

COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY

VOLUME XLIX

Recombination at the DNA Level

FACHBEREICH BIOLOGIE (10)
der Technischen Hochschule Darmstadt
— Bibliothek —
D - 6100 Darmstadt / B. R. D.
Schriftenreihenstraße

Inv.-Nr. IVB|78

COLD SPRING HARBOR LABORATORY

1984

Contents

Symposium Participants	vii
Foreword	xix

Introduction

The DNA Enzymology of Protein Machines <i>B.M. Alberts</i>	1
--	---

Chromosomal Mechanics

Origins of Gene Conversion and Reciprocal Exchange in <i>Ascobolus</i> <i>J.-L. Rossignol, A. Nicholas, H. Hamza, and T. Langin</i>	13
Meiotic Roles of Crossing-over and of Gene Conversion <i>A.T.C. Carpenter</i>	23
Interallelic and Intergenic Conversion in Three Serine tRNA Genes of <i>Schizosaccharomyces pombe</i> <i>J. Kohli, P. Munz, R. Aeby, H. Amstutz, C. Gysler, W.-D. Heyer, L. Lehmann, P. Schuchert, P. Szankasi, P. Thuriaux, U. Leupold, J. Bell, V. Gamulin, H. Hottinger, D. Pearson, and D. Söll</i>	31
Recombination in <i>Saccharomyces cerevisiae</i> : REC-gene Mutants and DNA-binding Proteins <i>M.S. Esposito, J. Hosoda, J. Golin, H. Moise, K. Bjornstad, and D. Maleas</i>	41
Measurement of Restoration and Conversion: Its Meaning for the Mismatch Repair Hypothesis of Conversion <i>P.J. Hastings</i>	49

Yeast Systems

Meiotic Gene Conversion Mediates Gene Amplification in Yeast <i>S. Fogel, J.W. Welch, and E.J. Louis</i>	55
Physical Monitoring of Meiotic Recombination in <i>Saccharomyces cerevisiae</i> <i>R.H. Borts, M. Lichten, M. Hearn, L.S. Davidow, and J.E. Haber</i>	67
Involvement of Double-strand Chromosomal Breaks for Mating-type Switching in <i>Saccharomyces cerevisiae</i> <i>A.J.S. Klar, J.N. Strathern, and J.A. Abraham</i>	77
The Product of the HO Gene Is a Nuclease: Purification and Characterization of the Enzyme <i>R. Kostriken and F. Heffron</i>	89
Directionality and Regulation of Cassette Substitution in Yeast <i>R.E. Jensen and I. Herskowitz</i>	97
The Role of DNA Replication in the Repression of the Yeast Mating-type Silent Loci <i>A.M. Miller, R. Sternglanz, and K.A. Nasmyth</i>	105
Kinetics and Intermediates of Yeast Mitochondrial DNA Recombination <i>A.R. Zinn and R.A. Butow</i>	115

Mammalian Homologous Recombination

Analysis of Homologous Recombination in Cultured Mammalian Cells <i>K. Folger, K. Thomas, and M.R. Capecchi</i>	123
Homologous Recombination in Mouse L Cells <i>F.-L. Lin, K. Sperle, and N. Sternberg</i>	139
The Recombination and Integration of DNAs Introduced into Mouse L Cells <i>D.A. Brenner, S. Kato, R.A. Anderson, A.C. Smigocki, and R.D. Camerini-Otero</i>	151
Homologous Recombination with DNA Introduced into Mammalian Cells <i>O. Smithies, M.A. Koralewski, K.-Y. Song, and R.S. Kucherlapati</i>	161
Homologous Recombination between Defective neo Genes in Mouse 3T6 Cells <i>A.J.H. Smith and P. Berg</i>	171

