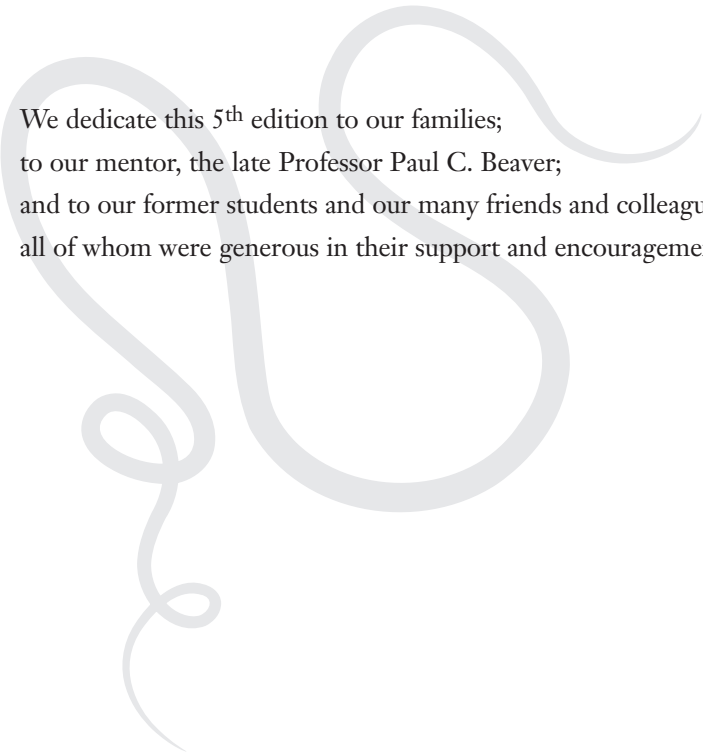


Ash & Orihel's
ATLAS OF Human
Parasitology



We dedicate this 5th edition to our families;
to our mentor, the late Professor Paul C. Beaver;
and to our former students and our many friends and colleagues,
all of whom were generous in their support and encouragement of our efforts.

Ash & Orihel's ATLAS OF Human Parasitology

5th edition

Lawrence R. Ash, PhD

Professor Emeritus of Infectious and Tropical Diseases
Department of Epidemiology
School of Public Health
University of California, Los Angeles
Los Angeles, California

Thomas C. Orihel, PhD

Professor Emeritus
Department of Tropical Medicine
School of Public Health and Tropical Medicine
Tulane University
New Orleans, Louisiana



American Society for
Clinical Pathology
Press

Publishing team

Adam Fanucci (graphics/production)

AC Racette (design/production)

Joshua Weikersheimer (publishing direction)

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Cryptosporidium (Plate 27:4), *Plasmodium falciparum* (Plate 33), *Wuchereria bancrofti* (Plate 62:1), Artifacts (Plate 100:1), *Capillaria philippinensis* (Plate 49:1)

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PREFACE

The four earlier editions of *Human Parasitology* sought to provide a comprehensive guide to the parasites of humans – the common, well-known species, the less frequently encountered ones, the “opportunistic” parasites, and the emerging zoonotic species. These parasitic infections have been typically encountered in the less developed, mostly tropical regions of the world. However, with the globalization of business and leisure, attendant travel opportunities for both work and pleasure, and radically increased urbanization, emigration and immigration, the geographical ranges of parasites have expanded, and many have simply changed. Consequently, the numbers of parasite species one may encounter in the laboratory anywhere in the world have greatly increased. Accurate diagnosis of all of these parasites is within the assisted expertise of competent, well-trained laboratory personnel. This new edition of *Human Parasitology* is designed to give you all the assistance you may need. While the focus of this new edition remains the same, its content has been increased and expanded.

The sequence of topics has been rearranged to provide a more laboratory user-friendly presentation. Diagnostic procedures and methodology have been carefully reviewed, and the most appropriate procedures, in light of current laboratory practice, have been added as a separate new section. The references have been thoroughly updated to provide readers with the most current information available. We have selected as general text references those that we believe are the most up-to-date, accurate, and comprehensive available. In addition, references concerning individual parasites or groups of parasites have been updated and appended—most references fall within the period between 2000 and 2006. However, some classic earlier references are retained because they cover subject matter that is not otherwise obtainable and is especially focused on diagnostic approaches to parasitic infections.

