

**GRIBBLE**

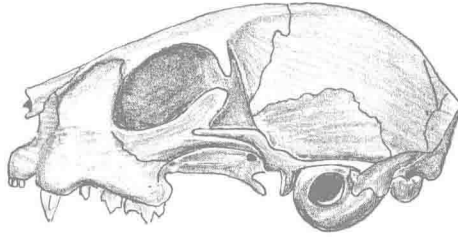
**COMPARATIVE**

**ANATOMY**

**LABORATORY**

**MANUAL**

**BLAKISTON**



# COMPARATIVE ANATOMY LABORATORY MANUAL

By LLOYD RAYMOND GRIBBLE, Ph.D.

Professor of Zoology, West Virginia University, Morgantown, W. Va.

*Illustrated*



*Published by The Blakiston Company, Philadelphia & Toronto*

---

1950

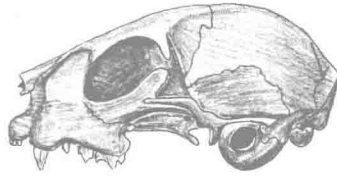
13.0 -  
8939

COPYRIGHT, 1950, BY THE BLAKISTON COMPANY

---

*This book is fully protected by copyright,  
and no part of it, with the exception of  
short quotations for review, may be repro-  
duced without the written consent of the  
publisher*

PRINTED IN THE UNITED STATES OF AMERICA  
BY REEHL LITHO. CO., INC., NEW YORK CITY



COMPARATIVE ANATOMY  
LABORATORY MANUAL

TO M. E. G. AND J. M. G.

## Preface

This manual is designed to serve as a guide in the dissection and comparative studies of the systems described. The original manuscript was completed several years ago and used as a guide by the students in a course in comparative vertebrate anatomy at West Virginia University. Since then the manual in its original form and subsequent revised editions have been in constant use.

Since the manual is intended primarily for student use, special care has been taken to present the facts in such a manner that they may be easily and clearly comprehended by the average student. During the years in which it has been used, wherever the descriptions have seemed vague or confusing to the student, an attempt has been made to revise and clarify the statements. Thus the manual in its present form represents the product of a gradual and constant evolutionary development in the direction of a more thorough and more adequate comprehension of the details of comparative anatomy by the student.

The fundamental purpose of a course in comparative vertebrate anatomy is to teach the anatomy of vertebrates and the relationships existing between the homologous structures in the forms studied. The writer believes that the comparative method is the ideal approach for the study of vertebrate anatomy, and consequently, in the preparation of this manual, this method of approach has been kept in view constantly. Since it may not be feasible to employ the comparative method in

some laboratories, an attempt has been made to describe each system of each form in such a way that the descriptive material may be used separately and independently. Thus any of the forms or independent systems of any given form may be used or omitted, at the discretion of the instructor.

In a course in comparative anatomy, emphasis should be placed upon the securing of an adequate knowledge of the principles of comparative anatomy, the formulation of procedures to aid in the development of that knowledge, and the achievement of accuracy in dissection techniques. Drawings are useful but not as an end in themselves. We have found unlabeled drawings useful as time-saving devices, as a reliable guide, and a convenient and dependable method of review. Therefore, a considerable number of representative unlabeled drawings have been included in the manual, but the use to be made of these drawings is left to the discretion of the instructor.

The descriptions given are based on dissections made either by the writer or by some of his colleagues. The osteological descriptions are based on skeletal material in the collections of the Department of Biology at West Virginia University. Each description given has been very carefully checked by observations and study of many specimens, extending over a period of years; also by comparison with the descriptions found in the standard texts dealing with comparative anat-

omy, the specific anatomical details of the different forms described, and human anatomy.

The various drawings depict the principal anatomical details seen in dissections made by the author, the artist, or by some of our colleagues, and features observed in other specimens available in the collections at West Virginia University. An attempt has been made to include a sufficient number of sketches to supply the student, after he has properly affixed all the appropriate and necessary labels, with a complete set of pictorial notes.

