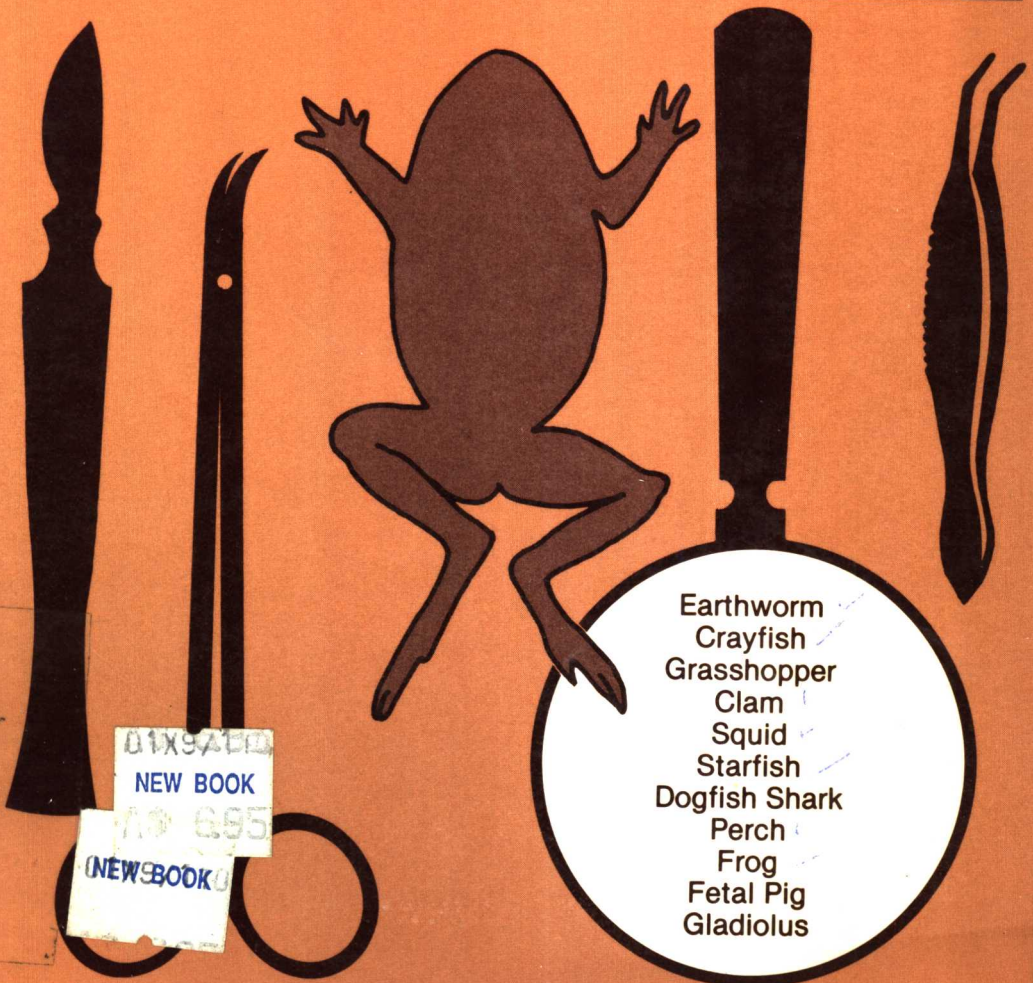


EXPLORING WITH PROBE AND SCALPEL

HOW TO DISSECT

SPECIAL PROJECTS FOR ADVANCED STUDY

WILLIAM BERMAN



Fourth Edition

HOW TO DISSECT

EXPLORING WITH PROBE AND SCALPEL

Fourth Edition

WILLIAM BERMAN

Chairman (Retired) of the Department of
Biological and Physical Sciences
S.J. Tilden High School
Brooklyn, New York



PRENTICE HALL PRESS

New York London Toronto Sydney Tokyo

Copyright © 1961, 1965, 1978, 1984 by William Berman

All rights reserved, including the right of reproduction in whole or in part in any form.

