Towards 100 years

सत्यमेव जयते
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जहाँ है हरियाली ।
वहाँ है खुशहाली ॥

Foreword

India is one of the seventeen mega-biodiversity countries in the world that occupied about 2.7% of global land area but support more than 7.5% of the global animal species described so far. Large varieties of ecosystems as present in the ten bio-geographic zones of India have provided appropriate environments to all such diverse fauna to survive and propagate. Before industrialization of the modern civilization man always lived in harmony with nature including the natural biotic components and understood the need of their effective and rational uses for the sake of sustainable development. Human population explosion and industrial expansion have put various stresses on every biosphere through fragmentation, modification and even by destruction. Large number of species of both plants and animals are living under several degrees of threats. Through traditional knowledge and cultural heritage the people of India through thousands of years have understood the need of conservation of bio-resources for prosperity and posterity. Those traditions have instituted our national emblem depicting animal icons with appropriate significance from more than 2000 years old erection of Emperor Ashok.

It is imperative to project and focus the animal wealth of our country to the people of India to induce their sense of attachment with such faunal resources so far as their presence utility, the threats perceived and the possible conservation strategies for their successful implementation with the people's participation. Popularization of macroscopic extant species that are commonly found in nature throughout the subcontiment as well as information on species of human cultural and conservation importance, bio-prospecting, example of different phyla and relationships between

them, national and state animals of India is necessary to arouse general awareness amongst the people towards effective conservation.

I feel proud to write this foreword to such an informative book on the valuable "Creatures of India-Guide to Animal in India with up-to-date systematic". The efforts and pains taken by the author shall find its worth on receiving appreciations form the valued readers.

17-06-2013 **K. Venktaraman**

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Preface

Indian Biodiversity, albeit being one of the richest in the world with three of the 32 "Biodiversity Hotspots", is unfortunately in a serious sate of neglect from the administration and the general public alike. Four big-sized animals, Pink-headed Duck, Himalayan Mountain Quail, Lesser Indian Rhinoceros and Indian Cheetah, have gone extinct in the last century alone. IUCN enlist India at 7th rank of shame-list, countries struggling to protect its biodiversity. With almost 18% of world population cramming into less than 2% of area, sub-continental forest cover has been steadily shrinking, so as its biodiversity. This report is first of its kind in India, a comprehensive assessment of status and trends of commonly found animals in the subcontinent with its up-to-date taxonomic positions, overview on the systematics, bio-prospecting and conservation. This work also serves as a "binomen dictionary" for looking up binomial names of virtually every animal species that you might encounter in daily life in India.

The idea to write this book sprang from one of the class assignments as part of BSS.506: Biosystematics and Biodiversity course here at the Central University of Punjab, Bathinda. The assignment was to make a database of Indian Biodiversity. While I appreciate the passion that my students put in the creation of

database, most of their entries were well-described taxa from North America and Europe-presumably obtained through online resources, highlighting the dire need to categorize Indian Biodiversity. Zoological Survey of India (ZSI) has published few checklists of animal taxa in India but those did not include several of the important animal phyla. Checklists merely enlist scientific names without common name or any other information and therefore their utility in practical identification is extremely limited. This inspired me to write a book with following focuses:

1. Limit to the macroscopic extant species that are commonly found in nature throughout the subcontinent.

2. Species of human importance; a note on bio-prospecting that highlights commercially cultivated/medicinally important/ culturally significant taxa discussed in each chapter introduction.

3. Species of conservation importance; a note on conservation discussed in each chapter introduction and common names are appropriately superscribed throughout (CR: Critically Endangered, EN: Endangered, VU: Vulnerable and NT: Near Threatened.)

4. Example families and genera covering all iconic metazoan phyla and phylogenetic trees to illustrate evolutionary relationships between them; to aid in understanding and appreciation of animal systematics.