The chapter on anomalies and variations

represents a compilation of data obtained from observations on the cat during a period of 18 years. In reporting these variations, no priority claim is made nor intended, but it is hoped that the presentation of these modifications may give the student some idea of the possible frequency of their occurrence. This chapter is included to impress upon the student the necessity of making careful observations, and to remind him that in the study of any individual specimen certain details of structure may deviate somewhat from the descriptions given which represent the situation in a majority of specimens.

L. R. G.

## Acknowledgments

It is utterly impossible to acknowledge here all the numerous sources and individuals from whom help has been obtained in the preparation of this manual. However, the author especially desires to acknowledge with gratitude his indebtedness to the following: Professor P. J. Zuccherro of Kent State University, Mr. Harvey A. Martin and Professor James T. Handlan of Potomac State School of West Virginia University, and Professor George Hunt of Fairmont State College, who used the original manuscript in their classes and offered valuable criticisms and suggestions; President Paul R. Stewart of Waynesburg College, whose boundless enthusiasm and skillful teaching first kindled the interest of the writer in this subject; Professor A. S. Margolin of Phoenix College, who aided in the preparation of the original dissections and planned many original illustrations; Mr. Loyal H. Jones of Phoenix

College, who aided in the checking of the descriptions and offered valuable criticisms and suggestions; Professors L. H. Taylor and A. M. Reese of West Virginia University, and P. D. Strausbaugh, formerly of West Virginia University, for their interest, encouragement, and assistance; Dean W. P. Shortridge of West Virginia University, who gave permission to utilize the time required to carry on the research necessary for preparing the chapter on anomalies and variations; Dr. James B. Lackey, Mr. William F. Keller, Mr. William Brown McNett, and Miss Laura E. Moore of The Blakiston Company, for their many helpful suggestions and criticisms; Miss Gene Hope Smith of West Virginia University, who has made all of the drawings and aided in the reading of proof and checking of nomenclature, has my special thanks for her sincere devotion to these tasks.

L. R. G.



# Contents

Preface . . . . .	vii	FROG: Skull, 37.
Acknowledgments . . . . .	ix	ALLIGATOR: Skull, 38.
1. Amphioxus . . . . .	1	CHICKEN: Skull, 40.
2. Appendicular Skeleton . . . . .	7	CAT: Skull, 41; Bones of the Skull, 45; Joints of the Skull, 47; Foramens of the Skull, 48; Teeth, 49.
CARP: Pectoral Girdle, 7; Pectoral Fin, 7.		WOODCHUCK: Skull, 49; Teeth, 52.
FROG: Pectoral Girdle and Sternum, 7; Anterior Appendage, 7.		SHEEP: Skull, 52; Teeth, 54.
ALLIGATOR: Pectoral Girdle, 8; Anterior Appendage, 8.		VERTEBRAL COLUMN AND RIBS: Component Parts of a Typical Vertebra, 54; Shapes of Centra, 54; Ribs, 55.
PIGEON: Pectoral Girdle, 8; Anterior Appendage, 9.		DOGFISH: Vertebrae, 55; Ribs, 55.
BAT: Pectoral Girdle, 9; Anterior Appendage, 10.		CARP: Vertebrae, 55; Ribs, 56.
SEAL: Pectoral Girdle, 10; Anterior Appendage, 10.		FROG: Vertebrae, 56; Ribs, 56; Sternum, 56.
CAT: Pectoral Girdle, 12; Anterior Appendage, 12.		ALLIGATOR: Vertebrae, 56; Ribs, 57; Sternum, 57; Gastralia, 57.
SHEEP: Pectoral Girdle, 13; Anterior Appendage, 14.		CHICKEN: Vertebrae, 57; Ribs, 58; Sternum, 58.
CARP: Pelvic Girdle, 15; Pelvic Fins, 15.		CAT: Vertebrae, 58; Ribs, 60; Sternum, 60.
FROG: Pelvic Girdle, 15; Posterior Appendage, 16.		
ALLIGATOR: Pelvic Girdle, 16; Posterior Appendage, 16.		4. Muscles, Mammary Glands, Salivary Glands . . . . .
PIGEON: Pelvic Girdle, 17; Posterior Appendage, 17.		
BAT: Pelvic Girdle, 18; Posterior Appendage, 18.		73
SEAL: Pelvic Girdle, 18; Posterior Appendage, 18.		AMPHIOXUS: Muscles, 73.
CAT: Pelvic Girdle, 19; Posterior Appendage, 20.		DOGFISH: Muscles, 73.
SHEEP: Pelvic Girdle, 21; Posterior Appendage, 21.		FROG: Muscular System, 73.
3. Axial Skeleton . . . . .	35	CAT: Mammary Glands, 77; Salivary Glands, 77; Muscles, 78.
DOGFISH: Skull, 35.		5. Digestive System, Hepatic Portal System, and the Peritoneum . . . . .
CARP: Skull, 36.		
		111
		DOGFISH: Digestive System, 111; Hepatic Portal System, 112.
		NECTURUS: Digestive System, 113; Hepatic Portal System, 114.
		FROG: Hepatic Portal System, 114.
		TURTLE: Digestive System, 115; Hepatic Portal System, 116.
		PIGEON: Digestive System, 116; Hepatic Portal System, 117.