Published in 1986 by Prentice Hall Press
A Division of Simon & Schuster, Inc.
Gulf + Western Building
One Gulf + Western Plaza
New York, NY 10023

Previously published by Acro Publishing, Inc.
Drawings prepared from author's sketches.

PRENTICE HALL PRESS is a trademark of
Simon & Schuster, Inc.

Library of Congress Cataloging-in-Publication Data

Berman, William.
How to dissect.

Includes index.

Summary: A guide for dissecting animals, beginning with the earthworm and progressing to more complex anatomies such as grasshopper, starfish, perch, and ultimately a fetal pig. Includes a chapter on dissecting flowers.

1. Dissection—Juvenile literature. [I. Dissection.

2. Anatomy] I. Title.

QL812.5.B4 1984 591.4'07'8 83-27510

ISBN 0-668-05939-7 (Reference Text)

ISBN 0-668-05941-9 (Paper Edition)

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2

Preface to the Fourth Edition

HOW TO DISSECT ORIGINALLY WAS INTENDED TO BE A CLEAR AND uncomplicated guide for students with little or no experience in dissection. Another objective was to articulate the dissections to produce the effect of an interconnected series paralleling the biological emergence of the groups represented by the individual dissections. Finally, the book was designed to humanize the disparate dissections by revealing anatomical relationships that ultimately result in a better understanding of our place in the world of living things.

As the writing progressed, the need to expand the scientific literacy of the dissectors became more pressing. The earlier chapters were written with simplified text and directions. Gradually, the experience gained in each chapter became a ladder of incremental learning for the next dissection, until the level of the final chapters was considerably heightened. This basic plan remained a self-injunction to balance simplicity with the need for sophistication, rather like moving from freshman to sophomore and toward the senior status for the two new chapters, "The Clam" and "The Perch."

The clam was included in this new edition to provide a better appreciation of a very large taxonomic group of animals common to human experience. The perch was chosen as an example of the group of animals that dominates the waters of the world, a group whose diverse development included organisms that foretold a future of the subphylum Vertebrata.

Somewhat more emphasis has been placed on the rationale of taxonomy and on the probable lines of evolutionary development. A taxonomic summary of chordate classification and an illustration of the Evolutionary Tree of Life that can be useful throughout the book are included at the beginning of the chapter on the fetal pig.

Twenty-two new illustrations and several new projects have been added. The book now covers the spectrum of most organisms generally used for dissections in science classrooms and laboratories and should have greater value for students and their instructors.

Once again I express my admiration and respect for Betty, my wife, companion, and personal editor, for her devoted assistance and time in preparing the fourth edition.

William Berman
1984

Contents

Acknowledgments	ix
Preface to the Fourth Edition	xi
1. Dissection Is Adventure	1
<i>Dissection helps us understand how living things evolved. Basic techniques. Do's and don'ts for successful dissection. Dissecting equipment. Opportunities for experiment, project work, and advanced study. Compass points of anatomy. How the biology student can benefit from this book.</i>	
2. Night Crawlers in the Laboratory: The Earthworm	9
<i>Night life of the earthworm—its habits and environment. External anatomy. Arranging specimen for dissection. Digestive and circulatory systems. Excretory system—the sanitation department. Reproductive system—starting the next generation. The nervous system—keeping in touch.</i>	
<i>Special Projects: Demonstrating the beating hearts of the earthworm. Investigating sex cells of the earthworm. The Yerkes experiment to study the earthworm's behavior. Cultivating earthworms. Effects of pesticides.</i>	
3. Animals with Armor: The Crayfish	25
<i>Gill breathers that walk backward, forward, and sideways. Preparing for dissection. Exposing the gills. Internal anatomy. Exposing the main organ systems. Circulatory system. Appendages.</i>	
<i>Special Projects: Behind the chitin curtain—comparative study of crustacea. Photographing the appendages. New parts for old—regeneration experiments. Home life of crayfish—setting up and studying crayfish in an aquarium.</i>	

