Preface

Each generation in a sexually reproducing organism such as a fly or a mouse passes through the bottleneck of meiosis, which is the specialized cell division that gives rise to haploid reproductive cells (sperm, eggs, spores, etc.). The principal function of meiosis is to reduce the genome complement by half, which is accomplished through sequential execution of one round of DNA replication followed by two rounds of chromosome segregation. Within the extended prophase between DNA replication and the first meiotic division in most organisms, homologous maternal and paternal chromosomes pair with one another and undergo homologous recombination, which establishes physical connections that link the homologous chromosomes until the time they are separated at anaphase I. Recombination also serves to increase genetic diversity from one generation to the next by breaking up linkage groups.

The unique chromosome dynamics of meiosis have fascinated scientists for well over a century, but in recent years there has been an explosion of new information about how meiotic chromosomes pair, recombine, and are segregated. Progress has been driven by advances in three main areas: (1) genetic identification of meiosis-defective mutants and cloning of the genes involved; (2) development of direct physical assays for DNA intermediates and products of recombination; and (3) increasingly sophisticated cytological methods that describe chromosome behaviors and the spatial and temporal patterns by which specific proteins associate with meiotic chromosomes. Often, the biggest insights have been obtained at the intersection between these historically separate approaches. New assays are being developed and classical methods are being applied in new ways, all in a diverse range of organisms from single-celled fungi, to plants, to animals both big and small.

These two volumes provide detailed protocols for genetic, molecular, and cytological methods for studying meiotic chromosome dynamics, in particular homologous recombination, higher-order chromosome structures, and chromosome segregation. Broad coverage is provided of many of the experimental organisms in which meiosis is often studied (e.g., the yeasts *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*, the nematode *Caenorhabditis elegans*, the fruit fly *Drosophila melanogaster*, the plant *Arabidopsis thaliana*, and the house mouse *Mus musculus*). Coverage is also provided of methods applicable to the study of meiosis in humans, as well as in other organisms which often offer distinct experimental advantages or unique mechanistic or evolutionary insights.

These books are aimed at scientists in (at least) three main categories: (1) Students of meiosis who want to "cross over" and apply basic techniques from other disciplines to the biological problems in which they are most interested. For example, cytologists who want to connect microscopic observations to the underlying DNA events will find guides to molecular methods for studying recombination. Likewise, geneticists who want to connect mutant phenotypes to the details of chromosome dynamics will find cytological methods that allow them to do so. (2) Students of meiosis in one organism

who wish to examine similar processes and conserved proteins in another organism, or who wish to gain a better understanding of both the possibilities and the limitations of methods for studying meiosis in other organisms. Ideally, the hope is that this book will play at least a small role in fostering crosstalk between investigators working in different experimental systems. (3) Students of basic chromosome biology in mitotically dividing cells who want to extend studies into meiosis, and, more generally, geneticists studying any biological process who find in hand a mutation that unexpectedly affects fertility and who need a handy primer on how to study this phenotype further. Indeed, this latter group has not been uncommon in the era of reverse genetic gene targeting in mouse.

The first volume, *Meiosis: Volume 1, Molecular and Genetic Methods,* is divided into two parts. The chapters in Part I of the first volume are devoted to genetic analyses, including methods for culturing and manipulating commonly used model organisms and methods for detecting and quantifying meiotic recombination or other aspects of chromosome dynamics. Part II of the first volume describes techniques for the direct study of meiotic recombination events through physical analysis of DNA or of protein–DNA interactions. Numerous approaches are described in budding and fission yeasts and in mouse and human.

The second volume, *Meiosis: Volume 2, Cytological Methods,* is subdivided for convenience by the general type of organism: fungi in Part I, plants and small animals (mostly invertebrates) in Part II, and mammals in Part III. Although there is some redundancy in certain aspects of the cytological methods, there are also many instances of species-specific differences—or even gender-specific differences within a species—that make it important to provide separate detailed protocols for different organisms. Cytology is a visual science, and the use of color and animation is often critical to the appropriate display of experimental results. As a consequence, Springer has graciously agreed to provide a companion CD for the second volume, on which can be found color versions of many of the figures that are reproduced in grayscale in the printed volume. The CD also contains a number of movies that illustrate results of real-time imaging of chromosome dynamics in yeasts, that show animations of three-dimensional reconstructions of meiotic nuclei, or that demonstrate particular experimental manipulations. A computer macro can also be found that provides analytical tools for evaluating the spatial distribution of cytological protein complexes on chromosomes. It is hoped that the contents of this CD will be a useful resource for readers of this volume.

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