Preface

The past two decades have witnessed a rediscovery among researchers of the value of comparative vertebrate anatomy. In large part this has been due to the establishment of phylogenetic systematics and the renewed awareness of the vast contribution that morphology can make to our understanding of the history of vertebrates. This is perhaps even more apparent now than just a few years ago, when the first edition of this manual was in preparation. Indeed, as noted by Budd and Olsson (2007:1), there "has never been a better time to study morphology." However, the study of anatomy at the introductory and intermediate college levels has suffered and continues to do so, as both its stature and perceived importance have diminished. There are several reasons for this. Certainly, and regrettably, the trend at most major academic institutions has followed a path away from whole organism biology, as genetics and molecular biology, for good reason, have become popular. Despite the intense focus on genetics over the last several decades, it remains "clear that morphology still stands at the heart of comparative biology. From functional morphology to ultrastructure, morphological topics link into ecology and physiology, developmental genetics and the fossil record; they connect them all" (Budd and Olsson, 2007:1). A further hindrance to introductory study in this field is that there has been increased resistance from some quarters to the use of animals in various scientific endeavors. As well, the development of easily accessible computer software allows convenient visual journeys through vertebrate bodies without the effort, expense, and "mess" of actual dissection.

The study of anatomy and morphology has much to offer the student wishing to pursue a career in biological or medical fields. Proper training in vertebrate anatomy must include a practical component that involves dissection, in addition to lectures. No other method, regardless of how intricate in presentation and scope, can replace the actual hands-on experience. It is only through a careful, patient, and repeated practical approach that we gain the expertise and practice required for understanding the spatial relationships that are essential to learning how a vertebrate body is constructed, how its component structures are related to each other, and how form and function interact.

There are those who would suggest that such a course of study is unnecessary and that anatomy can be learned through texts or software. While such materials (this text among them) may prove to be invaluable as aids or tools for learning, we ought not to substitute these adjuncts for the means through which we *must* come to know the vertebrate body. To do so would be akin to preparing for an acting career by watching films, rather than through rehearsing and acting workshops. Few of us would feel comfortable with mechanics trained solely through the Internet, trust a surgeon who has learned the craft strictly through instructional videos, or fly with a pilot who has only flown missions on a flight simulator. It is not because such instructional methods are not useful that we would be suspicious. Rather, we recognize that, for fields whose subject matter includes components arranged in complex spatial relationships, these media are meant to be used as tools that supplement and guide the trainee through a methodical, first-hand experience with the subject matter itself. And science, of course, is an empirical endeavor. When practiced, science is based on observation and experience. If we are to train students to become scientists, it is not sufficient merely to present them with the products of science, but we must engage students in actual scientific practice.

The debate on the value of dissection is particularly lively for human medical anatomy (see, for example, Rizzolo, 2002; Pawlina and Lachman, 2004; and Elizondo-Omaña et al., 2005). Many researchers are clearly in favor of dissection, but also see the need to incorporate the advanced imaging technologies currently available. Indeed, a combination of the two techniques apparently leads to superior results (see Biasutto et al., 2006). The same logic should apply for any vertebrate, but similarly advanced technologies are unlikely to be applied to a broad range of vertebrates in the foreseeable future.

The central theme of most previous dissection manuals has been the structural changes in vertebrates through their evolution from fish to mammals, with the ultimate goal being to place mammalian anatomy in context. This is certainly a necessary prerequisite for anyone interested principally in mammalian systematics or medicine. However, not all students or instructors are

interested primarily in mammals. Two of the important lessons emphasised by phylogenetics are that all living vertebrates have as long an independent evolutionary history as mammals have, and that their anatomy has as much to tell us about evolution, function, and morphology. Indeed, a common complaint among academic faculty is that comparative vertebrate anatomy courses have become courses on the anatomy of the cat. Be that as it may, it is important to remember that negative perceptions can often be detrimental to the well-being of a field of study and may sway departmental decisions on whether the continuation of some courses is worth the effort and expense. It is up to those of us who teach comparative anatomy to push forward and maintain its vigour and centrality, in part by relating its wide applicability to related fields, such as systematics, evolutionary biology, paleontology, paleobiology, and functional morphology; and as a prerequisite for higher level zoology courses, such as mammalogy, herpetology, ornithology, developmental biology, and vertebrate paleontology.