4. **Danger: Grasshopper** 37
The top of the invertebrate ladder—insects. External anatomy. Dissection techniques. Removing antenna, compound eye, and pronotum. Internal anatomy. Respiratory, digestive, excretory, reproductive, and nervous systems.
Special Projects: Fountain of youth—working with juvenile hormones. Measuring the strength of a grasshopper's leg muscles. Veins will tell—"vein print" technique to study evolutionary linkages.
5. **The Clam: A Mollusc** 51
What is a mollusc? Classes of molluscs. Preparing for dissection. External and internal anatomy. How the clam moves. Pearls for defense. Respiration. Digestive, circulatory, excretory, and nervous systems. Receptors—sentries to the clam's world. The reproductive system.
Special Projects: Test-tube zygotes. Preparing shells for a permanent collection—preservation techniques; preserving the entire organism, shell and all. Studying the heartbeat of mussel and snail. The digger and the darter—moving on.
6. **The Hunter and the Hunted: The Squid** 73
Squid—the rocket of the sea. External anatomy. Internal anatomy—dissecting the squid. The digestive, respiratory, circulatory, excretory, and nervous systems. Skeletal and reproductive systems.
Special Projects: Cockles, mussels, and devilfish—comparative dissections of clam, octopus, and squid. The shipworm (*teredo*)—a live wood drill.
7. **Star of the Sea: The Starfish** 84
The starfish is not a fish. How starfish uses the power of the sea. Preparing for dissection. Dissecting techniques. External anatomy. Internal anatomy. Framework of the starfish ray. Transportation by tube feet. The digestive and reproductive systems. The heartless, bloodless circulatory system.
Special Projects: Ocean life at home—how to set up a marine aquarium. Determining the sex of starfish.
8. **A Boneless Fish: The Dogfish Shark** 94
The shark as a successful example of survival from prehistoric time. Menu for the shark. External anatomy. Segments and gills. Dissection techniques. Body cavities

of shark. Digestive system. How to expose heart and main veins. The hepatic portal system. Main arteries. Reproductive organs of male and female. Nervous system.

Special Projects: Comparative study of hearts—sharks and other specimens. Tips from scales—identifying species from their scales. Evolution in the aquarium.

9. **A Member of the Master Class of Fishes: The Perch**

110

Bony fishes versus cartilaginous fishes. Setting the stage for dissection. Getting the specimen ready. Features of the perch, *Perca flavescens*. External anatomy. Internal anatomy. The digestive, excretory, and circulatory systems. The gills and respiration—how the fish breathes under water. The nervous system. Anatomy of reproduction—how the tribe increases. Prelude to the Tetrapoda.

Special Projects: The cardiac concern: reverse animal experimentation; observing the effects of household medicines on fish. Disappearing through camouflage. How to tell a tale from head to tail.

10. **The Fabulous Frog**

134

The frog leads a double life—the aquanaut and terranaut. Preparing for dissection. External anatomy. The inside story of the frog's anatomy. Circulatory, respiratory, excretory, and reproductive systems. In charge—the nervous system.

Special Projects: Changing the spots on a leopard frog. Remote control of heartbeats—repeating Otto Loewi's experiment.

11. **Dissection of a Mammal: The Fetal Pig**

154

Classification (taxonomy). Structure and anatomy of a vertebrate. Dissecting the abdominal cavity. Male and female urogenital systems. Thorax, head and neck, mouth and pharynx, eye. Tracing the circulatory system—placenta to placenta in the fetal pig, heart to heart in the adult. Dissecting and studying the heart and brain of a mammal.

Special Projects: Identification of the contents of the digestive system. Preparing slides and comparing the microscopic structures of the various parts of fetal pig anatomy.

12. Flowers Can Be Dissected Too: The Gladiolus	206
What scientists can learn by dissecting flowers. Dissecting procedures. Ovary and ovule. The next generation—from ovule to seed.	
<i>Special Projects:</i> Microscopic anatomy. Embedding specimens in plastic. Problems of survival in manned spaceships—experimenting with algae (chlorella).	
Index	215

1

DISSECTION IS ADVENTURE

YOU ARE ABOUT TO EMBARK ON A NEW KIND OF ADVENTURE. WITH probe and scalpel you will explore the anatomy of animal and plant life. Dissection not only reveals the architectural plan of living creatures; it also shows how life has evolved from the simple to the most complex forms.