Homologous Recombination between Repeated Chromosomal Sequences in Mouse Cells <i>R.M. Liskay, J.L. Stachelek, and A. Letsou</i>	183
Homologous Recombination in Monkey Cells and Human Cell-free Extracts <i>R.S. Kucherlapati, D. Ayares, A. Hanneken, K. Noonan, S. Rauth, J.M. Spencer, L. Wallace, and P.D. Moore</i>	191
Transposons	
Origin of Cryptic λ Prophages in <i>Escherichia coli</i> K-12 <i>R.J. Redfield and A.M. Campbell</i>	199
Functional Difference of the Two Ends of Insertion Sequence IS1 in Transposition and Cointegration <i>K. Ishizaki and E. Ohtsubo</i>	207
Transposon Tn5: Specific Sequence Recognition and Conservative Transposition <i>D.E. Berg, J. Lodge, C. Sasakawa, D.K. Nag, S.H. Phadnis, K. Weston-Hafer, and G.F. Carle</i>	215
Site-specific Recombination in Transposition and Plasmid Stability <i>D. Sherratt, P. Dyson, M. Boocock, L. Brown, D. Summers, G. Stewart, and P. Chan</i>	227
Mechanism and Regulation of Tn10 Transposition <i>N. Kleckner, D. Morisato, D. Roberts, and J. Bender</i>	235
Resolvase-mediated Recombination Intermediates Contain a Serine Residue Covalently Linked to DNA <i>R.R. Reed and C.D. Moser</i>	245
Replicative and Conservative Transpositional Recombination of the Insertion Sequences <i>T.A. Weinert, K. Derbyshire, F.M. Hughson, and N.D.F. Grindley</i>	251
Mu	
Mapping and Properties of the <i>gam</i> and <i>sot</i> Genes of Phage Mu: Their Possible Roles in Recombination <i>J. Akroyd, B. Barton, P. Lund, S. Maynard Smith, K. Sul-tana, and N. Symonds</i>	261
Analysis of the Regulation of the Transposition Functions of Bacteriophage Mu by Using Gene Fusions <i>T.A. Patterson, K.A. Martin, and A.I. Bukhari</i>	267
Nonreplicative DNA Transposition: Integration of Infecting Bacteriophage Mu <i>R.M. Harshey</i>	273
Transposition of Bacteriophage Mu DNA: Expression of the A and B Proteins from λp_L and Analysis of Infecting Mu DNA <i>G. Chaconas, G. Gloor, J.L. Miller, D.L. Kennedy, E.B. Giddens, and C.R. Nagainis</i>	279
Substrate and Enzyme Requirements for In Vitro Site-specific Recombination in Bacteriophage Mu <i>R. Kahmann, F. Rudt, and G. Mertens</i>	285
Inversion of DNA In Vivo and In Vitro by Gin and Pin Proteins <i>R.H.A. Plasterk and P. van de Putte</i>	295
Comparative Analysis of Invertible DNA in Phage Genomes <i>D. Kamp, E. Kardas, W. Rittehler, R. Sandulache, R. Schumucker, and B. Stern</i>	301
Programming of DNA Rearrangements Involving Mu Phrophages <i>J.A. Shapiro and P.M. Brinkley</i>	313
Plant Transposons/T4 Recombination	
Endogenous Transposable Elements Associated with Virus Infection in Maize <i>S.L. Dellaporta, P.S. Chomet, J.P. Mottinger, J.A. Wood, S.-M. Yu, and J.B. Hicks</i>	321
Transposable Elements <i>Ac</i> and <i>Ds</i> at the <i>Shrunken</i> , <i>Waxy</i> , and <i>Alcohol Dehydrogenase 1</i> Loci in <i>Zea mays</i> L. <i>U. Courage, H.-P. Döring, W.-B. Frommer, R. Kunze, A. Laird, A. Merckelbach, M. Müller-Neumann, J. Riegel, P. Starlinger, E. Tillmann, E. Weck, W. Werr, and J. Yoder</i>	329
Isolation of <i>Spm</i> Controlling Elements from Maize <i>N. Fedoroff, M. Shure, S. Kelly, M. Johns, D. Furtek, J. Schiefelbein, and O. Nelson</i>	339
Insertion and Excision of <i>Ds</i> Controlling Elements in Maize <i>W.J. Peacock, E.S. Dennis, W.L. Gerlach, M.M. Sachs, and D. Schwartz</i>	347
Transposable Elements in <i>Antirrhinum majus</i> and <i>Zea mays</i> <i>H. Saedler, U. Bonas, A. Gierl, B.J. Harrison, R.B. Klösgen, E. Krebbers, P. Nevers, P.A. Peterson, Z. Schwarz-Sommer, H. Sommer, K. Upadhyaya, and U. Wienand</i>	355

