

Contents

Foreword	vii
Acknowledgements	viii
1. General principles	1
Introduction	1
PART I. Biosafety guidelines	5
2. Microbiological risk assessment	7
Specimens for which there is limited information	8
Risk assessment and genetically modified microorganisms	8
3. Basic laboratories – Biosafety Levels 1 and 2	9
Code of practice	9
Laboratory design and facilities	12
Laboratory equipment	14
Health and medical surveillance	16
Training	16
Waste handling	17
Chemical, fire, electrical, radiation and equipment safety	19
4. The containment laboratory – Biosafety Level 3	20
Code of practice	20
Laboratory design and facilities	21
Laboratory equipment	22
Health and medical surveillance	22
5. The maximum containment laboratory – Biosafety Level 4	25
Code of practice	25
Laboratory design and facilities	25
6. Laboratory animal facilities	28
Animal facility – Biosafety Level 1	29
Animal facility – Biosafety Level 2	29
Animal facility – Biosafety Level 3	30
Animal facility – Biosafety Level 4	31
Invertebrates	32
7. Guidelines for laboratory/facility commissioning	33
8. Guidelines for laboratory/facility certification	36

PART II. Laboratory biosecurity	45
9. Laboratory biosecurity concepts	47
PART III. Laboratory equipment	49
10. Biological safety cabinets	51
Class I biological safety cabinet	51
Class II biological safety cabinets	53
Class III biological safety cabinet	56
Biological safety cabinet air connections	56
Selection of a biological safety cabinet	57
Using biological safety cabinets in the laboratory	57
11. Safety equipment	61
Negative-pressure flexible-film isolators	61
Pipetting aids	63
Homogenizers, shakers, blenders and sonicators	63
Disposable transfer loops	64
Microincinerators	64
Personal protective equipment and clothing	64
PART IV. Good microbiological techniques	67
12. Laboratory techniques	69
Safe handling of specimens in the laboratory	69
Use of pipettes and pipetting aids	70
Avoiding the dispersal of infectious materials	70
Use of biological safety cabinets	70
Avoiding ingestion of infectious materials and contact with skin and eyes	71
Avoiding injection of infectious materials	71
Separation of serum	72
Use of centrifuges	72
Use of homogenizers, shakers, blenders and sonicators	73
Use of tissue grinders	73
Care and use of refrigerators and freezers	73
Opening of ampoules containing lyophilized infectious materials	74
Storage of ampoules containing infectious materials	74
Standard precautions with blood and other body fluids, tissues and excreta	74
Precautions with materials that may contain prions	76
13. Contingency plans and emergency procedures	78
Contingency plan	78
Emergency procedures for microbiological laboratories	79
14. Disinfection and sterilization	82
Definitions	82
Cleaning laboratory materials	83

CONTENTS

Chemical germicides	83
Local environmental decontamination	88
Decontamination of biological safety cabinets	89
Hand-washing/hand decontamination	90
Heat disinfection and sterilization	90
Incineration	92
Disposal	93
15. Introduction to the transport of infectious substances	94
International transport regulations	94
The basic triple packaging system	95
Spill clean-up procedure	95
PART V. Introduction to biotechnology	99
16. Biosafety and recombinant DNA technology	101
Biosafety considerations for biological expression systems	102
Biosafety considerations for expression vectors	102
Viral vectors for gene transfer	102
Transgenic and "knock-out" animals	102
Transgenic plants	103
Risk assessments for genetically modified organisms	103
Further considerations	104
PART VI. Chemical, fire and electrical safety	105
17. Hazardous chemicals	107
Routes of exposure	107
Storage of chemicals	107
General rules regarding chemical incompatibilities	107
Toxic effects of chemicals	107
Explosive chemicals	108
Chemical spills	108
Compressed and liquefied gases	109
18. Additional laboratory hazards	110
Fire hazards	110
Electrical hazards	111
Noise	111
Ionizing radiation	111
PART VII. Safety organization and training	115
19. The biosafety officer and biosafety committee	117
Biosafety officer	117
Biosafety committee	118

20. Safety for support staff	119
Engineering and building maintenance services	119
Cleaning (domestic) services	119
21. Training programmes	120
PART VIII. Safety checklist	123
22. Safety checklist	125
Laboratory premises	125
Storage facilities	125
Sanitation and staff facilities	126
Heating and ventilation	126
Lighting	126
Services	126
Laboratory biosecurity	127
Fire prevention and fire protection	127
Flammable liquid storage	128
Compressed and liquefied gases	128
Electrical hazards	128
Personal protection	129
Health and safety of staff	129
Laboratory equipment	130
Infectious materials	130
Chemicals and radioactive substances	130
PART IX. References, annexes and index	133
References	135
Annex 1 First aid	138
Annex 2 Immunization of staff	139
Annex 3 WHO Biosafety Collaborating Centres	140
Annex 4 Equipment safety	141
Equipment that may create a hazard	141
Annex 5 Chemicals: hazards and precautions	145
Index	170