CAT: Digestive System, 118; Hepatic Portal System, 119; Abdominal Cavity and Peritoneum, 120.	<b>8. Respiratory System . . . . . 165</b>
<b>6. Urogenital and Renal Portal Systems . 125</b>	DOGFISH, 165.
DOGFISH: Kidneys, 125; Urogenital System of the Male, 125; Urogenital System of the Female, 125; Renal Portal System, 126.	NECTURUS, 165.
NECTURUS: Kidneys, 126; Urogenital System of the Male, 126; Urogenital System of the Female, 127; Renal Portal System, 127.	TURTLE, 166.
FROG: Renal Portal System, 127.	PIGEON, 166.
TURTLE: Cloaca, 128; Urinary Bladder, 128; Genital System of the Male, 128; Genital System of the Female, 128; Kidneys and Urinary Ducts, 128; Renal Portal System, 129.	CAT: Tongue, 167; Mouth, 167; Pharynx, 167; Hyoid Bone, 167; Larynx, 168; Trachea, 168; Bronchi, 168; Lungs, 168; Thyroid Gland, 168; Thoracic Cavity and Pleura, 169; Thymus, 169.
PIGEON: Cloaca, 129; Kidney and Urinary Duct, 129; Genital System of the Male, 129; Genital System of the Female, 129; Renal Portal System, 130.	<b>9. Nervous System . . . . . 173</b>
CAT: Urinary System, 130; Genital System of the Male, 130; Genital System of the Female, 131; Kidney Section, 132.	DOGFISH: Brain, 173.
<b>7. Circulatory System . . . . . 135</b>	FROG: Central Nervous System, 175; Peripheral Nervous System, 177; Spinal and Sympathetic Nerves, 177.
DOGFISH: Heart, 135; Arteries, 135; Veins, 138; Inner Structure of the Heart, 139.	NECTURUS: Brain, 178.
NECTURUS: Heart, 139; Arteries, 139; Veins, 140; Inner Structure of the Heart, 141.	TURTLE: Brain, 180.
FROG: Heart, 142; Arteries, 142; Veins, 143; Inner Structure of the Heart, 143.	CHICKEN: Brain, 182.
TURTLE: Heart, 144; Arteries, 144; Veins, 145; Inner Structure of the Heart, 146.	SHEEP: Brain, 184.
PIGEON: Heart, 146; Arteries, 146; Veins, 148; Inner Structure of the Heart, 148.	CAT: Meninges, 189; Spinal Nerves, 189; Sympathetic Nerves, 193; Spinal Cord, 193.
CAT: Heart, 149; Arteries, 149; Veins, 156; Pulmonary Circulation, 158; Inner Structure of the Heart, 158; Fate of Aortic Arches, 159.	SENSE ORGANS: 194; Olfactory Organ, 194; Ear, 194; Eye, 196; Gustatory Organs, 199; Motor Nerve Endings, 199.
	<b>10. Anomalies and Variations in the Cat 207</b>
	TYPES AND FREQUENCY: Medial Sacral Vein, 207; Common Iliac Vein, 207; Persistent Posterior Cardinal Veins, 208; Inferior Vena Cava and Tributaries, 209; Hepatic Portal Vein and Tributaries, 211; Superior Vena Cava and Tributaries, 211; Aorta and Its Branches, 212; Innominate Artery, 214; Subclavian Artery, 214; Common Carotid Artery, 215; Abnormal Kidneys, 215; Alimentary Canal, 215; Pancreatic Duct, 215; Gallbladder, 215; Great Omentum, 215; Digits, 216; Bilateral Reversal of Organs, 216.

