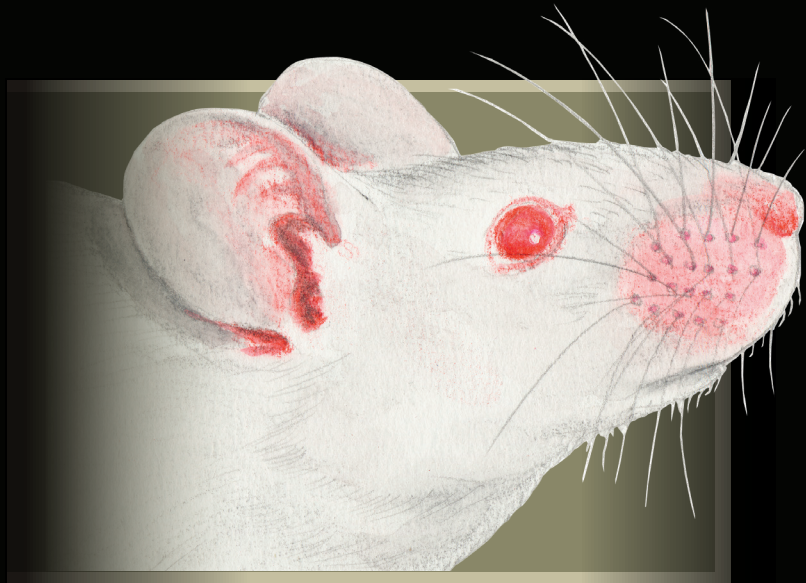


COMPARATIVE ANATOMY OF THE MOUSE AND THE RAT A COLOR ATLAS AND TEXT

ILLUSTRATIONS AND TEXT BY
GHEORGHE M. CONSTANTINESCU, DVM, PHD, DVM, PHD, MULT. DRHC.