5. Designated animals representing national and state level administration.

This book is still incomplete; as a privileged reader who appreciates the biodiversity, a column in all the tables are waiting for you to complete; "Name in Regional Language". With seventeen official languages, India is so linguistically diverse that if I sought out to include a multilingual list of taxa covered in this book, it would have doubled the weight of this book and wasted a number of pages! Instead I made this book like a class-activity notebook; it is for you to find, identify and complete the name in local dialect/ regional language in the space provided (***Activity: 1***), a simple, yet pedagogically-sound method. If you have a camera I suggest taking photographs of species that you come across and share it to the world with appropriate copyrights in websites such as http:// picasaweb.google.com.

While images greatly aid in the identification of taxa, I have not included them in this book for two reasons; it would have significantly increased number of pages (not eco-friendly) and the printing cost (not econo-friendly). What easier way to explain how ecosystems intricately relate to the global economics! I suggest the readers to look-up each taxa presented in this book at http:// images.google.com to find photographs for assisting the identification (***Activity: 2***). However let me warn that some of the photographs in the internet that is crawled by the Google might be wrongly identified and there are no easy way to figure out is it correctly identified or not. A curated list of online identification keys and links to photography sites are available at the Encyclopedia of Life website http://eol.org/collections/108 .

Hope you will enjoy this book and complete the activities to broaden your appreciation of animal biodiversity in India. Comments and suggestions for the improvement are most welcome. Next in this series focuses on plant biodiversity and is expected to come out later this year.

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Acknowledgment

To my students of BSS.506: Biosystematics and Biodiversity course here at the Central University of Punjab, Bathinda, as idea to write this book sprang from one of the class assignments as part of this course. Datasets in most of the chapters were indeed modified from the class assignment that was primarily drafted by them and therefore their contribution had been an integral part on the completion of this work. Following are the students and their respective contributions: Pinkee Batham (Aquatic Animals), Navreet Kaur (Insects), Rimplejeet Kaur (Butterflies), Divya Singh (Amphibians), Sheetal Sharma (Reptiles), Pawandeep Kaur (Birds), and Ankur Jairat & Jatinder Kaur (Mammals).

To my sweetheart, Swapna, for all the support and inspiration that she had extended throughout the making of this work. I hope my daughter, Haritha (which means Green in Malayalam!), who is one year at the time of writing this book, will someday read this book and understand why her abba (she calls me that way!) spent so much time in front of the laptop. I've made up for the lost time by paying good number of visits to the National Zoo, haven't I? I'd like to thank my parents and sister for allowing me to follow my ambitions throughout my childhood. My family, including my in-laws, has always supported me throughout my career and authoring this book and I really appreciate it.

Research in preparation of this work was done at the Central University of Punjab, my employer for the last three years. I thank Prof. Jai Rup Singh, Vice-Chancellor, for supporting me in completion of this work. I also thank Prof. P. Ramarao, Dean, Academic Affairs and Prof. R.G. Saini, Coordinator, Centre for Biosciences for their support and suggestions. Ms. Gagandeep Kaur helped with typeset of a number of chapters.

Finally, to my readers. I hope this book of activities will cultivate great reverence and fascination for the biodiversity around us! The very fact that you are reading this book shows how much you care for the nature. I hope each of you passionately dive into the preservation of all creatures-great and small, like the old James Herriot!

How to Use this Book?

- First chapter is a thorough introduction to the tree of life, origin and evolution of animals reflecting current systematics.

- Chapters 2-8 are arranged in ascending order of animal complexity and evolution. Each of these chapters begin with a quick introduction of animal group, followed by brief descriptions of major phyla/family, bio-prospecting and conservation information and finally a core table of commonly found animals of respective group.

