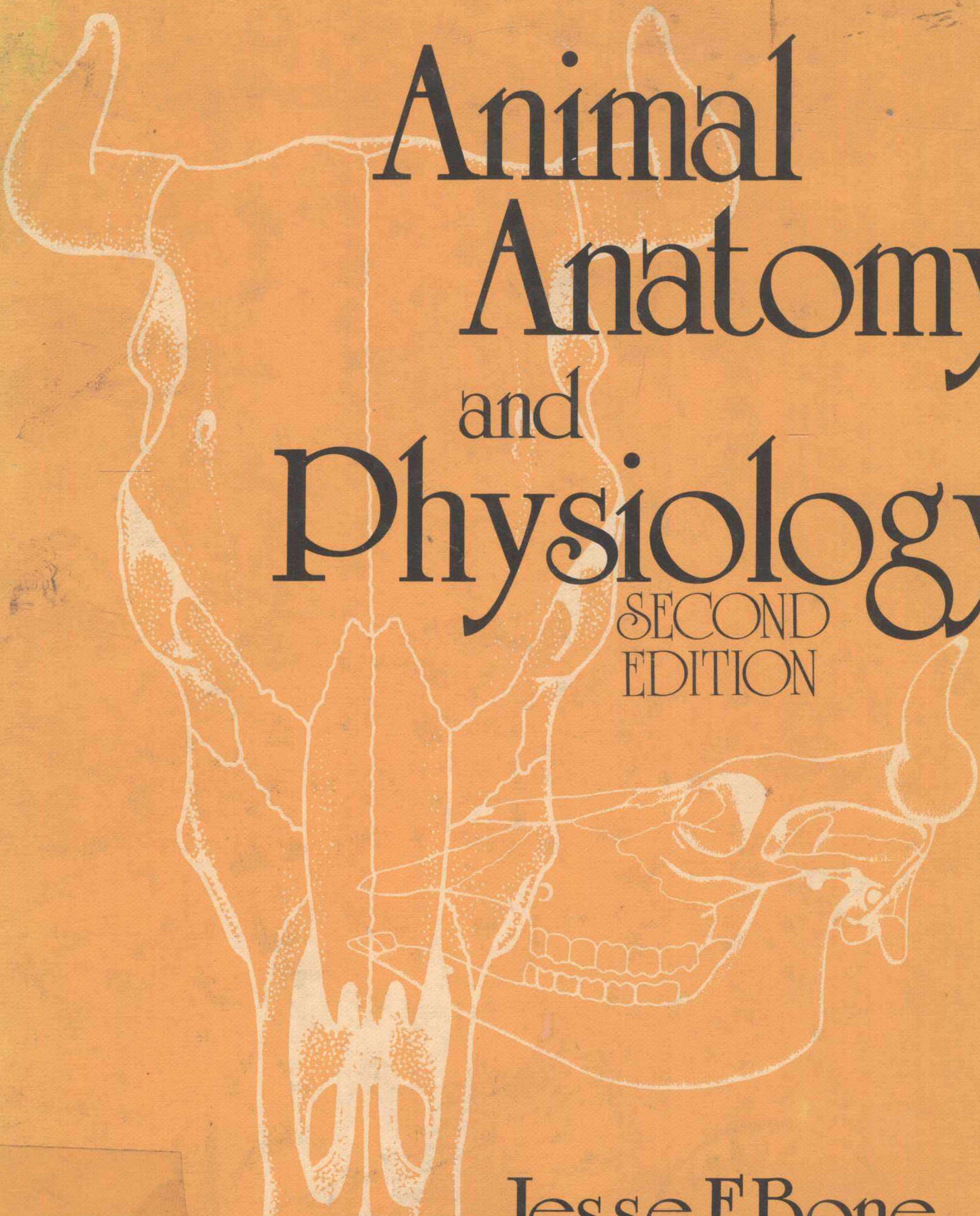
# Animal Anatomy and Physiology

SECOND EDITION



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*To my wife Faye—*
*without whose inspiration and encouragement*
*this book would not have been written*

# Preface

It comes as no surprise to me that this edition contains a number of changes. It would be surprising if it did not, since discoveries and developments, errors, omissions, and dissatisfaction with the grammar and syntax of certain passages all combine to exert pressure for change. Moreover, colleagues have a penchant for pointing out mistakes; for this I am truly grateful, since I have no desire to confuse or misinform readers.

Under these varied pressures, it is difficult to keep a book basic; but I have tried to keep the necessary changes and additions as brief as possible so as not to sacrifice the original aim of the text.