AMERICAN ASSOCIATION FOR LABORATORY ANIMAL SCIENCE

COMPARATIVE ANATOMY
OF THE MOUSE AND THE RAT
A COLOR ATLAS AND TEXT

COMPARATIVE ANATOMY OF THE MOUSE AND THE RAT A COLOR ATLAS AND TEXT

ILLUSTRATIONS AND TEXT

GHEORGHE M CONSTANTINESCU, DVM, PHD, MULT. DRHC

SCIENTIFIC EDITOR AND CONTRIBUTOR

NICOLE DUFFEE, DVM, PHD

CONTRIBUTOR

CYNTHIA BESCH-WILLIFORD, DVM, PHD, DACLAM

REVIEWERS

LYNDA LANNING, DVM, DABT

TRACY GLUCKMAN, MS, DVM, DACLAM

MARK HOENERHOFF, DVM, PHD, DACVP

JULIE WATSON, MA, VETMB, DACLAM

GRAPHIC DESIGN AND LAYOUT

AMY B TIPPETT, BFA

EDITORIAL ASSISTANCE

NICOLE BROWN, MA

MELISSA BAGAGLIO, BS

PAMELA GRABEEL, MA

Table of Contents

Acknowledgments	viii
Preface	ix
Nomenclature and Abbreviations	xi
Body Regions	1
Figure 1. Body regions (lateral aspect), shown in the male rat.....	2
Figure 2. Body regions (ventral aspect), shown in the male rat.....	3
Figure 3. Female reproductive landmarks (ventral aspect), shown in the rat.....	4
Figure 4. Facial regions of the head (lateral aspect), shown in the rat.....	5
Figure 5. Landmarks for access to cervicothoracic vessels (ventral aspect), shown in the rat.....	6
Juvenile Features and Sex Differentiation	9
Figure 6A. Mouse. Neonate, albino (lateral aspect), age less than 24 hours, after feeding.....	10
Figure 6B. Rat. Neonate, albino (lateral aspect), age less than 24 hours, after feeding.....	11
Figure 7A. Mouse. Sexing juveniles, albino (perineal aspect), 5 th day of age.....	14
Figure 7B. Rat. Sexing juveniles, albino (perineal aspect), 5 th day of age.....	15
Figure 8A. Mouse. Sexing juveniles, agouti (perineal aspect), 11 th day of age.....	18
Figure 8B. Rat. Sexing juveniles, albino (positioned with head down, perineal aspect), 11 th day of age.....	19
Figure 8C. Rat. Sexing juveniles, albino (positioned with head up, perineal aspect), 11 th day of age.....	20
Figure 9A. Mouse. Sexing juveniles (perineal aspect), 21 st day of age.....	24
Figure 9B. Rat. Sexing juveniles (perineal aspect), 21 st day of age.....	25
Figure 10A. Mouse. Sexing adults (perineal aspect).....	28
Figure 10B. Rat. Sexing adults (perineal aspect).....	29
External Features	33
Figure 11A. Mouse. Male adult (dorsal aspect).....	34
Figure 11B. Rat. Male adult (dorsal aspect).....	35
Figure 12A. Mouse. Male adult (ventral aspect).....	38
Figure 12B. Rat. Male adult (ventral aspect).....	39
Figure 13A. Mouse. Female adult (ventral aspect).....	42
Figure 13B. Rat. Female adult (ventral aspect).....	43
Figure 14A. Mouse. Feet (palmar and plantar aspects).....	46
Figure 14B. Rat. Feet (palmar and plantar aspects).....	47
Mammary Glands	51
Figure 15A. Mouse. Mammary glands in lateral, ventral, and dorsal aspects.....	52
Figure 15B. Rat. Mammary glands in lateral and ventral aspects.....	53
Structures of the Head and Neck	57
Figure 16A. Mouse. Head, facial (lateral aspect), showing vibrissae.....	58
Figure 16B. Rat. Head, facial (lateral aspect), showing vibrissae.....	59
Figure 17A. Mouse. Head, lacrimal and salivary glands (lateral aspect).....	62
Figure 17B. Rat. Head, lacrimal and salivary glands (lateral aspect).....	63
Figure 18A. Mouse. Orbital veins and venous plexus (lateral aspect).....	66
Figure 18B. Rat. Orbital veins and venous plexus (lateral aspect).....	67
Figure 19A. Mouse. Brain with arterial and venous vasculature (dorsal aspect).....	70
Figure 19B. Rat. Brain with arterial and venous vasculature (dorsal aspect).....	71
Figure 20A. Mouse. Brain with arterial vasculature (ventral aspect).....	74
Figure 20B. Rat. Brain with arterial vasculature (ventral aspect).....	75
Figure 21A. Mouse. Brain with arterial vasculature (left lateral aspect).....	78
Figure 21B. Rat. Brain with arterial vasculature (left lateral aspect).....	79
Comparative Anatomy of the Mouse and the Rat	v