- Tables are presented in an **organized manner;** based on ascending alphabetical order of phyla, then orders, families, binomens and finally common name, to facilitate the look-up in top-to-bottom order of taxonomical hierarchy. For *eg*., if you would like to find commonly occurring cockroaches (Order: Blattodea) in India, you could easily find it from Chapter 3 (Terrestrial Invertebrates), table No. 3.1 searching from right to left (Arthropoda > Blattodea > Blattidae & Polyphagidae) if you know the classification. Alternately, you may start right from common name (cockroach), as all are arranged in a systematic manner. You can see three species each of leaches and earthworms and two species of spiders in the same table:

Table 3.1 List of Common Terrestrial Invertebrates of India

S.NO.	COMMON NAME	COMMON NAME IN REGIONAL LANGUAGE	*BINOMIAL NAME*	FAMILY	ORDER	PHYLUM
1	Stream Leach		*Haemadipsa sp.*	Erpobdellidae	Arhynchobdellida	Annelida
2	Small river Leach		*Herpobdelloidea indica*	Erpobdellidae	Arhynchobdellida	Annelida
3	Stone Leach		*Myxobdella sp.*	Erpobdellidae	Arhynchobdellida	Annelida
4	Indian Blue Earthworm		*Perionyx sp.*	Megascolecidae	Haplotaxida	Annelida
5	Common Earthworm		*Plutellus sp.*	Megascolecid	Haplotaxida	Annelida
6	Common Earthworm		*Drawida sp.*	Moniligastridae	Moniligastrida	Annelida
7	Tent-web Spider		*Cyrtophora moluccensis*	Araneidae	Araneae	Arthropoda
8	Arboreal Tarantula Spider		*Poecilotheria regalis*	Theraphosidae	Araneae	Arthropoda
9	Oriental Cockroach		*Blatta orientalis*	Blattidae	Blattodea	Arthropoda
10	Seven spotted Cockroach		*Therea petiveriana*	Polyphagidae	Blattodea	Arthropoda
11	Tiger Beetle		*Cicindela aurofasciata*	Carabidae	Coleoptera	Arthropoda
12	Ladybird		*Coccinell magnifica*	Coccinellidae	Coleoptera	Arthropoda

1 2 3

- Each table has a column **"Common Name in Regional language"** for the readers to complete in their own regional language; an activity to facilitate the identification and learning process as well as to captivate general interest in systematics.

Chhattisgarh	Wild Buffalo^{EN}
Gujarat	Asiatic lion^{VU}
Himachal Pradesh	Snow leopard^{EN}
Jammu and Kashmir	Kashmir stag^{CR}

- **IUCN conservation status** of all organisms-wherever available- are labeled throughout with following superscription legend: CR: Critically Endangered, EN: Endangered, VU: Vulnerable and NT: Near Threatened

- Important scientific terminologies are bolded and are defined in **glossary** at the end to help students.

- An **organism index** is provided at the end for speedy reverse look-up of organisms with its common name

How to Read Phylogenetic Trees?

This book contains a number of phylogenetic trees (also known as phylogram, evolutionary tree and cladogram). One of the first illustrations of phylogenetic trees was made by Charles Darwin in his "Origin of species" in 1859 to depict the process of evolution. Interpreting phylogenetic trees is straight forward, with terms like leaf, node, branch and root as analogy to the real trees:

- Trees represent evolutionary relationships between a group of **taxa** (group of organisms), which appears on the leaves (tips). For example, refer Fig. 3.1. In this tree, leaves consist of following taxa: Anura, Caudata and Gymnophiona. With first branching point between Anura and Caudata, we interpret that these two taxa are more related than either of these two with Gymnophiona. Branching patterns like this are called "topology".
- Nodes (internal branching points) represent ancestors (more precisely, **Most Recent Common Ancestor** -MRCA), splitting of which are in fact speciation events whereby new species are formed.
- Branches leading to nodes are generally labeled with the name of the taxonomical group in which nodes and all its descendants are part of. These groups, i.e., one ancestor and

all its descendants, are called “clades”. For example, in the previous example, Batrachia is the name for the clade consisting of Anura and Caudata. With respect to Batrachia, Gymnophiona is outside of this clade and is called an “Outgroup” taxa.

