

V. Anesthetic Machines	145	IV. Oversight, Planning, and Organization	224
VI. Ventilators	151	V. Monitoring and Intervention	226
VII. Induction Chambers and Masks	155	VI. Record Keeping	233
VIII. Injectable Anesthetic Delivery Systems	158	VII. Conclusions	233
IX. Equipment for Airway Access and Control	159	References	233
Additional Reading	167		
References	167		
Chapter 6 Monitoring of Anesthesia	171	Section III—Practical Anesthesia and Analgesia of Traditional Laboratory Animal Species	237
<i>Jennifer C. Smith and Peggy J. Danneman</i>			
I. Introduction	171	Chapter 10 Anesthesia and Analgesia for Laboratory Rodents	239
II. Monitoring of the Anesthetized Patient	172	<i>Diane J. Gaertner, Troy M. Hallman, F. Claire Hankenson, and Margaret A. Batchelder</i>	
III. Special Circumstances	180	I. Introduction	240
IV. Summary and Conclusions	181	II. Considerations in selection of Anesthetics for Rodents	245
Acknowledgement	181	III. General Anesthetic Plan	249
References	181	IV. Recommended Anesthetic Methods for Routine Use in Rodents	250
		V. Drugs Used as Adjuvants to Primary Anesthetic Agents	261
 		VI. Anesthetic Regimens Used for Special Purposes	265
Chapter 7 Waste Anesthetic Gas Safety	183	VII. Other Anesthetics	266
<i>Jennifer C. Smith</i>		VIII. Use of Neuromuscular Blocking Agents and Antagonists	266
I. Introduction	183	IX. Analgesics for mice and rats	268
II. Potential Health Effects	185	X. Anesthesia and Analgesia in Neonatal Mice and Rats	277
III. Sources of Waste Anesthetic Gas	187	XI. Special Considerations for Postprocedural Monitoring of Rodents	278
IV. Evacuation of WAG	188	XII. Other Rodents, Including Guinea Pigs, Hamsters, and Gerbils	279
V. Risk Assessment and Mitigation	189	References	282
VI. Summary and Conclusions	192		
References	192		
Chapter 8 Strategies for Assessing and Minimizing Pain	195	Chapter 11 Anesthesia and Analgesia in Rabbits	299
<i>Alicia Z. Karas, Peggy J. Danneman, and Joan Cadillac</i>		<i>Neil S. Lipman, Robert P. Marini, and Paul A. Flecknell</i>	
I. Introduction	195	I. Introduction	300
II. Why Prevent Pain?	196	II. Preoperative Considerations	300
III. Preprocedural Considerations: Predicting and Preventing Pain	199	III. Methods of Delivery/Administration	306
IV. Postprocedural Considerations: Recognizing and Monitoring Pain	206	IV. Parenteral Techniques	310
V. Summary	213	V. Inhalation Anesthesia	317
References	213	VI. Regional Anesthesia	319
		VII. Special Anesthetic Considerations	320
 		VIII. Intraoperative Support and Monitoring	321
Chapter 9 Postprocedural Care of Commonly Utilized Research Animal Subjects	219	IX. Postoperative Considerations	323
<i>Victoria A. Hampshire and Judith A. Davis</i>		X. Analgesia	324
I. Introduction	219	References	327
II. Recruitment and Organization of Space	220		
III. Staffing and Personnel	223		

Chapter 12 Anesthesia and Analgesia in Nonhuman Primates	335
<i>Sulli J. Popilskis, Donald R. Lee, and David B. Elmore</i>	
I. Introduction	336
II. Preanesthetic Considerations	336
III. Anesthetic Delivery and Techniques	337
IV. Anticholinergic Drugs	340
V. Parenteral Anesthetics	340
VI. Inhalational Anesthesia	348
VII. Intraoperative Monitoring	351
VIII. Intraoperative Support	352
IX. Special Anesthetic Considerations	353
X. Postoperative Care	357
XI. Analgesia	358
References	360
Personal Communications	363

