosomal RNA genes of *Escherichia coli* (Morgan), algae (Berger and Schweiger), fungi (Bollon), *Dictyostelium* and *Physarum* (Weiner and Emery), and other protozoans (Blackburn). Special features of the rRNA product of *Tetrahymena* are discussed by Cech *et al.* The rDNA of higher organisms is reviewed for insects (Beckingham), sea urchins (Wilson and Stafford), and humans (Wilson). Recent developments in structural analysis of 18 S rRNA and rDNA, the evolutionary patterns of 28 S rDNA, and the mitochondrial rDNA are presented in the chapters by Maden, Gerbi *et al.*, and Grant and Lambowitz.

Volumes XI–XII of this treatise deal with the 5 S DNA, nucleolar, and other rDNA-containing chromatin as visualized by light and electron microscopy and with the organization of rDNA in chromatin. In addition, the important subjects of transcription and transcriptional control of the rDNA genes, the amplification of rDNA, and the controls of ribosomal protein genes will be presented.

The pace of progress in this area continues to be very rapid, and increasingly important information on the basic mechanisms that regu-

late rRNA synthesis, coordinate rRNA and r-protein synthesis, control the number of ribosomal RNA genes per genome, and conserve the nucleotide sequence of the multiple copies of rDNA per genome will undoubtedly be forthcoming soon.

Harris Busch
Lawrence Rothblum

Contents of Other Volumes

Volume I

Nuclear Structure

Localization of Nuclear Functions as Revealed by Ultrastructural
Autoradiography and Cytochemistry

M. Bouteille, M. Laval, and A. M. Dupuy-Coin

The Nucleolus and Nucleolar DNA

Karel Smetana and Harris Busch

Ultrastructural Organization of Plant Cell Nuclei

Jean-G. Lafontaine

The Nucleus of the Plasmodial Slime Molds

Joyce Mohberg

Structures and Functions of the Nuclear Envelope

Werner W. Franke and Ulrich Scheer

Chemical and Biochemical Properties of the Nuclear Envelope

Charles B. Kasper

Nuclear-Cytoplasmic Interactions

Movement of Molecules between Nucleus and Cytoplasm

Lester Goldstein

Heterokaryons and Their Uses in Studies of Nuclear Function

E. Sidebottom

The Genome in Specialized Cells, as Revealed by Nuclear
Transplantation in Amphibia

J. B. Gurdon

Chromatin

The Molecular Organization of the Chromatin Fiber

Alberto J. Solari

The Structure of Human Chromosomes

David E. Comings

Ultrastructure and Function of Heterochromatin and Euchromatin

John H. Frenster

Author Index—Subject Index

Volume II**Chromosomes—General**

Mammalian Chromosomes

Frances E. Arrighi

The Human Cell Nucleus: Quinacrine and Other Differential Stains
in the Study of Chromatin and Chromosomes

*Frederick Hecht, Herman E. Wyandt, and R. Ellen Heath
Magenis*

Studies of Isolated Mammalian Metaphase Chromosomes

John Mendelsohn

The Kinetics of DNA Replication in Chromosomes

Elton Stubblefield

The Organization of Meiotic Chromosomes

Peter Luykx

Progress in Human Gene Mapping by Somatic Cell Hybridization

*Raju S. Kucherlapati, Richard P. Creagen, and Frank H.
Ruddle*

Chromosomes—Specific

Chromosomes of Birds

Robert N. Shoffner

Plant Cytogenetics

A. K. Sharma

Polytene Chromosomes in Studies of Gene Expression

J.-E. Edström

Giant Chromosomes*Wolfgang Henning***Chromosomes—Pathology****Clinical Cytogenetics***Jean de Grouchy***Viruses and Chromosomes***Warren W. Nichols***Mitosis and Meiosis****The Mitotic Apparatus***John F. Hartmann and Arthur M. Zimmerman***Genome Separation Mechanisms in Prokaryotes, Algae, and Fungi***I. Brent Heath***Author Index—Subject Index****Volume III****Nucleic Acids****Nuclear DNA***Bernard S. Strauss***Nuclear DNA Polymerases***R. K. Craig and H. M. Keir***Precursor of mRNA (Pre-mRNA) and Ribonucleoprotein Particles Containing Pre-mRNA***G. P. Georgiev***Nuclear High-Molecular-Weight RNA***Yong C. Choi, Ross N. Nazar, and Harris Busch***Low-Molecular-Weight Nuclear RNA's***Tae Suk Ro-Choi and Harris Busch***Nuclear Proteins****Nuclear Proteins***Mark O. J. Olson and Harris Busch***Animal Nuclear DNA-Dependent RNA Polymerases***P. Chambon, F. Gissinger, C. Keding, J. L. Mandel, and M. Meilhac*