- Mostly nodes are bifurcating, i.e., splitting into two. Descendants that split from same node are called “sister groups” or “sister clades”. For example, refer Fig. 1.1. Clades “unikonts” and “bikonts” are sister clades. Sometimes it could trifurcate (splitting into three), as in Fig. 1.2 (node leading to Annelids, Mollusks and Arthropods), or more. In Fig. 8.1, group consisting of taxa from Lagomorpha to Proboscidea forms a giant “polytomy”. Polytomies generally indicate insufficiency of data to resolve the tree topology clearer.
- Groups that split earlier with respect to the “root” of the tree are called “basal” to the groups that split latter. I.e., basal groups are evolutionarily more primitive than groups which are located near the edges. For example, in Fig 1.2, clade consisting of Cnidaria and Ctenophora is basal with respect to clade labeled “deuterostomes” and therefore were evolved much earlier. Sometimes these **extant** taxa which are evolved millions of years ago are called “living fossils”. For example, fish called Coelacanth (which belongs to Sarcopterygii) is a “living fossil” with respect to tetrapods, as illustrated in Fig. 1.3.
- Unless otherwise stated, phylogenetic trees convey only branching history of common ancestry. This is the case for all trees illustrated in this book. Branch lengths are irrelevant; they are drawn in whatever way trees look tidier.

Contents

1 A Primer on Animal Biodiversity

What is an Animal?

Most definitions of what it makes and constitute an animal fail to adequately capture its attribute. We traditionally define an animal as motile **multicellular** organism, but this is largely incorrect as many animals, including sponges, barnacles, corals and tunicates are **sessile**. All animals-which are grouped under Kingdom Metazoa (Animal Kingdom)-are multicellular **eukaryotes** having no cell wall with mode of nutrition being **heterotrophic**. Three related kingdoms- Protozoa, Amoebozoa and Fungi- had been traditionally grouped under Animalia, but later removed to their respective kingdoms, still contested by taxonomists. Most of the heterotrophic unicellular eukaryotes that are not plants, like euglena, paramecium, amoeba etc., are

grouped under Protozoa or Amoebozoa. Heterotrophic eukaryotes containing chitin in their cell walls are grouped under Fungi. Position of metazoa in tree of life is illustrated in Fig.1.1.

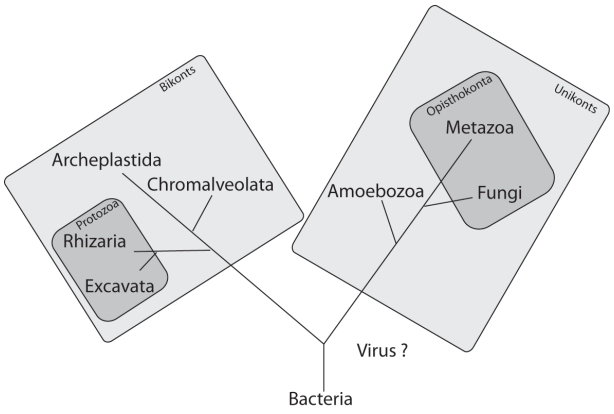

FIG. 1.1: Position of metazoa in the tree of life based on Cavalier-Smith's "six kingdom" model (Cavalier-Smith 2004).

As illustrated in Fig 1, metazoans, along with fungi and amoebozoans, are **unikonts**- organisms with ancestrally one emergent **flagellum** as opposed to **bikonts**-organisms with ancestrally two emergent flagella, which include plants (Archeplastida), brown algae (Chromalveolata) and protozoans. Here the word 'ancestrally' implies that defining character was present in the **Most Recent Common Ancestor (MRCA)** of the whole group and that some of the descendants might have lost it (e.g., Amoebozoa-that contains no flagella) or gained (e.g., Chromalveolata with three flagella). Alternatively, not all cells of multicellular organisms might be flagellated; most of the multicellular organisms have flagellated cells at some point of their life cycles though. Sperm cells of most of the animals-

including humans- consist of single emergent flagellum at the **posterior** end that helps cells to propel-a characteristic shared by all opisthokonts. Other distinguishing features of the animals are tissues linked by proteins, cells-surrounded by extracellular matrix and linked by **cell junctions**, and **embryos** that pass through distinctive **blastula** stage.