One notable feature of this edition is the virtual elimination of italics except for paragraph headings, generic and specific names, and word analyses. This should eliminate some confusion and reduce the cluttered appearance of certain pages. Italics, unfortunately, can be used for too many purposes, and when they all come together on a single page, the result is chaos! If readers wish to emphasize words or passages, they can do so by means far better than my use of italics.

My personal opinion is that this edition has been improved, and little that is germane to the philosophy of the first edition has been omitted. If I am wrong, I would appreciate comments and suggestions; for there might, someday, be a third edition.

For those who may miss the italics, I offer this bit of italic consolation: *Asperitate viae noli perturbare; scientia permotus.**

Jesse F. Bone

*Don't be disturbed by the roughness of the road; you are being bounced by science.

# Preface to the First Edition

This is a basic book. It is my intention to present a fundamental understanding of animal structure and function. Advanced knowledge is more properly taught in medical and veterinary schools and in advanced courses in the life sciences.

The material contained herein is neither particularly complex nor difficult, nor is it intended to be. It is designed to open the gates to a broad field of knowledge that can be an endless fascination.

The text is presented from a systemic anatomical viewpoint, and consequently the organization of subject matter is different from works that are primarily physiologically oriented. This is the result of over a quarter century of teaching and conferring with students. For those who are not professionally involved with research or diagnostics, an anatomic approach appears to be more understandable, probably because it is based upon things about which students already have some knowledge. To initially expose nonprofessionally-oriented students to the complex acts of neural function, or the equally complex mechanisms of fluid and gaseous interchange, is one of the better ways to extinguish the light of comprehension and the excitement of learning.

In this text the horse will be used as the basic animal and comparison—where indicated—will be made with similar structures or functions in other species. While the cow and the dog have largely replaced the horse as the basic animal in professional schools, I feel that the relative simplicity and large size of equine structures make this animal an excellent subject for demonstration and study in a nonprofessional course. Additionally, there is a great bulk of relatively uncomplicated literature about horses which is available for outside reading by students who wish to travel beyond the restricted boundaries of this text.

Emphasis has been placed upon those portions of anatomy and physiology that have a practical function—which may explain the otherwise puzzling emphasis on skeletal anatomy, dentition, and locomotion. These subjects are important to people who have a functional interest in livestock and pets. It is of no great interest to the generalist or to animal science, agriculture, or wildlife students to have more than general knowledge of intermediate metabolism, ultrastructures, mathematical models, test procedures, or the histogenesis of organs and systems. Therefore, this and similar material is mainly left for the advanced texts designed for medical and veterinary students, specialists, and professionals; such specialist data that is included is simply for illustrative purposes.

This book will, I think, fill a gap that presently exists between the superficialities of survey courses in mammalian structure and function, and the complexities of the advanced works which assume a fundament of knowledge that often does not exist.

# Contents

# Introduction

## ANATOMY

Anatomy (Gr. *ana*—apart; *tomy*—cut) is the study of the structure of a body and the relation of its parts. The subject is usually studied by dissection and observation. It is one of the oldest branches of biological science, dating back at least to the fourth century, B.C., when the Greek philosopher Aristotle published some of his observations on the structure of fish and animals. For this work, Aristotle won the distinction of being called "the father of anatomy."

It has been said that, "It's a wise father who knows his own child," and as far as anatomy is concerned, the statement contains a considerable amount of truth. During the 23 centuries since it was "born," Aristotle's child has developed into one of the major branches of biological science. It is basic to any understanding of why and how an organism functions, and is important in introducing biological terminology and the locations and relationships of organs and systems that combine to form a functioning body. With the aid of the light microscope, the electron microscope, biochemistry, and the various subdivisions of the life sciences, anatomy has become so diverse and complex that Aristotle might well have difficulty recognizing it. Moreover, it has also produced a number of secondary or surrogate "fathers," including Claudius Galen and Andreas Vesalius. Galen, a Graeco-Roman physician living in Rome during the 2nd century, A.D., and Vesalius, a Belgian anatomist of the

16th century, did great work in advancing the knowledge of mammalian anatomy. Because of his extensive studies and dissections, Vesalius is often referred to as "the father of modern anatomy." In the field of microanatomy, Robert Hooke, Schleiden and Schwann, and Rudolf Virchow probably hold as much title to the term "father" as any others. However, the knowledge explosion in the 19th and 20th centuries made the term "father" applied to any discipline or subdiscipline in the biological sciences something of a misnomer; "pioneer" would be a more appropriate term.