## Amphioxus

Those students who have not made a complete study of *Amphioxus* should do so as this animal exhibits the primary chordate characteristics in an elementary form. Any student who does not have the characteristics of *Amphioxus* well in mind should spend some time studying them.

**Gross Anatomy.** The body of *Amphioxus* is elongated, laterally compressed, and pointed at both ends. Along the dorsal surface there is a median fold of skin forming the *dorsal fin*. This fold is extended around the tail region as the *caudal fin* and is continued ventrally through the posterior third of the body as the *ventral fin*.

Anteriorly the head region overhangs as the *oral hood*. This structure is formed by the anterior extension of the dorsal portion of the body over the ventral portion. The edge of this hood bears 22 processes, the *buccal cirri*. In the center of the oral hood is an opening known as the *buccal opening*, which is completely surrounded by the buccal cirri.

Two lateral *metapleural folds* extend, on the ventral side, from the oral hood to the anterior end of the ventral fin. Notice a median ventral opening, the *atriopore*, at the junction of the metapleural folds and the ventral fin and an opening, the *anus*, about midway between the atriopore and the posterior end of the body.

The body wall is divided into 62 V-shaped muscle segments, the *myotomes*. These are

separated from each other by septums of connective tissue, the *myocommas*.

Study a cleared and stained specimen that has been mounted for microscopic examination. Notice the buccal opening into a space known as the *buccal cavity* which in turn leads into the *pharynx*.

The pharynx is much wider than the buccal cavity. A muscular diaphragm, the *velum*, separates the two. The center of the velum is pierced by a small opening, the *mouth*. Twelve projections, the *velar tentacles*, extend anteriorly from the velum into the buccal cavity and form a fringe around the mouth. The pharynx is attached dorsally and hangs down into a cavity known as the *atrium*. The wall of the pharynx is composed of solid portions, the *gill bars*, separated from each other by open spaces or *gill clefts*. The pharynx opens posteriorly into a long *intestine* which passes posteriad to the *anus*. Attached to the junction of the pharynx and the intestine there is a diverticulum, the *liver*, which projects anteriorly into the atrium on the right side of the pharynx.

Dorsal to the pharynx and intestine there is a conspicuous rod, the *notochord*, which extends throughout the entire length of the body. A *nerve cord* almost as long as the notochord lies just dorsal to it. A large dark spot, the *eyespot*, is found on the anterior end of the nerve cord; other smaller dark spots, the *pigment spots*, are found along its entire length.

Just dorsal to the nerve cord appears a nar-

row region characterized by the presence of diagonal lines. This is a portion of the body wall; the lines are *myocommas*; and the region between any two of the lines is a *myotome*.

Dorsal to the region of nerve cord and notochord are markings similar to rectangular blocks arranged serially. This marking defines the *fin rays* or the supporting structure for the fin. The dorsal fin lies above the region of fin rays.

*Are fin rays present in any other region of the body?*

The male and female organs are outwardly similar. The *gonads* are found along the inner wall of the atrium at the lower ends of the tenth to thirty-fifth myotomes. There are 26 pairs present.

**Section.** Examine a section made through the body in the region of the posterior part of the pharynx. Note that:

The section has roughly the shape of a triangle, the apex being formed by the *dorsal fin* and the base by the ventral surface between the two lateral *metapleural folds*.