Figure 22A. Mouse. Brain (median section).....	82
Figure 22B. Rat. Brain (median section).....	83
Figure 23A. Mouse. Head (median section).....	86
Figure 23B. Rat. Head (median section).....	87
Figure 24A. Mouse. Pharynx (rostral aspect from the open mouth).....	90
Figure 24B. Rat. Pharynx (rostral aspect from the open mouth).....	91
Figure 25A. Mouse. Head and neck to upper thorax, including the heart and great vessels (ventral aspect).....	94
Figure 25B. Rat. Head and neck to upper thorax, including the heart and great vessels (ventral aspect).....	95
Heart, Vascular Tree, and Respiratory Tract	99
Figure 26A. Mouse. Projection of the thoracic viscera (left aspect).....	100
Figure 26B. Rat. Projection of the thoracic viscera (left aspect).....	101
Figure 27A. Mouse. Projection of the rib cage and the thoracic viscera (left aspect).....	104
Figure 27B. Rat. Projection of the rib cage and the thoracic viscera (left aspect).....	105
Figure 28A. Mouse. Projection of the thoracic viscera (right aspect).....	108
Figure 28B. Rat. Projection of the thoracic viscera (right aspect).....	109
Figure 29A. Mouse. Projection of the rib cage and the thoracic viscera (right aspect).....	112
Figure 29B. Rat. Projection of the rib cage and the thoracic viscera (right aspect).....	113
Figure 30A. Mouse. Projection of the thoracic viscera (ventral aspect).....	116
Figure 30B. Rat. Projection of the thoracic viscera (ventral aspect).....	117
Figure 31A. Mouse. Projection of the rib cage and thoracic viscera (ventral aspect).....	120
Figure 31B. Rat. Projection of the rib cage and thoracic viscera (ventral aspect).....	121
Figure 32A. Mouse. Topography of the heart in situ (left aspect).....	124
Figure 32B. Rat. Topography of the heart in situ (left aspect).....	125
Figure 33A. Mouse. Topography of the heart in situ (right aspect).....	128
Figure 33B. Rat. Topography of the heart in situ (right aspect).....	129
Figure 34A. Mouse. Heart (atrial and auricular aspects).....	132
Figure 34B. Rat. Heart (atrial and auricular aspects).....	133
Figure 35A. Mouse. Heart in situ (ventral aspect) and reflected cranially (dorsal aspect).....	136
Figure 35B. Rat. Heart in situ (ventral aspect) and reflected cranially (dorsal aspect).....	137
Figure 36. Longitudinal section through the heart (atrial aspect), semi-schematic.....	140
Figure 37A. Mouse. Cervicothoracic organs (ventral aspect).....	142
Figure 37B. Rat. Cervicothoracic organs (ventral aspect).....	143
Figure 38A. Mouse. Heart and vascular tree (ventral aspect).....	146
Figure 38B. Rat. Heart and vascular tree (ventral aspect).....	147
Abdominal Structures	151
Figure 39A. Mouse, male. Abdominal topography (left aspect).....	152
Figure 39B. Rat, female. Abdominal topography (left aspect).....	153
Figure 40A. Mouse, male. Abdominal topography (right aspect).....	156
Figure 40B. Rat, female. Abdominal topography (right aspect).....	157
Figure 41A. Mouse, female. Abdominal topography (ventral aspect).....	160
Figure 41B. Rat, female. Abdominal topography (ventral aspect).....	161
Figure 42A. Mouse, female. Liver, stomach, and intestines (ventral aspect), intestines displaced.....	164
Figure 42B. Rat, male. Liver, stomach, and intestines (ventral aspect), intestines displaced.....	165
Figure 43A. Mouse. Upper abdominal structures (ventral aspect), liver reflected cranially.....	168
Figure 43B. Rat. Upper abdominal structures (ventral aspect), liver reflected cranially.....	169
Figure 44A. Mouse. Stomach, distal esophagus, and proximal duodenum (internal aspect). Left, median section through the long axis. Right, section through the major curvature.....	172

Figure 44B. Rat. Stomach, distal esophagus, and proximal duodenum (internal aspect). Left, median section through the long axis.	
Right, section through the major curvature.	173
Figure 45A. Mouse. Parietal lymph nodes of the roof of the abdominal cavity (ventral aspect).	176
Figure 45B. Rat. Parietal lymph nodes of the roof of the abdominal cavity (ventral aspect).	177
Male Urogenital Apparatus	181
Figure 46A. Mouse. Male caudal abdominal and pelvic viscera including the testicle (left lateral aspect).	182
Figure 46B. Rat. Male caudal abdominal and pelvic viscera including the testicle (left lateral aspect).	183
Figure 47A. Mouse. Male reproductive and urinary apparatus (ventral aspect).	186
Figure 47B. Rat. Male reproductive and urinary apparatus (ventral aspect).	187
Figure 48A. Mouse. Testicle, epididymis, and spermatic cord (left lateral aspect).	190
Figure 48B. Rat. Testicle, epididymis, and spermatic cord (left lateral aspect).	191
Figure 49A. Mouse. Testicle, epididymis, and spermatic cord (right medial aspect).	194
Figure 49B. Rat. Testicle, epididymis, and spermatic cord (right medial aspect).	195
Figure 50A. Mouse. Penis, reflected caudally (dorsal aspect).	198
Figure 50B. Rat. Penis, reflected caudally (dorsal aspect).	199
Figure 51A. Mouse. Proximal urethra and urethral recess (dorsal aspect, positioned with head up), median section through urethral recess.	202
Figure 51B. Mouse. Latex cast of pelvic urethra (lateral aspect, positioned with head to the left).	203
Figure 51C. Mouse. Latex cast of pelvic urethra (dorsal aspect, positioned with head to the left).	204
Figure 51D. Rat. Proximal urethra and related structures (median section, positioned with head to the left).	205
Figure 52A. Mouse. Penis (median section), stained by hematoxylin and eosin.	208
Figure 52B. Rat. Penis (median section), stained by hematoxylin and eosin.	209
Female Urogenital Apparatus	213
Figure 53A. Mouse. Female caudal abdominal and pelvic viscera (left lateral aspect).	214
Figure 53B. Rat. Female caudal abdominal and pelvic viscera (left lateral aspect).	215
Figure 54A. Mouse. Female reproductive and urinary apparatus (ventral aspect).	218
Figure 54B. Rat. Female reproductive and urinary apparatus (ventral aspect).	219
Figure 55A. Mouse. Round ligament of the uterus (ventral aspect).	222
Figure 55B. Rat. Round ligament of the uterus (ventral aspect).	223
Pelvic Limb Vessels and Nerves	227
Figure 56A. Mouse. Pelvic limb, left (lateral aspect).	228
Figure 56B. Rat. Pelvic limb, left (lateral aspect).	229
Figure 57A. Mouse. Pelvic limb, left (medial aspect).	232
Figure 57B. Rat. Pelvic limb, left (medial aspect).	233
Structures of the Tail	237
Figure 58A. Mouse. Base of the tail (cross section), stained by hematoxylin and eosin.	238
Figure 58B. Rat. Base of the tail (cross section), stained by hematoxylin and eosin.	239
Skeletal Structures	243
Figure 59A. Mouse. Skeleton (left lateral aspect).	244
Figure 59B. Rat. Skeleton (left lateral aspect).	245
Figure 60A. Mouse. Skull and details of teeth (left lateral aspect).	248
Figure 60B. Rat. Skull and details of teeth (left lateral aspect).	249
Bibliography	253
References	255
Index	257