The Use of Affinity Chromatography to Study Proteins Involved in Bacteriophage T4 Genetic Recombination <i>T. Formosa and B.M. Alberts</i>	363
On the Role of DNA Replication, Endonuclease.VII, and rII Proteins in Processing of Recombinational Intermediates in Phage T4 <i>G. Mosig, M. Shaw, and G.M. Garcia</i>	371
 Topoisomerase, Resolvase, and Gyrase	
A Topological Treatment of Recombination and Topoisomerases <i>N.R. Cozzarelli, M.A. Krasnow, S.P. Gerrard, and J.H. White</i>	383
Nonhomologous Recombination Mediated by <i>Escherichia coli</i> DNA Gyrase: Possible Involvement of DNA Replication <i>H. Ikeda and M. Shiozaki</i>	401
The Cleavage of DNA by Type-I DNA Topoisomerases <i>K. Kirkegaard, G. Pflugfelder, and J.C. Wang</i>	411
Site-specific Recombination in the <i>oriV1</i> Region of the F Factor <i>M.B. O'Connor and M.H. Malamy</i>	421
DNA Structural Features That Lead to Strand Breakage by Eukaryotic Type-I Topoisomerase <i>J.J. Champoux, W.K. McCoubrey, Jr., and M.D. Been</i>	435
 <i>Escherichia coli</i> General Recombination	
Host Functions in Amplification/Deamplification of Tn9 in <i>Escherichia coli</i> K-12: A New Model for Amplification <i>S.K. Mahajan, N.N. Pandit, and J.F. Sarkari</i>	443
Genes of the RecE and RecF Pathways of Conjugational Recombination in <i>Escherichia coli</i> <i>A.J. Clark, S.J. Sandler, K.D. Willis, C.C. Chu, M.A. Blanar, and S.T. Lovett</i>	453
Purification and Characterization of Exonuclease V from <i>Escherichia coli</i> K-12 <i>C.C. Dykstra, K.M. Palas, and S.R. Kushner</i>	463
Genetic Analysis and Regulation of Inducible Recombination in <i>Escherichia coli</i> K-12 <i>S.M. Picksley, R.G. Lloyd, and C. Buckman</i>	469
RecF and RecBC Function during Recombination of Nonreplicating, UV-irradiated Phage λ DNA and during Other Recombination Processes <i>J.B. Hays, T.A.G. Smith, S.A. Friedman, E. Lee, and G.L. Coffman</i>	475
Roles of RecBC Enzyme and Chi Sites in Homologous Recombination <i>G.R. Smith, S.K. Amundsen, A.M. Chaudhury, K.C. Cheng, A.S. Ponticelli, C.M. Roberts, D.W. Schultz, and A.F. Taylor</i>	485
The Mechanism of the Chi-cos Interaction in RecA-RecBC-mediated Recombination in Phage λ <i>I. Kobayashi, M.M. Stahl, and F.W. Stahl</i>	497
 RecA	
A Model for the Core Structure of the <i>Escherichia coli</i> RecA Protein <i>M.A. Blanar, D. Kneller, A.J. Clark, A.E. Karu, F.E. Cohen, R. Langridge, and I.D. Kuntz</i>	507
Intermediates in Homologous Pairing Promoted by RecA Protein and Correlations of Recombination In Vitro and In Vivo <i>S.S. Flory, J. Tsang, K. Muniyappa, M. Bianchi, D. Gonda, R. Kahn, E. Azhderian, C. Egner, S. Shaner, and C.M. Radding</i>	513
Unidirectional Branch Migration Promoted by Nucleoprotein Filaments of RecA Protein and DNA <i>M.M. Cox, S.W. Morrical, and S.K. Neuendorf</i>	525
Studies of the Mechanism of DNA Pairing by the RecA Protein of <i>Escherichia coli</i> <i>F.R. Bryant, P.W. Riddles, and I.R. Lehman</i>	535
Roles of Processive Unwinding in Recombination Reactions Promoted by RecA Protein of <i>Escherichia coli</i> : A Study Using a Monoclonal Antibody <i>T. Shibata, O. Makino, S. Ikawa, T. Ohtani, M. Iwabuchi, Y. Shibata, H. Maeda, and T. Ando</i>	541
Visualization of SSB-ssDNA Complexes Active in the Assembly of Stable RecA-DNA Filaments <i>J.D. Griffith, L.D. Harris, and J. Register III</i>	553
Visualization of RecA-DNA Complexes Involved in Consecutive Stages of an In Vitro Strand Exchange Reaction <i>A. Stasiak, A.Z. Stasiak, and T. Koller</i>	561
Molecular Mechanisms of General Genetic Recombination: The DNA-binding Sites of the RecA Protein <i>P. Howard-Flanders, S.C. West, J.R. Rusche, and E.H. Egelman</i>	571