The exterior is completely covered by the *epidermis*.

The greater part of the interior is occupied by the *atrium*.

The *fin ray* lies just ventral to the dorsal fin.

The *nerve cord*, whose center is occupied by a cavity, the *neurocoele*, lies beneath the fin ray.

The *notochord* is just beneath the nerve cord.

The *pharynx* is in the middle of the atrium. Its walls appear interrupted owing to the presence of *gill bars* and *gill clefts*. The dorsal and ventral walls of the pharynx are folded to form the *epibranchial groove* and the *endostyle*, respectively.

The *liver* lies on the right side of the pharynx.

The *gonads* are attached to the lateral walls of the atrium near the ventral side, the *testes* present a mass of deeply stained small spots and have a general streaked appearance, but the *ovaries* present cells with large nuclei.

Fragments of *nephridia* are attached to the outer sides of the most dorsal gill bars. These are short irregular tubes opening into the atrium.

Each *metapleural fold* has a cavity or *lymph space* in it.

The body wall is made up of a series of *myotomes* separated by connective tissue, the *myocommas*.

**Circulatory System.** The circulatory system is composed of vessels and sinuses. The system lacks a heart. A junction point of vessels, frequently called the *sinus venosus*, is located at the posterior end of the pharynx. A vessel called the *ventral aorta* or *truncus arteriosus* passes anteriorly from the sinus venosus and branches to both sides into the gill bars. Each branch presents an enlargement and then ascends the gill bar as an *aortic arch* to the *dorsal aorta* of the corresponding side. Each arch contributes branches to the plexus of the nephridium or the corresponding gill bar.

The paired dorsal aortas begin at the anterior end of the animal, extend backward between the pharynx and notochord, and unite to form the single dorsal aorta just caudad (posterior) of the posterior end of the pharynx. The dorsal aorta passes caudad to become finally the *caudal artery* of the tail.

The *caudal vein* begins on the ventral side of the end of the tail. At the anus it branches into the *right* and *left posterior cardinal vein* and the *subintestinal vein*.

The subintestinal vein passes along the ventral side of the intestine and breaks up into a network of vessels in the intestinal wall. Vessels from the capillary network unite to form

the *hepatic portal vein* ventral to the liver. This vessel passes forward to join the sinus venosus.

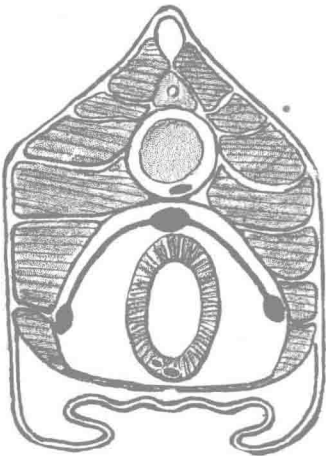
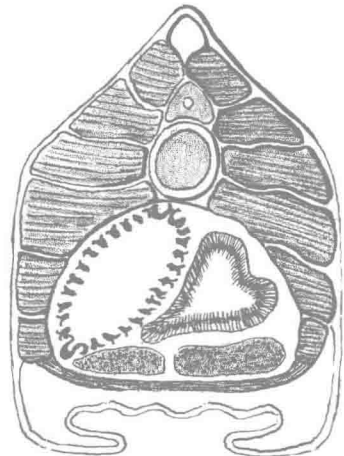
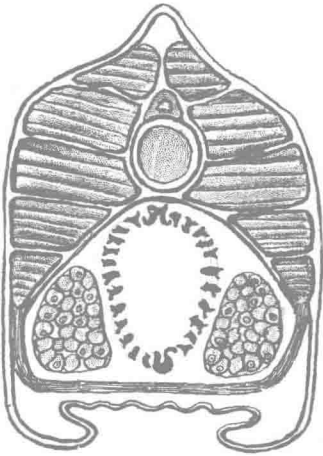
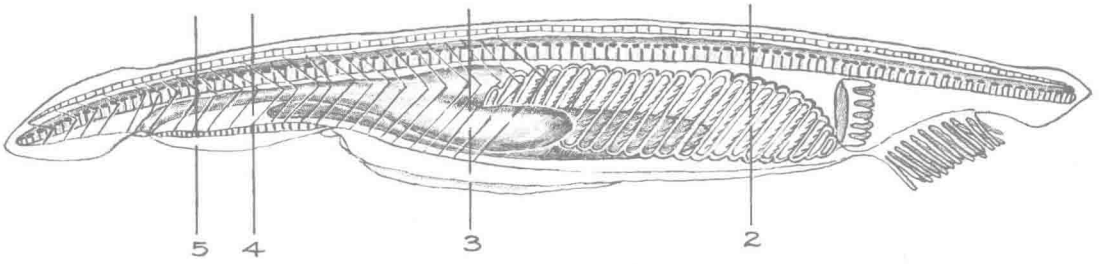
The posterior cardinal veins pass forward along the middle of the body wall just inside the myotomes. At the level of the sinus venosus each posterior cardinal joins a corresponding *anterior cardinal vein* extending posteriad from the anterior end of the body to