Acknowledgments

The **Color Atlas and Text of Comparative Anatomy of the Mouse and the Rat** could not have been printed without the contribution of many specialists in the field.

Many thanks go to Dr. Beth Bauer, clinical assistant professor, for her contribution to identification of different strains of mice and rats; to senior research laboratory technician Bonita (Bo) Cowan, laboratory supervisor and histotechnologist Jill Gruenkemeyer, and histotechnologist Jan Adair for their contribution to processing the histological sections; and to Laurie Wisdom, laboratory supervisor, for providing hundreds of mouse and rat specimens from the necropsy room for dissection.

High appreciation and respect for her continuous help in identification of anatomical structures and in providing various information about the anatomy of these species go to my friend and colleague Dr. Cynthia (Cindy) Besch-Williford, associate professor, who was in constant contact with the author throughout the dissection of specimens and illustration of the anatomical structures of mice and rats as well as during the editing stage. Cindy's exceptional professional knowledge and expertise in the field of laboratory animals was very helpful.

All of the contributors listed above belong to the Research Animal Diagnostic and Investigative Laboratory (RADIL) of the Veterinary Pathobiology Department of the University of Missouri College of Veterinary Medicine.

Special thanks go to my friends and day-by-day contributors: medical photographer and senior multimedia specialist Howard Wilson and senior multimedia specialist Don Connor from the College of Veterinary Medicine of Missouri University in Columbia.

The author thanks wholeheartedly the review subcommittee: Dr. Lynda Lanning (also chair of the Educational Resources Committee), Dr. Tracy Gluckman, Dr. Mark Hoenerhoff, and Dr. Julie Watson, who spent hours in teleconferences coordinated by Dr. Nicole Duffee reviewing and suggesting improvements of the text accompanying the illustrations. As a result of these discussions, several more anatomical structures have been investigated and illustrated for both species.

Thanks also to the Educational Resources Committee for their continuous support and encouragements.

Sincere thanks and gratitude go to Dr. Ann Tourigny Turner, executive director of AALAS, for remaining in contact with us and following step by step the development of the atlas.

Many thanks to the AALAS staff for their editorial support: education manager Pam Grabeel, communications resource editor Nicole Brown, and editorial specialist Melissa Bagaglio.

Special thanks to Amy Tippett, freelance graphic designer, for her professional hard work and dedication to this project. She meticulously followed our directions, sometimes more than once for the same label, until all labels were updated and correctly added to the illustrations.