Chapter 13 Anesthesia and Analgesia in Dogs and Cats	365
<i>Elizabeth Armitage-Chan</i>	
I. Introduction	366
II. Preanesthetic Considerations	366
III. Anesthetic Techniques	368
IV. Preanesthetic Medications	370
V. Induction of Anesthesia	372
VI. Anesthetic Maintenance	374
VII. Monitoring	375
VIII. Supportive Care	376
IX. Recovery	377
X. Analgesia	377
XI. Specific Considerations	380
Suggested Additional Reading	383
References	383

Chapter 14 Anesthesia and Analgesia of Ruminants	385
<i>Alexander Valverde and Thomas J. Doherty</i>	
I. Introduction	386
II. Physiological and Anatomical Considerations	386
III. Premedication	389
IV. Induction	395
V. General Anesthesia	398
VI. Local and Regional Anesthesia	401
VII. Anesthesia for Husbandry Procedures	404
VIII. Monitoring the Anesthetized Patient	405
IX. Intraoperative Support	407
X. Analgesia	407
References	408

Chapter 15 Anesthesia and Analgesia in Swine	413
<i>Alison C. Smith and M. Michael Swindle</i>	
I. Introduction	414
II. Breed, Anatomic, and Physiologic Characteristics	414
III. Anesthetic Delivery	415
IV. Inhalational Anesthesia	417
V. Injectable Anesthetics and Tranquilizers	419
VI. Regional Analgesia	422
VII. Analgesia	423
VIII. Intraoperative Monitoring and Support	423
IX. Cardiac Arrhythmias	424
X. Support	424
XI. Postsurgical Care	425
XII. Special Anesthetic Considerations	425
XIII. Cardiopulmonary Bypass	426
XIV. Summary and Additional Reference Material	431
Appendix Tables	432
A1: Dissociative Anesthetics and Combinations	432
A2: Tranquilizers, Hypnotics, and Sedatives	433
A3: Miscellaneous Anesthetic and Perioperative Drugs	434
A4: NSAID and Opioid Analgesics	434
A5: Protocol for Routine Surgery without Physiologic Measurements	435
A6: Protocol for Nonsurvival Teaching Laboratories	435
A7: Opioid Infusion Protocol for Cardiopulmonary Bypass with Cardiac Compromise	435
References	436
Section IV—Practical Anesthesia and Analgesia of Nontraditional Laboratory Animal Species	441
Chapter 16 Anesthesia and Analgesia in Ferrets	443
<i>Jeff Ko and Robert P. Marini</i>	
I. Introduction	443
II. Preanesthetic Considerations	444
III. Anesthetic Techniques	444
IV. Preanesthesia: Sedative and Analgesic Drugs in Ferrets	445
V. Anesthetic Induction and Maintenance	449
VI. Monitoring Techniques	452
VII. Recovery and Pain Management	453
VIII. Special Considerations	454
IX. Authors' Preferences	454
References	455
Additional Reading	456
Chapter 17 Anesthesia and Analgesia in Other Mammals	457
<i>Jeff Wyatt</i>	
I. Marsupialia: Marsupials	458
II. Scandentia and Insectivora: Insectivores	459