form a *duct of Cuvier*. The right and left ducts of Cuvier, thus formed, cross the atrium and enter the sinus venosus.

All major vessels give off or receive segmentally arranged branches or tributaries from the body wall and alimentary canal.

An additional pair of longitudinal vessels, the *parietal veins*, are located in the dorsal wall beneath the myotomes.









## Appendicular Skeleton

### Carp

**Pectoral Girdle.** Dermal components, i.e., bones originally derived from expansion and fusion of placoid scale basal plates, form the greater part of the pectoral girdle. A series of these bones extend dorsoventrally from the skull. The dorsal bone of this series is the *posttemporal*, a V-shaped bone attached by one arm of the V to the caudal end of the skull. The ventral end of the posttemporal joins the *supracleithrum* which in turn articulates ventrally with the large *cleithrum*. Two closely united bones, the *scapula* and *coracoid*, which are the cartilage bones of the girdle, join the cleithrum to the pectoral fin. The scapula is dorsal to the coracoid.

**Pectoral Fin.** The pectoral fin consists of approximately 18 elongated *dermal fin rays* and five small *radials* which articulate with the scapula and coracoid.

### Frog

**Pectoral Girdle and Sternum.** Examine the ventral side of the skeleton of a frog. The various bones of the pectoral girdle and sternum lie between the two arms of the animal.

Beginning at the anterior and going toward the posterior end, the following bones or cartilages are seen: the extreme anterior portion consists of a thin, broad, rounded piece of cartilage, the *episternum*. Directly posterior to this there is a long bone, the *ommosternum*, in the median line. Posterior to the ommosternum are a pair of long narrow transverse

bones, the *clavicles*. One of these extends to the right and the other to the left from the median line. A broader pair of transverse bones, the *coracoids*, lie directly posterior to the clavicles. Lying in the median line between the right and left clavicles and between the right and left coracoids there is a narrow strip of cartilage, the *epicoracoid*. Extending posteriorly from the posteromedian border of the two coracoids and from the posterior end of the epicoracoid there is a narrow bone, the *mesosternum*. The *xiphisternum*, a thin, bilobed, cartilaginous plate, is attached to the posterior end of the mesosternum.

The lateral end of the clavicle articulates with the lateral end of the corresponding coracoid. Note that another bone, the *scapula*, articulates with the lateral end of the clavicle and passes from the ventral side dorsally. The dorsal end of the scapula articulates with the *suprascapula*, a broad, thin plate of bone and cartilage forming the dorsal element of the girdle. In the angle between coracoid and scapula is a mass of cartilage, the *paraglenoid cartilage*, containing the *glenoid cavity*, a depression into which the front leg articulates.

**Anterior Appendage.** The front leg consists of three divisions called, in order from the point of articulation, the *proximal division*, the *middle division*, and the *distal division*.

The proximal division consists of one bone, the *humerus*, which extends from the shoulder to the elbow. The *head* of the humerus fits into the glenoid cavity. Just distad to the head