This is not a "cookbook" of dissection "recipes." Our directions for dissecting must be, and we hope they are, clear and easy to follow. But you should go beyond the limits of dissection itself. For the inquisitive young scientist with questions which exceed the scope of this book, we have included suggestions for more advanced work. For example, in addition to dissecting the earthworm, you might want to study its ability to solve problems! In addition to dissecting a flower, you may want to look into the problem of developing a method of supplying food and oxygen for our travelers in outer space. Dissection is a tool, a technique of investigation used in the service of science.

You will retrace the steps of some of the great biologists. You will travel along roads branching off to other roads, and at the end you may find yourself in new bypaths, yet uncharted by science. In these days of expanding scientific knowledge, young scientists often find themselves advancing toward the frontiers of research. You will meet some of the unsolved problems and stirring challenges facing our scientists. Perhaps some day you will help find the answers to some of these problems.

In your work with dissection you may find the answer to your own future. Do you want to be a doctor, a science instructor, a dentist? Perhaps you would rather be a chemist or a physicist, doing research in cancer, in heredity, and in many other vital areas. The choices are many and are often bewildering. Few of us make early decisions. We all need guidance. This book can help give you a start in mastering background you will need before you can determine whether you are suited for a profession in science. Besides promoting

a knowledge of anatomy that will increase your understanding of the human body, it can provide evidence of your own aptitudes and capabilities. You may decide to join the dedicated army of scientists and make research your life work.

This book should be especially helpful to biology students from the secondary school through junior college and freshman college levels. It will be useful to students in advanced courses in high school zoology and in advanced college placement biology courses in high school. College students will find that our simplified dissecting techniques and directions will enable them to benefit more thoroughly from their required readings in physiology, evolution, and other related topics.

Most people have a strange notion about dissecting. They see themselves standing in a pool of blood, gripping bloodied instruments. This notion is all wrong. A dissection is clean. The only "blood" present in the prepared specimen is the latex injected into the blood vessels in the biological supply house by which the arteries are stained red and the veins blue. This "color map" helps us trace the circulatory systems. When you receive the specimen it has already been treated with preservatives to keep the tissues from hardening and drying out. All you need do before dissecting is to wash away thoroughly the excess preservative under running water.

Another false notion about dissecting is that all you do is cut and slice. A specimen is not a loaf of bread; it is a marvelously assembled and intricate set of structures held together by tissue, mostly connective tissue. You might compare a specimen to a carton of fragile, expensive dishes you are about to open. Each article is separately wrapped and you are going to unwrap it very cautiously. That's what we do when we dissect; we make careful incisions to expose parts. We then use a probe (often called a seeker), a long, thin, pliable metal rod with a smooth, rounded tip, to separate organs from their coverings. In a sense, we are carefully unwrapping the parts of the specimen without injuring any of the parts. Except for major incisions, *don't cut—dissect!*

All you need to profit from this book is the curiosity you were born with, and the ability to read well enough to understand and to follow directions. However, this is not the kind of book that can be merely read as you would read a novel. Except for the introductory remarks in each chapter, you must work with the specimen before you because the text and the illustrations or diagrams refer to the specimen. It often happens that many organs which may be difficult to visualize from the text can readily be seen in the specimen. The diagrams have been simplified to make it easy to identify parts on the specimen. A picture may be worth a thousand words, but the real

thing is better than a thousand pictures. To avoid confusion, very small blood vessels and nerves are not shown in the diagrams. After you have mastered the main techniques of dissection you might consult a more advanced book on comparative anatomy for more technical study.