Cytochemistry of Nuclear Enzymes

Andrzej Vorbrodt

Nuclear Protein Synthesis

LeRoy Kuehl

Special Aspects of Nuclear Function

Effects of Female Steroid Hormones on Target Cell Nuclei

Bert W. O'Malley and Anthony R. Means

The Nucleus during Avian Erythroid Differentiation

N. R. Ringertz and L. Bolund

Inhibitors as Tools in Elucidating the Structure and Function of the Nucleus

René Simard, Ives Langelier, Rosemonde Mandeville, Nicole Maestracci, and André Royal

Intranuclear Viruses

Ursula I. Heine

Author Index-Subject Index

Volume IV: Chromatin, Part A

Chromosome Chromatin

Ultrastructure of Chromatin and Chromosomes as Visualized by Scanning Electron Microscopy

Yerach Daskal and Harris Busch

The Regular Substructure of Mammalian Nuclei and Nuclear Ca-Mg Endonuclease

L. A. Burgoyne and D. R. Hewish

Chromatin Structure

K. E. Van Holde and Wolfgang O. Weischet

The Substructure of Nucleosomes

R. Tsanev

Protein-Protein Interactions of Histones

Irvin Isenberg

Chromatin Replication

Ronald L. Seale

Characterization of Human Chromatin

*Chintaman G. Sahasrabudde, Phyllis A. Shaw, M. Tien Kuo,
and Grady F. Saunders*

Histone Antibodies—Structural Probes for Chromatin and Chromosomes

Michael Bustin

Chromosome Components**Chromatin Isolation**

Keiji Marushige and Yasuko Marushige

Model of Chromatin Reconstitution

Robert A. Gadski and Chi-Bom Chae

Proteins Involved in Positive and Negative Control of Chromatin Function

Tung Y. Wang and Nina C. Kostraba

Nonhistone Proteins and Gene Organization

*J. Sanders Sevall, L. L. Jagodzinski, S. Tsai, C. E. Castro, and
D. Lee*

Compartmentalization of Nuclear and Chromatin Proteins

David E. Comings

Phase-Specific Nuclear Proteins

John J. Wille, Jr.

Index**Volume V: Chromatin, Part B****Active Chromatin****High Resolution Autoradiography Studies on Chromatin Functions**

Stanislav Fakan

Interpretation of Chromatin Structure by Circular Dichroism Analysis

Gerald D. Fasman and Mary K. Cowman

Circular Dichroism of Chromatin

C. H. Huang and R. Baserga

Reconstitution of Chromatin

Isaac Bekhor

Nuclease Digestion of Reconstituted Nucleohistone Complexes

Michael Steinmetz, Rolf E. Streeck, and Hans G. Zachau

Conformational Changes in Nucleosomes

C. L. F. Woodcock

Immunological Studies**Immunological Analysis of Protein Distributions in *Drosophila* Polytene Chromosomes**

Lee M. Silver and Sarah C. R. Elgin

Nuclear Protein Antigens

Lynn C. Yeoman

Antibodies to Nuclear Chromatin Fractions

Lubomir S. Hnilica, Jen-Fu Chiu, Kenneth Hardy, Hideo Fujitani, and Robert Briggs

Nucleolus**rDNA Organization in *Physarum polycephalum***

H. V. Molgaard

***In Vitro* Synthesis of Pre-mRNA as Isolated Nucleoli**

I. Grummt

Factors Affecting Nucleolar rDNA Readouts

Harris Busch, N. R. Ballal, M. R. S. Rao, Y. C. Choi, and L. I. Rothblum

Index**Volume VI: Chromatin, Part C****Chromosomal Organization****Supranucleosomal Levels of Chromatin Organization**

G. P. Georgiev, S. A. Nedospasov, and V. V. Bakayev

The Organization of Chromatin

R. Bruce Wallace

The Organization of the Ovalbumin Gene in the Chromosome

Annie Garel, Ruth Weinstock, Raymond Sweet, Howard Cedar, and Richard Axel

Special Proteins

Protein Migration and Accumulation in Nuclei

William M. Bonner

Modification of Nuclear Proteins: The Ubiquitin-Histone 24 Conjugate

Ira L. Goldknopf and Harris Busch

The High Mobility Group (HMG) Nonhistone Chromosomal Proteins

Graham H. Goodwin, John M. Walker, and Ernest W. Johns

Phosphorylation of Nonhistone Proteins

Lewis J. Kleinsmith

Physical Methods for Fractionation of Chromatin

A. J. MacGillivray and D. Rickwood

The Occurrence of Contractile Proteins in Nuclei and Their Possible Functions

Wallace M. LeSturgeon

Special mRNA

Structure and Control of the Globin Gene

R. Stewart Gilmour

Mammalian Chromatin: Structure, Expression, and Sequence Organization

James Bonner, Jose M. Sala-Trepat, William R. Pearson, and Jung-Rung Wu

Chromatin Controls in the Prostate

Khalil Ahmed and Michael J. Wilson

Steroid Receptor Interaction with Chromatin

Cary L. Thrall, Robert A. Webster, and Thomas C. Spelsberg

Index

Volume VII: Chromatin, Part D**Transcriptionally Active Chromatin**

Organization of Transcriptionally Active Chromatin in Lampbrush Chromosome Loops

Ulrich Scheer, Herbert Spring, and Michael F. Trendelenburg

Organization of Nucleolar Chromatin

Werner W. Franke, Ulrich Scheer, Herbert Spring, Michael F. Trendelenburg, and Hanswalter Zentgraf

Visualization of Fractionally Active Chromatin

Steven L. McKnight, Kathy A. Martin, Ann L. Beyer, and Oscar L. Miller, Jr.