Origin and Evolution of Animals

Theory of **evolution** was championed by Charles Darwin in 19th Century. Since then, scientists from various disciplines, including geology, chemistry, developmental biology, paleontology, physiology, natural history, molecular biology and bioinformatics, have come up with multitude of tools and techniques and the evidences that are still being accumulated by them immensely help in understanding the process of evolution. As per the current understanding, our universe is 13.5 billion (1350 crore) years old and earth is 4.5 billion (450 crore) years old. Life originated in our planet approximately 3.5 billion (350 crore) years ago from inorganic matter through a much debated hypothetical process known as **abiogenesis**. Earliest forms of life were marine unicellular prokaryotes-essentially a bacteria, that evolved to cyanobacteria and later to neomuran-MRCA of all archebacteria and eukaryotes. Metazoans (animals) are believed to have formed from marine **unicellular colonial** flagellate eukaryotes, choanoflagellate, around 600 million (60 crore) years ago in late Precambrian era. By around 530 million (53 crore) years ago almost all extant animal phyla have been formed in ocean, a geological event called “Cambrian explosion”.

Earliest known animals lacked tissue organization and are classified under parazoa (where phylum Porifera is part of). After the evolution of **tissues**, group of "true animals" (eumetazoa) have emerged that were further evolved based on development of body plans (*viz*., radial *vs*. bilateral ancestry). **Radially symmetrical** organisms including cnidarians and ctenophorans are sometimes grouped under "Radiata" while all other organisms which are ancestrally bilaterally symmetrical are grouped under "Bilataria". Mind that bilataria is a **paraphyletic** clade with some members –notably echinoderms- are radially symmetrical. Radiata embryos display two **germ layers**-viz. endoderm and ectoderm- and therefore are **diploblastic** while bilatarian embryos have three germ layers (endoderm, mesoderm and ectoderm) and are **triploblastic**. Endoderm, mesoderm and ectoderm develop into gut, muscle and skin respectively.

Bilaterians are further classified based on the evolution of **body cavities (Coelom)**. Acoleomates (like Platyhelminthes) have no body cavity while pseudocoelomates (like Nematodes) have body cavities-known as pseudocoelom- that is not surrounded by mesoderm. Coelomates have fluid-filled body cavities-coelom- that are surrounded by mesoderm. Coelom in human beings comprises of peritoneal cavity in the abdomen, pleural cavity in the lungs and pericardial cavity surrounding heart. An alternate classification is based on the developmental fate of the first opening of embryonic development -the blastopore. In **protostomes** (from Greek for "mouth first"), **blastopore** becomes mouth while in **deuterostomes** (from Greek for "mouth second") it becomes anus. In other words, in Protostomes, mouth formed first and anus second, while in

deuterostomes, mouth formed after anus. Well known protostome phyla include annelids, mollusks, arthropods, nematodes and platyhelminthes, while deuterostome phyla include echinoderms and chordates. However, after a recent discovery of "penis worm" (*Priapulus caudatus*)-which is a protostome but develops in deuterostome fashion in terms of gene expression, classic lineages of protostomes and deuterostomes have largely became obsolete (Martín-Durán *et al*. 2012).

With molecular data vastly aiding in the biosystematics, many of the traditional groups-that are mainly based on **ontogeny**- are being challenged. Traditional metazoan lineages based on ontogeny of body cavity (Coelomate Vs. Pseudocoelomate Vs. Acoelomate) and developmental fate of blastopore (Protostomes Vs. Deuterostomes) have been found to be **polyphyletic** in these molecular phylogenetic analyses and therefore new **clades** were proposed to reflect true relationships. One such clade defined based on phylogenetic systematics (**homology** of 18S rRNA genes) is ecdysozoa (Aguinaldo 1997) that is strongly supported by several independent studies. This superphylum consists of Arthropods and Nematods-organisms that shed their exoskeleton (a process called ecdysis). Another superphylum defined based on molecular evidence is Lophotrochozoa that includes well-known phyla annelids, mollusks and platyhelminthes. Evolution of major metazoan lineages (as per both traditional and molecular systematics) are illustrated in Fig. 1.2.