The dissections have been arranged so that we begin with relatively simple, primitive specimens and work our way up to the more advanced forms of life. We begin with the earthworm, a spineless creature, and close with the fetal pig, a vertebrate animal with a well-developed spine and which, in many structural features, is similar to man. The dissections provide a fascinating glimpse into the story of evolution. The basic techniques for dissecting the earthworm are used in dissecting more complicated specimens. However, each new dissection will require additional skills. When you have dissected the crayfish you will gain the basic training for dissecting the grasshopper. Dissecting the shark is excellent preparation for dissecting the frog, and the frog dissection is a fruitful basis for the dissection of a mammal, the fetal pig. The more dissecting you do, the more you will get out of this book.

IMPORTANT POINTS FOR SUCCESSFUL DISSECTIONS

Before dissecting, read directions carefully and examine accompanying diagrams thoroughly. When dissecting, turn the dissecting pan to the position most comfortable for you as you handle the instruments. Use the probe often for separating structures (veins, nerves, organs) from connective tissue, and for tracing the course of hollow structures by inserting the probe to see where they lead or originate. Trace and master one system at a time. Then see how the different systems are related to each other and to the general body plan.

Dissection is analytical. Separating and analyzing associated parts provides us with the basis for productive thinking when we assemble data to produce new ideas. When you dissect or take apart an organism, you are taking the first step toward putting together, or synthesizing, new theories and new knowledge. Do not be satisfied with dissecting only one example of a whole group of animals. Use the knowledge and skills you have gained in independent learning.

At the end of each chapter you will find ideas for exciting research, for science projects, and for enjoyable hobbies. Make your own diagrams and keep records of your dissections and findings. Compare the systems of every animal and plant you dissect to discover evolutionary connections. Take photographs of the dissections.

Each animal has its own story to tell. No dissection can be adequately meaningful if it is done as a single experience. It is like trying to judge a painting without having examined and analyzed other paintings.

What equipment will you need for dissection, in addition to the specimens? Certain basic tools will be useful in all dissections (see Fig. 1). Individual instruments or fully equipped dissecting kits may be obtained from biological supply houses and hobby shops. Additional instruments with special advantages for particular dissections are described in the text where they are needed. Following is a list of basic equipment:

- Dissecting pan
- Dissecting pins
- Dissecting needles
- Specimen jars
- A thin probe
- Scalpel, medium size
- Paper toweling
- Single-edge razor blade
- Straight-tipped forceps, medium size
- Curved-tipped forceps
- Hand lens, 5× to 10× magnification
- Dissecting microscope, 5× to 10×
- Dissecting scissors, 4 to 5 inches
(10 to 13 centimeters, or cm) long

Formaldehyde preserves specimens or organs for future study. A good mixture for preserving most specimens is a 4% solution of formalin, which is made by adding 4 milliliters (ml) of commercial formalin to 96 ml of water. The mixture is a very weak solution of formaldehyde. A little cold cream rubbed into your fingers will prevent the preservative from dehydrating your skin.

Order double-injected specimens by their scientific names as indicated in the text. Double-injected specimens are injected with two different colors—red for arteries, blue for veins.

Several scientific supply houses currently offer specimens for dissection, preserved with chemicals that do not have the irritating and potentially toxic effects of formaldehyde, although some formaldehyde may be used in conjunction with the nontoxic preservatives. The specimens may be purchased in sets, some of which include most organisms generally dissected in schools and universities.