In the Middle Ages, prior to the development and use of laboratory animals, the growth of anatomy as a branch of medicine depended a great deal upon cooperation of the local magistrates. Condemned criminals were in great demand and were often released into the custody of scientists for acute experimentation. This was very important for the advancement of anatomical studies, since cadavers tended to spoil rather quickly because of lack of refrigeration and/or embalming. A fresh cadaver was the best kind for making new and useful discoveries.

The 16th century anatomist Fallopius (of Fallopian tube fame) was once awarded two condemned criminals to "put to death in whatever way he pleases—and then anatomize them." Fallopius gave them opium. One survived, the other died. The magistrate pardoned the survivor, but Fallopius did not. He gave the unlucky man another 8 grains of opium—and thus helped establish the minimum lethal dose (MLD) for the drug. History, unfortunately, does not record the other results of Fallopius' studies upon these two cadavers.

Anatomy is generally considered to be a dead subject. With few exceptions, the work is performed upon carcasses or cadavers, although living animals (known as palpators) may be kept in or near the laboratory for reference. There is very little that is either new or dynamic in the anatomical field; the major disciplines are those of memory and correlation of various parts or structures into a complete organism. Yet the basics of any study are not new or dynamic. They are foundations upon which understanding is built. And it is in this sense that anatomy is important.

## Planes of Reference

In describing an animal's body anatomists have long used four arbitrary planes of reference to locate parts and structures. These planes are located in reference to the long axis of the body (which for practical purposes can be considered to be an imaginary line passing through the center of the spinal column) and can be applied regardless of the position or orientation of the animal.

The planes of reference are:

1. Median
2. Sagittal
3. Transverse
4. Frontal

The median plane is the primary plane of reference. It is a single plane which passes through the center of the long axis of the body and divides the body into two equal halves. There is only one median plane. All the other planes are constructed in relationship to it.

Sagittal planes are those parallel to the median plane. Sagittal planes do not pass through the median axis of the body.

Transverse planes are located at right angles to the median plane. All transverse planes pass through the long axis of the body. The transverse plane divides the body into anterior (cranial) and posterior (caudal) portions. Transverse planes divide the body into cross sections.

Frontal planes are those which are located at right angles to both the median and transverse planes. They divide the body into dorsal (back) and ventral (belly) portions.

One must remember that these planes of reference, while used for both man and animals, have a slightly different meaning when applied to man, or to primates. Man and the primates are considered anatomically to be upright bipedal animals with the long axis of the body vertical. Other animals are generally considered to have the long axes of their bodies horizontal. Consequently, the long axes of the limbs of man lie parallel to the long axis of the body, while in animals the long axes of the limbs lie generally at right angles to the long axis of the body.

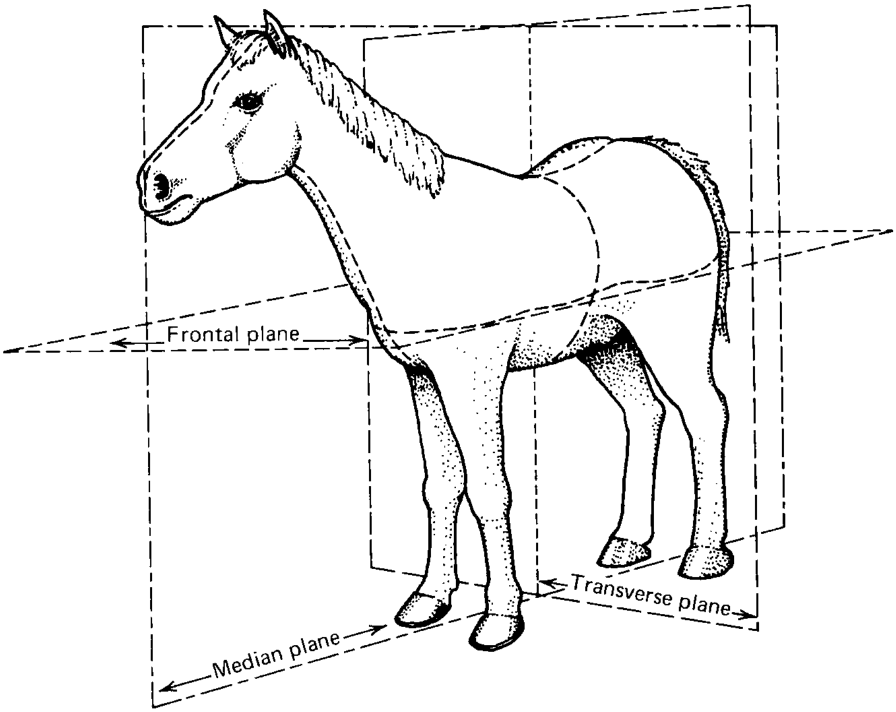


*FIGURE A  Planes of reference.*

Transverse planes in man and the primates will divide both trunk and limbs into cross sections, but will divide only the trunk of an animal into cross sections. Cross sections of most animals' limbs will be cut by frontal planes.