Species descriptions have been carefully evaluated and updated where required. Illustrations of characteristic clinical features of parasitic infections have been added to the text selectively, where most useful. In addition, although the identification of parasites in tissues may not be part of the usual diagnostic routine in laboratories, we felt it would be helpful to add illustrations of the histologic appearance of some of the more common

parasitic worms causing human disease. Tissue parasites are comprehensively described and illustrated in our companion book *Parasites in Human Tissues* (see text references at the end of this book).

Because so many parasites that were once rarely encountered may now be seen in the laboratory more often, “quick keys” have been added to assist laboratorians in arriving at the appropriate diagnosis. The four keys provided include those for diagnosing stained intestinal protozoa, helminth eggs, helminth larvae and microfilariae. These are linked to illustrations in the diagnostic section of *Human Parasitology*.

Not all specimens that find their way to the clinical laboratory are fecal samples, blood, urine, or body and tissue fluids. Sometimes, adult or larval stages of a parasite are submitted to the laboratory for identification. Although the laboratorian may easily recognize the egg or larval stage of a parasite, the adult stage of the organism might be more of a challenge. Representative examples of diagnostic features of some adult nematodes (eg, strongyles) are illustrated to acquaint the microscopist with morphologic features that are most immediately useful in identifying these and other species. Techniques for preparation of these worms for morphologic study have been added as well.

In the previous edition, we added a few examples of adult arthropods that occasionally are submitted to the laboratory for identification. We have expanded this in the new *Human Parasitology* with illustrations of the larval stages (maggot, bot) of some of these and with their clinical presentation because they too are increasingly submitted to the laboratory for identification.

Artifacts are frequently encountered by laboratorians because clinicians often confuse them with parasites. More examples of submitted artifacts, primarily in feces and blood, have been added. Especially in feces, there are always objects that bear a striking resemblance to parasite eggs and/or larvae. A less experienced microscopist may be led to believe that these are actually parasites. In addition, patients now more

frequently provide their physicians or other scientists with “samples” they have extracted from their bodies which they believe are parasites. These will, of course, find their way to the clinical laboratory for identification. Accordingly, we have expanded in the text our discussion of delusional parasitosis, one of the conditions that results in these specimens being submitted for identification.

As in the past, this new edition of *Human Parasitology* is not intended to be an exhaustive textbook of parasitology. Our goal is to provide the reader with the most comprehensive and up-to-date source of information for parasite diagnosis in the laboratory. We hope the new content and treatments, and especially the added features—morphologic keys, clinical images, new morphologic plates, important diagnostic procedures, and expanded consideration of parasitlike artifacts and pseudoparasites—will provide further help in improving your laboratory performance.

ACKNOWLEDGMENTS

During the nearly 30 years that have passed since the first edition of this Atlas was published, many of our friends and colleagues have provided us with very special and unique images which were incorporated into the publication. Additionally, they and others provided parasite materials for our photomicrography. Still others offered suggestions on how we might improve the Atlas and often these have been incorporated into our presentations in subsequent editions as well as this 5th edition. We have always chosen to do our own photomicrography; however, inevitably, there have been exceptional images provided by colleagues that we chose to add to our individual plates. Notably, of more than 800 images used, less than 8% were from other sources.

Gratefully, we wish to acknowledge the contributions of these individuals who have so generously provided these materials. They include: E. M. Andersen, F. Ardoin, M. Bartlett, C. Bedrossian, R. L. Benson, R. Bryan, J. H. Cross, J. Churg, R. DeMay, D. P. Dooley, T. R. Fritsche, S. Gatti, Y. Ishibashi, L. Karayianis, M. D. Little, E. Long, L. Measures, A. Meisels, M. Murray, T. Oshima, J. C. Petithory, J. S. Remington, M. Scaglia, L. Sloane, and J. H. Smith. The Armed Forces Institute of Pathology and the National Centers for Disease Control and Prevention likewise provided images. Some of these individuals also provided parasite materials for photomicrography.