Nucleolar RNA Polymerase and Transcription of Nucleolar Chromatin

Masami Muramatsu, Takashi Matsui, Toshio Onishi, and Yukio Mishima

In Vitro Chromatin Transcription

Ming-Jer Tsai, Sophia Y. Tsai, and Bert W. O'Malley

Androgen Receptor and Early Biochemical Responses

Shutsung Liao, Gabriele Mezzetti, and Chunshing Chen

Glucocorticoidal and Developmental Control of Specific Hepatic Messenger RNA Species in Vivo and in Hepatocytes in Vitro

Philip Feigelson, Linda DeLap, Ching-Ling C. Chen, Kwok-Ming Chan, and David T. Kurtz

Histone Genes: Their Structure and Control

G. S. Stein, S. Hochhauser, and J. L. Stein

Restricted Transcription of the SV40 Genome in Chromatin Isolated from SV40-Transformed Cells

Susan M. Astrin

Some Patterns of Genetic Induction of Protein Synthesis in Animal Cells

Rudolf I. Salganik

Chromatin Structure**Physical Studies of Chromatin**

J. F. Pardon and B. M. Richards

Dynamic Properties of the Nuclear Matrix

Ronald Berezney

Autoimmunity to Nuclear Antigens

Eng M. Tan

Nuclear Interaction of Polycyclic Aromatic Hydrocarbons

Thomas H. Zytkevich, Harold L. Moses, and Thomas C. Spelsberg

Carcinogenesis

Modifications of Nuclear Protein Structure and Function during Carcinogenesis

Vincent G. Allfrey and Lidia C. Boffa

The Epstein-Barr Virus Nuclear Antigen

George M. Pikler, Thomas C. Spelsberg, and Gary R. Pearson

Index

Volume VIII: Nuclear Particles, Part A

Immunolocalization and Structural Organization of Nascent RNP

John Sommerville

In Situ Localization of RNA Structures

Edmond Puvion and Gilles Moyne

Perichromatin Granules

Yerach Daskal

Transcription in Isolated Nuclei

Norman Maclean and Stephen P. Gregory

Isolation and Structure of the Ribonucleoprotein Fibrils Containing Heterogeneous Nuclear RNA

Monique Jacob, Ginnette Devilliers, Jean-Paul Fuchs, Hélène Gallinaro, Renato Gattoni, Clément Judes, and James Stévenin

Low-Molecular-Weight Nuclear Ribonucleoprotein Particles

Constantine E. Sekeris and Apostolia Guialis

U snRNA's of Nuclear snRNP's

Ramachandra Reddy and Harris Busch

Maturation of Low-Molecular-Weight RNA Species

George L. Eliceiri

Heterogeneous Nuclear RNA-Protein Complexes and Nuclear Matrix

A. Oscar Pogo

Human Antibodies to RNA-Containing Particles

Angeline S. Douvas and Eng M. Tan

Index

Volume IX: Nuclear Particles, Part B**Nuclear 30 S RNP Particles**

O. P. Samarina and A. A. Krichevskaya

The Composition and General Topology of RNA and Protein in Monomer 40 S Ribonucleoprotein Particles

Wallace M. LeStourgeon, Leonard Lothstein, Barbara W. Walker, and Ann L. Beyer

Two-Dimensional Gel Electrophoresis of Nuclear Particles

David E. Comings and Keith E. Peters

Immunocytochemistry of Nuclear hnRNP Complexes

Terence E. Martin and Carol S. Okamura

Enzymatic Activities Associated with hnRNP

Philippe Jeanteur

Digestion Products of Nuclear Ribonucleoprotein

Leonard H. Augenlicht

Nucleocytoplasmic Transport of mRNA

Thomas E. Webb, Dorothy E. Schumm, and Thomas Palayoor

Nucleocytoplasmic Transport of Ribosomal Subparticles: Interplay with the Nuclear Envelope

Frank Wunderlich

RNP Particles Involved in Release of *in Vitro* Synthesized Poly(A)-Containing RNA in Isolated Nuclei

R. K. Roy, S. Sarkar, C. Guha, and H. N. Munro

Nuclear Bodies as Functional Indicators in the Target Cells of Sex Steroid Hormones

Helen A. Padykula and James H. Clark

Nuclear Glycoproteins and Glycosaminoglycans

G. S. Stein, R. M. Roberts, J. L. Stein, and J. L. Davis

Index**Volume X: rDNA, Part A****Ribosomal RNA Genes in *Escherichia coli***

Edward A. Morgan

Characterization and Species Differences of rDNA in Algae

Sigrid Berger and Hans-Georg Schweiger