

Preface

This book deals mainly with chromosomal alterations which represent changes in the structure (chromosome mutations) or number (genome mutations) of chromosomes and with sister chromatid exchanges (SCE).

Double-strand breaks (DSB) in DNA are the ultimate lesions for the formation of chromosome mutation and SCE evaluated in the light microscope. Typical chromosomal alterations are chromosomal aberrations (CA) and micronuclei (MN). SCE result from repair of lesions during S phase ("true" SCE), or from chromosome-type CA induced during G1 phase ("false" SCE). Numerical alterations of chromosomes are discussed with respect to their importance in clinical cytogenetics, to their ability to give rise to MN containing whole chromosomes and to their origin during divisions of CA containing cells.

Evaluation of chromosomal alterations, especially CA, MN and SCE, has long been used in basic and applied research. Investigations into the mechanism(s) of the origin of chromosomal alterations lead to insights into the structure and function of chromosomes. Increased indices of chromosomal alterations in cells, in vitro and in vivo, are used as indicators of exposure to biological, chemical and physical genotoxins in our environment. Furthermore, elevated genotoxicity has been correlated with increased carcinogenicity. This fits with the observation of specific types of CA in cancer cells and with a positive correlation between elevated frequencies of CA and cancer risk in human populations.

DSB are induced directly by powerful DNA-damaging agents such as ionizing radiation and restriction endonucleases which lead to the formation of CA in the same cell cycle stage in which the DSB are induced: in G0/G1 phase as chromosome-type CA, in S phase as both chromosome-type and chromatid-type CA (depending on whether DSB occur in unreplicated or in replicated DNA, respectively) and in G2 phase as chromatid-type CA. Most genotoxic agents induce DNA lesions other than DSB which during S phase lead to chromatid-type CA and to "true" SCE.

CA, MN and SCE are analyzed in the light microscope after appropriate staining (generally Giemsa stain). Special pretreatment of fixed metaphase chromosomes on slides followed by staining with Giemsa stain leads to specific banding patterns that allow in-depth analyses of specific types of CA such as translocations and intra chromosomal and interchromosomal distributions

of CA. Application of fluorescence in situ hybridization (FISH) opened new insights into unexpected complexities of CA. Following differential substitution of chromosomal DNA with specific agents such as bromodeoxyuridine, SCE can be made visible by staining with Giemsa stain. MN result from CA or from whole chromosomes not distributed to the cell poles. Analyses of MN are usually carried out in binucleate second-division cells after exposure to a mutagen. FISH techniques are extremely useful to investigate mechanistic aspects of the formation of MN.

The book starts with a chapter on structural and functional aspects of human chromosomes. Chapters 2–8 describe DNA lesions leading to chromosomal alterations (including gene mutations), and the ability of the cells to repair such lesions. Chapters 9 and 10 explain how DNA damage can be measured by means of γ -H2AX foci and by the comet assay. Chapters 11–14 explore mechanisms of the origin of CA (Chap. 11), the influence of nuclear and chromatin structure on CA formation (Chaps. 12, 13) and CA and SCE in telomeric regions (Chap. 14). Chapters 15–17 are devoted to MN and SCE. FISH methods and their applications for the analysis of chromosomal alterations are presented in Chaps. 18 and 19. In the following chapters topics such as changing patterns of chromosomal alterations in ongoing cell cycles (Chap. 20), human-population monitoring (Chap. 21), biological dosimetry (Chaps. 22–24) and CA in peripheral lymphocytes of astronauts (Chap. 25) are included. Chapters 26–29 are devoted to the question of possible carcinogenic and chromosome-damaging effects of low- and high-frequency electromagnetic fields. The importance of chromosomal alterations in cancer cells and as indicators of cancer risk in human populations is highlighted in Chaps. 30 and 31.

We would like to thank our colleagues who generously and willingly contributed to this book.

The editors hope that the book will serve as a textbook for graduate students in biological sciences, residents in radiology and radiation oncology, as well as researchers interested in occupational exposures, ionizing and non-ionizing radiation, environmental mutagenesis and carcinogenesis.

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