III. Rodentia: Nontraditional Species of Laboratory Rodents	462	IV. Anesthetic Techniques	513
IV. Lagomorpha: Pikas, Hares	470	V. Physical Restraint and Handling	514
V. Xenarthra: Edentates (Armadillos)	471	VI. Routes of Drug Administration	514
VI. Chiroptera: Bats	472	VII. Immersion Anesthesia	514
VII. Carnivora: Bears, Hyena	473	VIII. Volatile Anesthesia	515
VIII. Prosimii: Gray Mouse Lemur	475	IX. Injectable Anesthesia	516
References	475	X. Topical/Regional Anesthesia	516
		XI. Preanesthesia/Anesthetic Induction	516
		XII. Anesthetic Maintenance and Monitoring	516
		XIII. Recovery	516
Chapter 18 Anesthesia and Analgesia in Birds	481	XIV. Pain Management/Analgesia	517
<i>John W. Ludders</i>		XV. Field Anesthesia	517
I. Introduction	481	XVI. Larval Anesthesia	517
II. The Pulmonary System: Form, Function, and Implications for Anesthetic Management	483	References	518
III. Specific Considerations for Anesthesia	489		
IV. Euthanasia of Birds	496	Chapter 21 Anesthesia and Restraint of Laboratory Fish	519
V. Recommended Reading	497	<i>Michael Stoskopf and Lysa Pam Posner</i>	
References	497	I. Introduction	519
		II. Fish and Pain	520
Chapter 19 Anesthesia and Analgesia in Reptiles	501	III. Physical Restraint of Fish	520
<i>Dorcas P. O'Rourke and Audrey L. Jenkins</i>		IV. Basic Principles and Application of Anesthesia in Fish	521
I. Introduction	501	V. Monitoring	522
II. General Considerations	501	VI. Anesthetic Agents	523
III. Preanesthetic Evaluation and Preparation	503	VII. Analgesic Agents	531
IV. Anesthetic Techniques	503	VIII. Nonchemical Methods	531
V. Physical Restraint and Handling	503	IX. Euthanasia in Fish	532
VI. Anesthesia of Venomous Species	503	References	533
VII. Routes of Drug Administration	505		
VIII. Inhalant Anesthesia	505	Chapter 22 Anesthesia and Analgesia of Invertebrates	535
IX. Injectable Anesthesia	506	<i>Cornelia Gunkel and Gregory A. Lewbart</i>	
X. Local/Regional Anesthesia	506	I. Introduction	535
XI. Total Intravenous Anesthesia	506	II. Anesthesia	536
XII. Neuromuscular Blocking Agents	506	III. Pain and Analgesia in Invertebrates	542
XIII. Preanesthesia	506	IV. Euthanasia	542
XIV. Anesthetic Induction	507	References	543
XV. Anesthetic Maintenance	507		
XVI. Monitoring	508	Section V—Special Topics in Anesthesia and Analgesia of Laboratory Animals	547
XVII. Recovery	508		
XVIII. Pain Management/Analgesia	508	Chapter 23 Pain Testing in the Laboratory Mouse	549
XIX. Prolonged/Repeated Anesthesia	508	<i>Dale J. Langford and Jeffrey S. Mogil</i>	
References	509	I. Introduction	549
		II. Experimental Models of Acute/Tonic Pain	550
Chapter 20 Anesthesia and Analgesia in Amphibians	511	III. Experimental Models of Chronic Pain	554
<i>Dorcas P. O'Rourke and Audrey L. Jenkins</i>		IV. Modulating Factors	556
I. Introduction	511	V. New Directions in Animal Pain Testing	557
II. General Considerations	511	References	557
III. Preanesthetic Evaluation and Preparation	512		

Chapter 24 Ethical Issues in Anesthesia and Analgesia in Laboratory Animals	561	VIII. Prevention of Post-Operative Pre-Term Labour	601
<i>Larry Carbone and Nelson Garnett</i>		IX. Functional Maturity of Key Organ Systems in Newborn Animals	601
I. Introduction	561	X. Anaesthesia of Neonatal Animals	602
II. Ethical Issues in Laboratory Animal Anesthesia, Analgesia, and Pain Management	564	XI. Supportive Measures During Neonatal Anaesthesia	603
Additional Reading	567	XII. Post-Operative Period	604
References	567	XIII. Neonatal Analgesia	604
		XIV. Concluding Comments	605
		References	606
Chapter 25 Regulatory Issues	569	Chapter 28 Novel Delivery Systems for Analgesic Drugs in Laboratory Animals	609
<i>Laura A. Conour, Sonja T. Chou, and Lynn C. Anderson</i>		<i>Lisa Krugner-Higby, Lesley J. Smith, and Timothy D. Heath</i>	
I. Introduction	569	I. Introduction	609
II. US Animal Welfare Regulations, Policies, and Standards	570	II. Other Approaches to Analgesic Drug Delivery in Laboratory Animals	611
III. Drug Enforcement Regulations and Policies	573	III. Conclusion	616
IV. Occupational Health and Safety Considerations	576	References	616
V. International Considerations	577		
References	579		
Chapter 26 Management of Chronic Pain	581	Chapter 29 Nonpharmacologic Pain Control	619
<i>George J. DeMarco</i>		<i>Sara Savage</i>	
I. Introduction	581	I. Introduction	619
II. Diagnosis	583	II. Preventative Strategies	620
III. Treatment	585	III. Nonpharmacologic Interventions	622
References	588	IV. Summary and Future Scope	627
		References	627
Chapter 27 Anaesthesia and Analgesia in the Foetus and Neonate	593	Chapter 30 Anesthetic Considerations for In Vivo Imaging Studies	629
<i>J.C. Murrell, D.J. Mellor, and C.B. Johnson</i>		<i>Anthony Nicholson and Brenda Klaunberg</i>	
I. Introduction	594	I. Introduction	629
II. Is the Foetus Conscious?	594	II. Imaging Modalities	630
III. Does Foetal Unconsciousness Persist During Noxious Interventions?	596	III. Anesthetic Considerations	633
IV. Does Noxious Stimulation Activate the Foetal Stress Response?	597	IV. Imaging-Specific Considerations	636
V. Might Noxious Stimulation of the Foetus Cause Long-Term Changes in Pain Processing?	597	V. Anesthesia	636
VI. Anaesthesia of the Dam for Foetal Surgery	598	References	637
VII. Epidural Analgesia/Anaesthesia	600	Index	641

