

# Table of Contents

<b>Section 1. Introduction and Overview . . . . .</b>	<b>1</b>
<b>Section 2. Sources and Nature of Fields and Exposure . . . . .</b>	<b>4</b>
2.1. Power Delivery Systems . . . . .	4
2.2. Electric and Magnetic Fields . . . . .	4
2.2.1. Electric Fields . . . . .	7
2.2.2. Magnetic Fields . . . . .	8
2.2.3. Shielding of Fields . . . . .	16
2.3. Electric and Magnetic Induction . . . . .	16
2.4. Contact Currents . . . . .	19
2.5. Measuring "Dose" . . . . .	19
2.6 Comparing Human Exposures From Different Sources . . . . .	20
2.7. Sources of Exposure at Non-Power Frequencies . . . . .	21
<b>Section 3. Cellular Level Experiments . . . . .</b>	<b>24</b>
3.1. Modulation of Ion and Protein Flow Across the Cell Membrane . . . . .	25
3.2. Chromosomal Damage and Interference With DNA Synthesis and RNA Transcription . . . . .	29
3.3. Interaction With Response to Hormones and Effects on Endocrine Tissue . . . . .	29
3.4. Interaction With the Cell Response to Neurotransmitters . . . . .	30
3.5. Interaction With Immune Response of Cells . . . . .	30
3.6. Interaction With Cells Relevant to Cancer . . . . .	31
3.7. General Observations on Cell Level Experiments . . . . .	33
<b>Section 4. Whole Animal Experiments . . . . .</b>	<b>35</b>
4.1. Detection, Behavior Learning and Avoidance Responses In Animals . . . . .	36
4.2. Effects on Hormone Levels and the Central Nervous System . . . . .	37
4.3. Effects on Blood and Immune System Chemistry . . . . .	39
4.4. Effects on Reproduction, Growth and Development . . . . .	39
4.5. Effects on the Circadian Systems of Animals and Humans . . . . .	48
4.6. Experiments With Human Subjects . . . . .	50
<b>Section 5. Comparing Laboratory and Human Exposures . . . . .</b>	<b>52</b>
5.1. Laboratory Animals-Electric Induction . . . . .	52
5.2. Laboratory Animals-Magnetic Induction . . . . .	52
5.3. In Vitro Experiments . . . . .	54
5.3.1. Pulsed Magnetic Field Exposures . . . . .	54
5.3.2. ELF-Modulated Radio Frequency Exposures . . . . .	55
5.3.3. Calcium Efflux From Chick Brains . . . . .	55
5.4. Comparison of Exposures in Bioeffects Studies to Common Human Exposure Situations . . . . .	55
<b>Section 6. Cancer and Electromagnetic Fields: Epidemiological Studies . . . . .</b>	<b>57</b>
6.1. Childhood Cancer and ELF Fields . . . . .	58
6.2. Residential Exposure and Adult Cancer . . . . .	62
6.3. Occupational Exposure and Cancer . . . . .	62
6.3.1. Leukemia . . . . .	63
6.3.2. Brain and Central Nervous System (CNS) Tumors . . . . .	64
6.4. General Conclusions on the Status of Understanding of the ELF Fields-Cancer Association . . . . .	65
<b>Section 7. General Conclusions About Biological Effects of ELF Fields and Their Implication . . . . .</b>	<b>67</b>
7.1. Central Nervous System Effects . . . . .	67
7.2. Cancer Promotion . . . . .	67
<b>Section 8. Major Programs and Funding Levels for ELF Bioeffects Research . . . . .</b>	<b>69</b>
<b>Section 9. Regulatory Activity and Exposure Standards . . . . .</b>	<b>73</b>
<b>Section 10. Policy Implications . . . . .</b>	<b>75</b>
10.1. Policy Alternatives . . . . .	76
10.2. Strategies for Research . . . . .	80
<b>References . . . . .</b>	<b>82</b>
<b>Endnotes . . . . .</b>	<b>95</b>