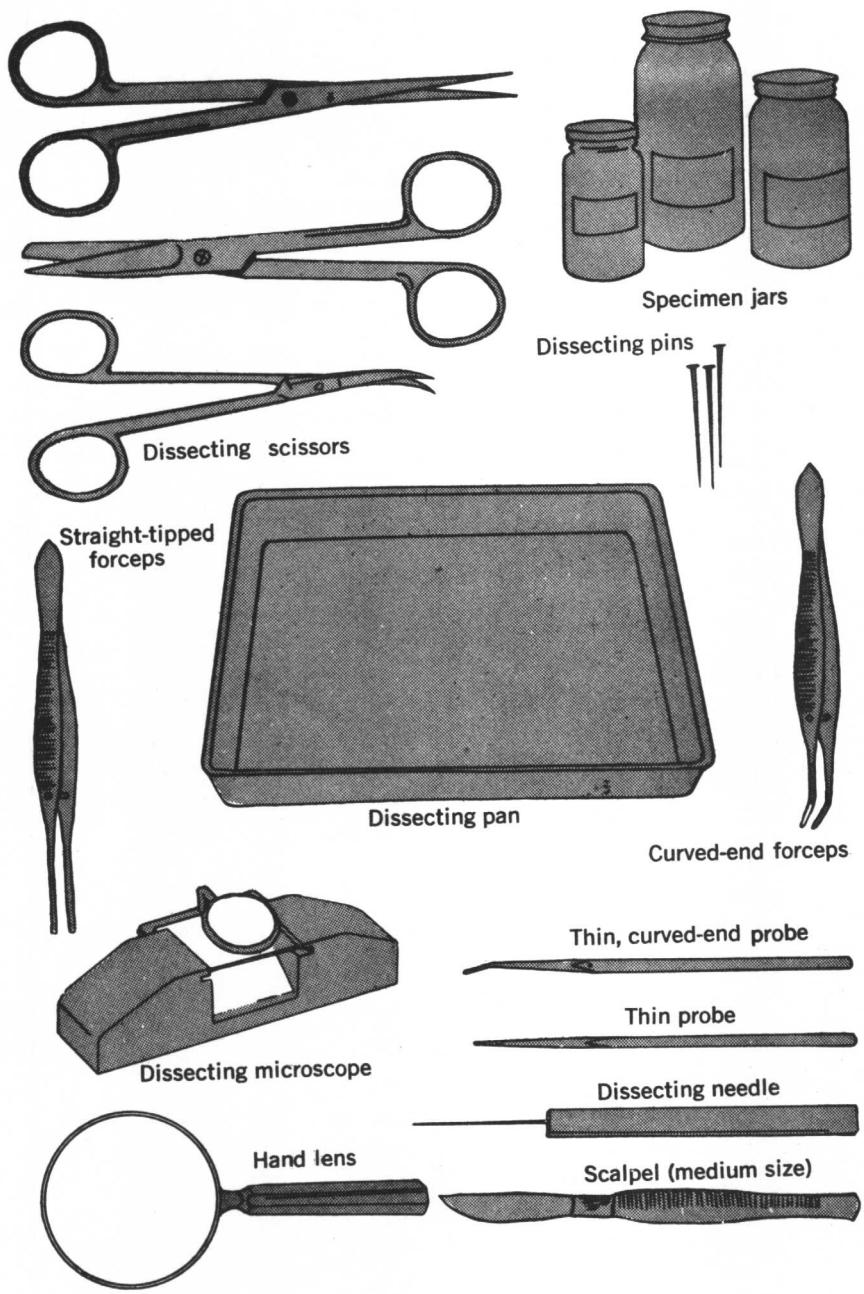


Figure 1. Basic Dissection Equipment.

CONVERSION TABLE FOR UNITS (APPROXIMATE EQUIVALENTS)

Length

1 inch = 2.54 centimeters
1 foot = 30.48 centimeters = 0.3048 meter
1 yard = 91.44 centimeters = 0.9144 meter
1 millimeter = 0.1 centimeter = 0.03937 inch
1 centimeter = 10 millimeters = 0.3937 inch
1 meter = 100 centimeters = 39.37 inches
1 kilometer = 1000 meters = 3280.8 feet = 0.621 mile

Area

1 acre = 0.4047 hectare
1 square mile = 640 acres = 259 hectares = 2.59 square kilometers
1 hectare = 2.47 acres
1 square kilometer = 0.3861 square mile