Chapter 24 Ethical Issues in Anesthesia and Analgesia in Laboratory Animals	561	VIII. Prevention of Post-Operative Pre-Term Labour	601
<i>Larry Carbone and Nelson Garnett</i>		IX. Functional Maturity of Key Organ Systems in Newborn Animals	601
I. Introduction	561	X. Anaesthesia of Neonatal Animals	602
II. Ethical Issues in Laboratory Animal Anesthesia, Analgesia, and Pain Management	564	XI. Supportive Measures During Neonatal Anaesthesia	603
Additional Reading	567	XII. Post-Operative Period	604
References	567	XIII. Neonatal Analgesia	604
		XIV. Concluding Comments	605
		References	606
Chapter 25 Regulatory Issues	569	Chapter 28 Novel Delivery Systems for Analgesic Drugs in Laboratory Animals	609
<i>Laura A. Conour, Sonja T. Chou, and Lynn C. Anderson</i>		<i>Lisa Krugner-Higby, Lesley J. Smith, and Timothy D. Heath</i>	
I. Introduction	569	I. Introduction	609
II. US Animal Welfare Regulations, Policies, and Standards	570	II. Other Approaches to Analgesic Drug Delivery in Laboratory Animals	611
III. Drug Enforcement Regulations and Policies	573	III. Conclusion	616
IV. Occupational Health and Safety Considerations	576	References	616
V. International Considerations	577		
References	579	Chapter 29 Nonpharmacologic Pain Control	619
		<i>Sara Savage</i>	
Chapter 26 Management of Chronic Pain	581	I. Introduction	619
<i>George J. DeMarco</i>		II. Preventative Strategies	620
I. Introduction	581	III. Nonpharmacologic Interventions	622
II. Diagnosis	583	IV. Summary and Future Scope	627
III. Treatment	585	References	627
References	588		
		Chapter 30 Anesthetic Considerations for In Vivo Imaging Studies	629
Chapter 27 Anaesthesia and Analgesia in the Foetus and Neonate	593	<i>Anthony Nicholson and Brenda Klaunberg</i>	
<i>J.C. Murrell, D.J. Mellor, and C.B. Johnson</i>		I. Introduction	629
I. Introduction	594	II. Imaging Modalities	630
II. Is the Foetus Conscious?	594	III. Anesthetic Considerations	633
III. Does Foetal Unconsciousness Persist During Noxious Interventions?	596	IV. Imaging-Specific Considerations	636
IV. Does Noxious Stimulation Activate the Foetal Stress Response?	597	V. Anesthesia	636
V. Might Noxious Stimulation of the Foetus Cause Long-Term Changes in Pain Processing?	597	References	637
VI. Anaesthesia of the Dam for Foetal Surgery	598		
VII. Epidural Analgesia/Anaesthesia	600	Index	641