Repair

Studies of HeLa DNA Polymerases during Excision-repair In Vitro with DNA and Chromatin Substrates <i>D.W. Mosbaugh, D.H. Evans, and S. Linn</i>	581
Repair of DNA Base-pair Mismatches in Extracts of <i>Escherichia coli</i> <i>A.-L. Lu, K. Welsh, S. Clark, S.-S. Su, and P. Modrich</i>	589
The <i>mutH</i> , <i>mutL</i> , <i>mutS</i> , and <i>uvrD</i> Genes of <i>Salmonella typhimurium</i> LT2 <i>P.P. Pang, S.-D. Tsen, A.S. Lundberg, and G.C. Walker</i>	597
An <i>Escherichia coli</i> Cell-free System That Catalyzes the Repair of Symmetrically Methylated Heteroduplex DNA <i>R.A. Fishel and R. Kolodner</i>	603
Involvement of <i>Escherichia coli</i> Mismatch Repair in DNA Replication and Recombination <i>R. Wagner, C. Dohet, M. Jones, M.-P. Doutriaux, F. Hutchinson, and M. Radman</i>	611
Formation of Inverted Dimer Plasmids after Transformation of Yeast with Linearized Plasmid DNA <i>S. Kunes, D. Botstein, and M.S. Fox</i>	617
Double-strand-break Repair, Gene Conversion, and Postdivision Segregation <i>R. Rothstein</i>	629

Eukaryotic Enzymes

Changes in the Chromosomal DNA of Yeast during Meiosis in Repair Mutants and the Possible Role of a Deoxyribonuclease <i>M.A. Resnick, T. Chow, J. Nitiss, and J. Game</i>	639
Integrative Recombination—A Role for the Retroviral Reverse Transcriptase <i>A.M. Skalka, G. Duyk, M. Longiaru, P. DeHaseth, R. Terry, and J. Leis</i>	651
Endonuclease J: A site-specific Endonuclease Cleaving Immunoglobulin Genes <i>S. Kondo, T. Kataoka, M. Nishi, M. Kodaira, S. Takeda, and T. Honjo</i>	661
Biochemical Characterization of <i>recI</i> Mutants and the Genetics Control of Recombination in <i>Ustilago maydis</i> <i>R. Holliday, S.Y. Taylor, E.B. Kmiec, and W.K. Holloman</i>	669
Homologous Pairing Promoted by <i>Ustilago</i> RecI Protein <i>E. Kmiec, P. Kroeger, R. Holliday, and W. Holloman</i>	675
Poly(ADP-ribosylation) of DNA Topoisomerase I: A Nuclear Response to DNA-strand Interruptions <i>A.M. Ferro, M.C. McElwain, and B.M. Olivera</i>	683