Volume

1 cubic inch = 16.387 cubic centimeters
1 cubic centimeter = 0.06102 cubic inch

Capacity

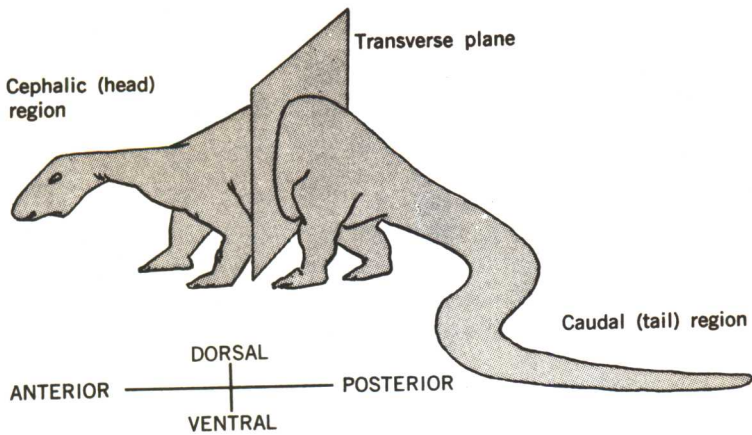
1 fluid ounce = 29.573 milliliters
1 quart = 16 fluid ounces = 0.946 liter
1 milliliter = 0.0338 fluid ounce
1 liter = 1000 milliliters = 1.0567 quarts

Weight

1 ounce = 2.83 grams
1 pound = 16 ounces = 0.455 kilogram
10 milligrams = 0.000353 ounce
1 gram = 1000 milligrams = 0.353 ounce
1 kilogram = 1000 grams = 2.2 pounds

Metric Abbreviations

mm	millimeter	(length)
cm	centimeter	(length)
m	meter	(length)
km	kilometer	(length)
cc	cubic centimeter	(volume)
ml	milliliter	(capacity)
mg	milligram	(weight)
g	gram	(weight)
kg	kilogram	(weight)



The compass points of anatomy (anterior, posterior, dorsal and ventral) appear in all forms of animal life from the simple, spineless creatures to man himself. These compass points help us observe how animal life evolved from a crawling stage to an upright position.

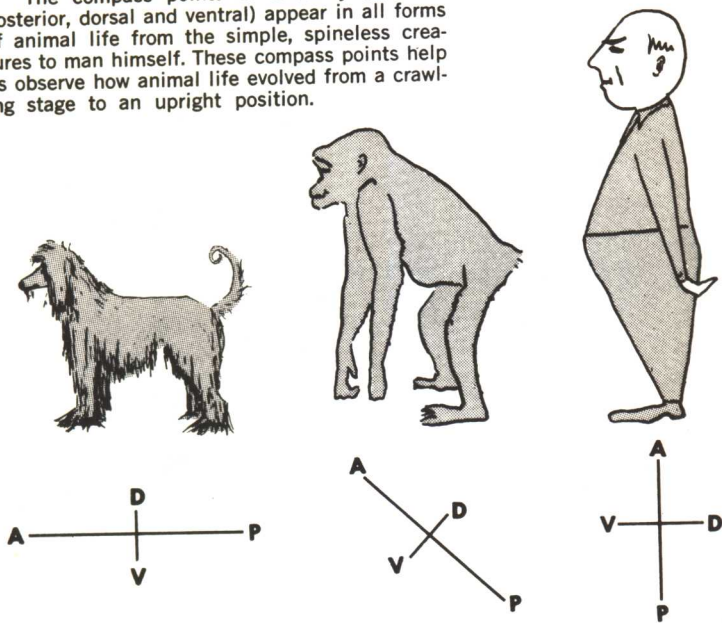


Figure 2. The Compass Points of Anatomy.

IMPORTANT TECHNICAL TERMS

And finally, here are a few of the important technical terms frequently used in dissection (see Fig. 2):

Dorsal—the back or upper part of the animal

Ventral—the abdominal side or lower part of the animal

Cephalic—the head region

Cranial—the upper part of the head

Anterior—the forward or front end of the body

Posterior—the hind or rear part of the body

Caudal—the tail end

Transverse—the cross section

Longitudinal—along the length of the body

Proximal—nearest to, or at point of origin or attachment

Distal—farthest from origin or point of attachment

Sagittal—along the median plane

There are many other technical terms used in dissection, but if you understand these terms you are ready to begin.

Did we say begin? Just so!