## Anatomical Methods

The mammalian body is a complex structure composed of a number of interrelated systems combined into an integrated whole. To break the body down into parts that can be studied individually has been a difficult task and one which cannot be perfect since the body is an integrated unit and each structure is related to the others. Over the years, a number of methods have been developed for the study of anatomy. Among these are included the following which are presently in use at various schools:

1. Systemic Anatomy
2. Topographic Anatomy
3. Regional Anatomy
4. Special Anatomy

Systematic or descriptive anatomy is the study of various organ groups or systems of the body. Each system is studied as a unit, and finally all the systems are correlated into a complete animal.

Topographic anatomy is the study of parts or systems in relation to their surrounding parts.

Regional anatomy is the study of limited portions or regions of the body. Under this method the body is normally broken down into four arbitrary regions which are studied topographically. These regions consist of the head and neck, thorax and forelimb, abdomen, and the pelvic region and hindlimb.

Special anatomy is the detailed study of certain limited regions of the body such as the teeth, the urogenital apparatus, the liver, stomach, lungs, or other specific structures.

Each of these methods has certain inherent advantages and disadvantages, but for a nontechnical course, systemic anatomy offers the best opportunity to gain the greatest amount of knowledge in a limited line.

## Systems of the Body

The body falls more or less naturally into eleven major organ groups or systems which can be listed as follows:

1. Skeletal
2. Muscular
3. Vascular
4. Digestive
5. Respiratory
6. Urinary
7. Reproductive
8. Nervous
9. Endocrine
10. Common Integument
11. Organs of Special Sense

Each of these systems is functionally related, and physically connected with one or more of the others. Yet, insofar as separation can be accomplished, this method has stood the test of time with fewer changes than might be expected.



## PHYSIOLOGY

Physiology (Gr. *physis*—nature; *logy*—study of) is the fountainhead of the "natural sciences" as they relate to living organisms. It deals with the function of living matter and includes a number of subsidiary disciplines such as behavior, biochemistry and biophysics. Being a more recent discipline than anatomy it has fewer fathers, and like the fictional Topsy has "just growed." If any man could qualify as the "father of physiology" it would probably be Dr. William Harvey a 17th century English physician who discovered that the blood circulates through a closed system, yet Harvey is usually considered to be an anatomist.

The time difference between Aristotle and Harvey is about 2,100 years which indicates that physiology is a johnny-come-lately to the medical and paramedical field. However, physiology has grown to giant size and has built a towering edifice of discovery. Compared to anatomy, which is essentially pedestrian, physiology is airborne. Today the total knowledge accumulated in physiology is probably beyond the comprehension of any single man and the amount of knowledge about physiological processes constantly increases from year to year.

While physiology is a separate subject in veterinary, medical and dental schools and is considered to be a separate branch of biological science, it is capable of being closely correlated with anatomy, and particularly with systemic anatomy. This has considerable value, since an understanding of the functions of an animal is of more practical importance than a knowledge of its structures. It is through function that the usefulness of a species is expressed. And it is through adapting and developing function that animal husbandry has risen to a place of importance in agriculture. It is, of course, the duty of the breeder or the geneticist to develop useful traits among domestic animals, but those traits must be present in the animal in such a form that they will respond to development. A dairy cow, no matter how physically perfect she may be, is of no great value unless she produces milk. A racehorse is valueless unless he can run fast. Beef cattle, sheep, and swine are uneconomical unless they can turn a minimum of feed into a maximum of meat. These are physiological responses associated with anatomy but not entirely dependent upon it.

Similarly, the physiology presented in these pages will be associated with, but not entirely dependent upon, the anatomy. In certain areas where the data do not conform to anatomic classification or where the physiological aspects are important enough to require special consideration, the material will be given separately. However, in the main, anatomy and physiology will be included together in a potpourri which should make both subjects more palatable.