Our format and coverage is aimed at striking a balance between presenting an evolutionary sequence to "higher" vertebrates and the anatomy of each representative vertebrate as inherently important. The sequence of vertebrates is similar to those presented by other authors, but we must remember that the living vertebrates are not and cannot be used as intermediates. For this reason, we provide discussions of the important features of each group based on the derived features that diagnose a particular phylogenetic grouping. We thus do not treat vertebrates by traditional grouping methods; we would rather, from the beginning, present the student with information that reflects our formal thinking and classification.

The main goal of this text is to provide today's visually oriented student population with a manual that links succinct and pedagogically effective textual direction with relevant, high quality, accurate, and attractive visual references to promote efficient learning of the complex, spatially abstract subject matter in the limited time available in a laboratory setting. Thus, a critical feature of *The Dissection of Vertebrates* is the inclusion of numerous high-quality, didactic, color illustrations. Each depicts the vertebrate approximately as it would appear in a particular stage of dissection, rather than presenting an idealized figure or photographs, as is the case for most other manuals. This in itself facilitates the use of these illustrations, both in learning and later during recall for studying purposes. Photographs are used sparingly. We have chosen illustration over photography in the vast majority of cases because illustration is the method that affords the most control in communicating the pertinent features of a particular dissection. Photographs are indiscriminate, whereas illustration in combination with color allows minimization of unnecessary and distracting background anatomical detail, while still maintaining it. Indeed, we have taken great care to ensure that the background anatomy in the illustrations is accurate. This is important because it gives the users (instructor and student) a context for the anatomical structures under study.

Although students aspiring to careers in systematics, vertebrate paleontology or functional morphology are the primary intended audience of this manual, *The Dissection of Vertebrates* is sufficiently flexible in scope and organization that it may be used in any course on vertebrate anatomy. We present a wide-ranging and encompassing reference manual that will both help students learn the basic anatomy of vertebrates and function as a guide once they are ready to venture into the primary literature.

The Dissection of Vertebrates presents dissection instructions on more vertebrates than is normally the case. The primary focus is on the shark, mudpuppy, and cat, as is usual, but it also provides detailed information on vertebrates either not usually considered or treated very superficially by most other manuals that include multiple vertebrates. It is ironic that the two most speciose groups of vertebrates, the birds and ray-finned fishes, are not adequately covered (if covered at all) in other dissection manuals. We hope that by providing reasonably detailed guides for these vertebrates, instructors will feel more inclined to include these readily available and inexpensive vertebrates in their courses.

This manual is organized by vertebrate. The anatomy of each is then presented systemically. This approach allows all the information on a particular vertebrate to be studied at one time and in sequence. We believe, based on years of instruction, that this method provides a more straightforward integration of the systems. The inclusion of many vertebrates and the organization by vertebrate makes *The Dissection of Vertebrates* more flexible for use in a broad-based full or half-year course at the introductory college level, and allows more convenient organization of course content, depending on time and availability of specimens and the instructor's preferences.

At the same time, we omit many topics that are often covered in most other manuals. Sections on vertebrates or structures that students are unlikely ever to dissect at the intended level of study are not included. Instead, we have focused the material on examples that are likely to be encountered in an introductory lab course, leaving those topics best presented in texts that accompany the lecture portion of a course.

Much of the required background information is presented in the Introduction and Chapter 1. This includes sections on planes of dissection and orientational terminology (see later), as well as an introduction to vertebrates and their relatives (Chapter 1). We suggest

that these sections be included as part of the assigned readings for a particular laboratory for each vertebrate. This method will expose students repeatedly to the broad evolutionary development of each system. Terms that are required learning are placed in boldface print throughout the manual. Boldfaced terms are listed in a Key Terms section (which also provides common synonyms in parentheses) following each major component. Students will know at a glance the structures for which they are responsible. We suggest that students use this section as a key to learning the structures by writing a short description for each. The Key Terms sections also allow instructors to adapt this manual to their personal preferences in running their course. Structures that are not required can be identified and crossed out, so that students know they are not responsible for them. This method effectively allows an instructor to limit the detail of the dissection.

We believe that the concise presentation of dissection instructions combined with minimal background information results in a straightforward text that will facilitate and focus the student's learning of anatomy in laboratory. In contrast to most other manuals, much of the background material presented in lecture is omitted here, so *The Dissection of Vertebrates* is less cumbersome to use even though it covers more vertebrates than do other manuals. All the information is relevant for laboratory purposes. This should facilitate matters for the instructor as well. Among other things, it will allow a clear answer to the often-asked question "What am I responsible for reading?" The response can be, without too much exaggeration, "All of it."