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INTRODUCTION

Parasitic diseases continue to have a significant impact on the world's populations, especially in the lesser-developed regions of the world where delivery of health care, sanitation, and vector control efforts are less than adequate. However, the increased mobility of populations, immigration and displacement of populations due to civil strife are contributing factors that may extend their geographic range, or at the very least, create new public health concerns in previously unaffected areas (non-endemic areas). Both urbanization as well as movement into suburban areas produce problems unique to both. Overcrowding in urban areas may test the adequacy of sanitation and control of the most common, soil-transmitted, parasite species. Movement into rural areas may expose (naive) populations to a variety of vector-transmitted parasitic infections (to say nothing of viral and bacterial zoonoses). Although there may not be a concern for reestablishment of endemicity, there is an important need to recognize parasitic infections in transient populations and to be prepared to identify and treat them. Laboratory personnel are expected to be sufficiently trained to identify uncommon parasites whenever they encounter them, no matter how infrequently.

As in previous editions, illustrations of parasites are shown in their typical state utilizing the most widely used methods and staining procedures. Although there is an evolving, non-microscopic technology, microscopic visualization of the parasite remains the ultimate diagnostic criterion. In this connection, the section on methods also has been modified to meet this need and additionally, diagnostic keys have been provided. Given the difficulties of collecting parasite materials for study and reference purposes in laboratories, we have expanded methodology for techniques useful for the collection and preservation of parasites.

It has been our practice not to include the sizes of individual organisms for each illustration. However, measurements, including ranges and means, are provided in the text descriptions of each parasite. Helminth eggs and microfilariae were photographed at low (10X) and high power (40X) magnifications. Protozoa, with few exceptions, were photographed under oil immersion.

Accurate identification requires that one must not be misled by objects normally encountered in feces,

blood, and other body fluids that mimic parasite stages. The inexperienced microscopist is the most likely victim. Unfortunately, the dearth of adequate reference samples of parasite stages for study and training in the laboratory is a contributing factor. For these reasons we have provided additional images of artifacts commonly encountered in feces and blood that, hopefully, will help avoid misidentification. Users of the book have enthusiastically endorsed the expansion of the "artifacts" section in this new edition.

Adult worms recovered in feces following treatment or passed spontaneously in the feces are often submitted to the laboratory for identification or confirmation of identification (eg, hookworms or other strongyles, and ascarids). Techniques for the preparation and study of these specimens are included.

Where the environments of human and animal populations overlap (peridomestic environment) there is great opportunity for animal parasite species (particularly vector-borne types) to infect humans even though the numbers of such cases may be relatively small. The important aspect of this is, of course, accurate identification of the parasite and determination of the reservoir of infection. In many well-developed regions of the world, zoonotic filarial infections attributed to a wide variety of species (*Dirofilaria*, *Brugia*, *Onchocerca* and others) have been reported with increasing frequency. Some of the clinical presentations are illustrated here for the first time.

In the last edition of *Human Parasitology*, a section was added dealing with adult arthropods that are sent to the laboratory for sundry reasons. We note that not only are adults submitted for identification but occasionally their larval stages as well. The latter are usually associated with impressive clinical presentations that, in most cases, quickly subside after the "maggot" (or other offending organism) is removed from the patient's tissues. New illustrations have been added to the 5th edition to acquaint laboratory personnel with these arthropod stages.

We wish to remind the reader that the taxonomy and nomenclature used here are based on current usage and are intended only to guide the reader. There is no intention to resolve existing taxonomic issues. Among some of the more difficult taxonomic challenges, we have seen *Pneumocystis* definitively regarded as a fungal organism, that there are suggestions of a close fungal relationship within the microsporidia, and that *Cryptosporidium* may not share characteristics ascribed to other coccidian species (eg, *Cyclospora*, *Isospora*, *Toxoplasma*). With the advent of new molecular tools we are finding that many organisms within a genus (eg, *Cryptosporidium*) have identical morphologic characteristics but can be differentiated by their molecular makeup. Differences noted at the molecular level among parasites are of relevance, in particular with chemotherapeutic approaches recommended. Increasingly, in the future, these avenues of research will be pursued, but for purposes of *Human Parasitology*, our efforts are directed at providing the best information at the morphologic level that will aid in proper diagnosis of parasitic infections. In instances where it appears appropriate to consider other taxonomic designations, we have attempted to indicate this by providing the alternative taxon.