Integration and Excision of Bacteriophage

Primary Structure and the <i>himA</i> Gene of <i>Escherichia coli</i> : Homology with DNA-binding Protein HU and Association with the Phenylalanyl-tRNA Synthetase Operon <i>H.I. Miller</i>	691
DNA Interactions during Bacteriophage λ Site-Specific Recombination <i>C.E. Bauer, S.D. Hesse, J.F. Gardner, and R.I. Gumpert</i>	699
Site-specific Recombination Systems of Phages ϕ 80 and P22: Binding Sites of Integration Host Factor and Recombination-induced Mutations <i>J. Leong, S. Nunes-Dubý, A. Oser, C. Lesser, P. Youderian, M.M. Susskind, and A. Landy</i>	707
Enzymes and Sites of Genetic Recombination: Studies with Gene-3 Endonuclease of Phage T7 and with Site-affinity Mutants of Phage λ <i>B. de Massy, F.W. Studier, L. Dorgai, E. Appelbaum, and R.A. Weisberg</i>	715
The Role of Specialized Nucleoprotein Structures in Site-specific Recombination and Initiation of DNA Replication <i>H. Echols, M. Dodson, M. Better, J.D. Roberts, and R. McMacken</i>	727
λ Integrative Recombination: Supercoiling, Synapsis, and Strand Exchange <i>P. Kitts, E. Richet, and H.A. Nash</i>	735
Quantitative Analysis of the Contributions of Enzyme and DNA to the Structure of λ Integrative Recombinants <i>S.J. Spengler, A. Stasiak, A.Z. Stasiak, and N.R. Cozzarelli</i>	745

Site-specific Recombination

In Vitro Analysis of Hin-mediated Site-specific Recombination <i>R.C. Johnson, M.B. Bruist, M.B. Glaccum, and M.I. Simon</i>	751
--	-----

The Nature of the Interaction of the P1 Recombinase Cre with the Recombining Site <i>loxP R. Hoess, K. Abremski, and N. Sternberg</i>	761
The Bacteriophage P1 Site-specific Recombinase Cin: Recombination Events and DNA Recognition Sequences <i>S. Iida, H. Huber, R. Hiestand-Nauer, J. Meyer, T.A. Bickle, and W. Arber</i>	769
Components of the Site-specific Recombination System Encoded by the Yeast Plasmid 2-micron Circle <i>M. McLeod, F. Volkert, and J. Broach</i>	779
In Vitro Systems for Genetic Recombination of the DNAs of Bacteriophage T7 and Yeast 2-micron Circle <i>P.D. Sadowski, D.D. Lee, B.J. Andrews, D. Babineau, L. Beatty, M.J. Morse, G. Proteau, and D. Vetter</i>	
Site-Specific Genetic Recombination Promoted by the FLP Protein of the Yeast 2- micron Plasmid In Vitro <i>L. Meyer-Leon, J.F. Senecoff, R.C. Bruckner, and M.M. Cox</i>	797
 Recombination in Vitro	
Genetic Recombination Catalyzed by Cell-free Extracts of <i>Saccharomyces cerevisiae L.S. Symington, P.T. Morrison, and R. Kolodner</i>	805
Resolution of Holliday Structures by Endonuclease VII As Observed in Interactions with Cruciform DNA <i>B. Kemper, F. Jensch, M.v. Depka-Prondzynski, H.-J. Fritz, U. Borgmeyer, and K. Mizuuchi</i>	815
On the Mu Repressor and Early DNA Intermediates of Transposition <i>H.M. Krause and N.P. Higgins</i>	827
The Mechanism of Transposition of Bacteriophage Mu <i>K. Mizuuchi, M. Mizuuchi, and R. Craigie</i>	835
 Summary	
Types of Recombination: Common Problems and Common Strategies <i>A. Campbell</i>	839
Author Index	845
Subject Index	847