

# Contents

<b>Preface</b> .....	iii
<b>Executive Summary</b> .....	1
<b>1. Introduction</b> .....	4
<b>1.1</b> Low Doses and Low Dose Rates .....	5
<b>1.2</b> Use of Radiation Biology Data to Reduce the Uncertainty in Risk Estimates ...	6
<b>2. General Approaches to Risk Assessment</b> .....	11
<b>2.1</b> Risk Assessment Process and Associated Uncertainties .....	11
<b>2.2</b> Modeling Uncertainties: Dosimetric, Epidemiologic and Biological .....	12
<b>2.3</b> Transfer of Risk Between Populations of Different Countries .....	13
<b>2.4</b> Extrapolating Low-Dose Effects from <i>In Vitro</i> to <i>In Vivo</i> ; Animal to Human ...	14
<b>3. Studies Integrating Biology and Epidemiology</b> .....	17
<b>3.1</b> Epidemiologic Studies Focused on Cancer Outcomes .....	17
<b>3.1.1</b> Chromosome Aberration Studies .....	17
<b>3.1.2</b> Atomic-Bomb Survivors .....	18
<b>3.1.3</b> Pelvic Irradiation Studies .....	19
<b>3.1.4</b> Occupational Studies .....	19
<b>3.1.5</b> Environmental Background Studies .....	20
<b>3.1.6</b> Transgenerational Studies .....	21
<b>3.1.7</b> Gene and Radiation Interaction: The Women’s Environmental Cancer and Radiation Epidemiology Study .....	22
<b>3.1.8</b> Retinoblastoma .....	23
<b>3.2</b> Epidemiologic Studies Focused on Noncancer Outcomes .....	24
<b>4. Bioindicators from Radiation Biology Studies</b> .....	25
<b>4.1</b> DNA Damage and Repair .....	25
<b>4.2</b> Signaling of DNA Damage at Low Doses .....	26
<b>4.3</b> Chromosome Alterations .....	27
<b>4.4</b> Mutations .....	28
<b>4.5</b> Radiation-Induced Genomic Instability .....	30
<b>4.6</b> Modulators of Response .....	32
<b>4.6.1</b> Adaptive Responses .....	32
<b>4.6.2</b> Bystander Effects .....	33
<b>4.6.3</b> Genetic Susceptibility and Interactions with Radiation .....	34
<b>4.6.4</b> Interactions with Environmental and Lifestyle Factors .....	35
<b>5. Closing the Gaps Towards an Integrated Approach</b> .....	37
<b>5.1</b> Targeted Research to Identify Adverse Outcome Pathways and Bioindicators of Response .....	37
<b>5.2</b> Biologically Based Modeling .....	38
<b>5.2.1</b> Biologically Based Dose-Response Approach .....	39
<b>5.2.2</b> Systems Biology .....	40

<b>5.3</b>	Registries of Medical-Imaging Exposures Linked to Outcomes and Biological Materials .....	41
<b>5.4</b>	Facilities and Interdisciplinary Training .....	42
<b>5.4.1</b>	Facilities .....	42
<b>5.4.2</b>	Interdisciplinary Training .....	42
<b>Abbreviations and Acronyms</b>	.....	43
<b>Glossary</b>	.....	44
<b>References</b>	.....	48
<b>Scientific Committee Members</b>	.....	73
<b>NCRP Commentaries</b>	.....	78