I am deeply grateful to, and have the highest appreciation for, Dr. Nicole Duffee, director of education and scientific affairs at AALAS. She is a respected and dear colleague and friend of mine, who orchestrated this atlas on the basis of two previous posters: *Anatomy of the Mouse* and *Anatomy of the Rat*. During a phone conversation, Nicole and I envisaged the opportunity to build up a comparative atlas of mouse and rat anatomy, extending and deepening the two posters and adding explanatory text for each figure. Through hundreds of email messages, and phone calls between Nicole and me, and teleconferences with the review subcommittee, we built the foundation of the atlas.

All my contributors merit a big round of applause.

And finally, I thank warmly my lovely wife, Dr. Ileana A. Constantinescu, for her unlimited support, understanding, encouragements, and above all her sacrifice throughout the development of this atlas.

The author is open for any suggestions, comments, or criticism, and kindly asks readers to send them to the AALAS office in care of Dr. Nicole Duffee.



Gheorghe M. Constantinescu
Professor of Veterinary Anatomy and Medical Illustrator
Professional Member of the Association of Medical Illustrators
College of Veterinary Medicine
University of Missouri-Columbia

Preface

Comparative Anatomy of the Mouse and Rat: a Color Atlas and Text was developed to provide detailed comparative anatomical information for those who work with mice and rats in animal research, mainly researchers and laboratory veterinary professionals. These individuals require information on the anatomical features and landmarks for conducting a physical examination, collecting biological samples, making injections of therapeutic and experimental materials, using imaging modalities, and performing surgeries. This atlas compares in these species the structures of the skeleton; the skull and teeth; the pharynx; the digestive, respiratory, and genitourinary organs; the heart and major blood vessels; the brain; the tail; and the major vessels and nerves of the pelvic limb. The nomenclature for regions of the body and the topography of thoracic and abdominal structures is shown in lateral and ventral views.

An important aspect of this atlas is the use of the veterinary anatomical nomenclature from the *Nomina Anatomica Veterinaria* (NAV), 5th edition, 2005.⁷ Anatomical terms are referenced in the Index, in which the page numbers refer to the labeled figures only, not the text corresponding to the figures.

In each set of illustrations, the same view is depicted in the mouse and the rat. Text is provided with all illustrations to draw attention to the anatomical features which are important for supporting the care and use of these animals in research. This work departs from a classical atlas illustrating all body systems and structures because its purpose is to provide the reader with essential information for research and clinical purposes and to describe structures that are not shown in any other anatomy atlas. For example, the muscles of the pelvic limb are deemphasized in transparency to depict the vessels and nerves used for common procedures such as injections and blood collection.

In the development of the figures, considerable emphasis was given to revealing the structures of the urogenital apparatus, particularly in the male. In both species, a median section of the penis, stained with hematoxylin and eosin, was prepared to show the corpus spongiosum glandis and the os penis (penis bone) in detail. This atlas includes a dorsal view of the internal genitalia, which is an unusual view in anatomical publications but quite valuable for developing an understanding of the glandular structures associated with the urethra, such as the coagulating gland, the vesicular gland, and the prostate gland. In the mouse, the urethra is incised to show the urethral fold over the fibro-cartilaginous plate in the urethral floor. A latex cast was prepared of the mouse pelvic urethra and the initial part of the penile urethra to highlight the urethral recess, the bulbourethral diverticulum, and the spatial relationship of the urethra with associated glands and ducts in the lateral and dorsal aspects of the urethral epithelium. In the rat, the proximal urethra and related structures are shown in a sagittal section to best illustrate the presence of a urethral recess, the opening of the bulbourethral gland, and the absence of a bulbourethral diverticulum. These differences add a new dimension to the knowledge of the comparative anatomy of these two species.

Multiple specimens were dissected to generalize the normal anatomical findings in each species. For example, abdominal organs can vary greatly in their location due to the animals' state of feeding and fasting. Therefore, body landmarks approximate, at best, organ positions in the abdomen. The illustrations provide a typical position for the organs, as determined over the multiple specimens used to prepare each figure.

In each set of illustrations, mice and rats are presented in the same size, so that comparative details in anatomy can be best appreciated. Anatomical information is generalized to the species, without regard to animal strain or stock. Albino animals were most commonly dissected: CD-1 or Swiss Webster mice and CD/SD or Wistar rats. Pigmented animals were used for some figures: C57BL/6 mice, agouti mice of a mixed background (F2 generation from B6C3F1 or B6D2F1 cross), and rats of a mixed background (cross of Sprague Dawley with either Long Evans or ACI).