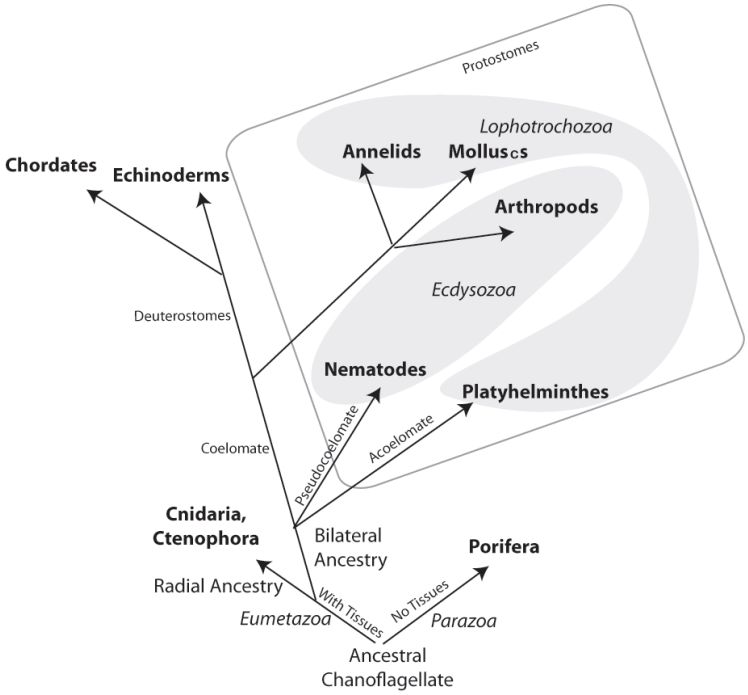

Fig 1.2: Evolution of major metazoan phyla. Phyla are represented as bold, major character states for phyletic delineation marked along lines in smaller font size, major supra-phyletic groups in italics and groups defined solely based on molecular evidences inside gray areas.

Diversity of Chordates

Chordates are organisms having a distinctive **notochord** (primitive "backbone") in the embryos. Other unique features of chordates include presence of hollow dorsal nerve cord (that develop to brain and spinal cord), endostyle (ciliated groove in the pharyngeal wall that produces mucus to collect food particles) and muscular post-anal tail at some point in their life cycles. Well-known subphyla of chordates include Urochordates

(Tunicates-sessile marine organisms; ca 3,000 species) and Vertebrates (Craniates; ca 60,000 species). Vertebrates, by far, is the most conspicuous animals in a human-centric perspective such that all animals other than vertebrates are often referred as "invertebrates". Unique features of vertebrates include presence of vertebral column, skull and closed circulatory system. Most well-known classes of vertebrates include Chondrichthyes (Cartilaginous Fishes including Sharks and Rays; ca 1000 species), Actinopterygii (Ray-finned Bony Fishes; ca 30,000 species) and Tetrapods-which include Sarcopterygii ("Lobe-finned fish" like Coelacanths and Lung Fishes, less than 50 species), Amphibians (ca 6000 species), Reptiles (ca 9000 species), Aves (ca 10,000 species) and Mammals (ca 6000 species). The last four classes are included in superclass tetrapoda (animals with four limbs), of which classes Reptiles, Aves and Mammals form a distinct clade Amniota (animals with amnios-pouch in which embryo develops). Reptiles and Aves form yet another clade Sauropsida ("Lizard-face").

Evolution of vertebrates, to an extent, is interestingly portrayed in Hindu concept of "Dashavatara" (ten incarnations of Lord Vishnu), as originally noted by famous British Evolutionary Biologist J.B.S. Haldane. Incarnations sequentially depicts the following: Matsya (Fish), Kurma (Reptile), Varaha (Wild Boar), Vamana (Dwarf Man) and finally to Parashurama (Man with an Axe). In addition, many of the Hindu epics including Ramayana and Mahabharatha portray exotic humanoid creatures called "Vanara", which in fact brilliantly portray hominid evolution.

Tree illustrating evolution of major chordate classes is presented as Fig. 1.3, to aid in the above discussion.

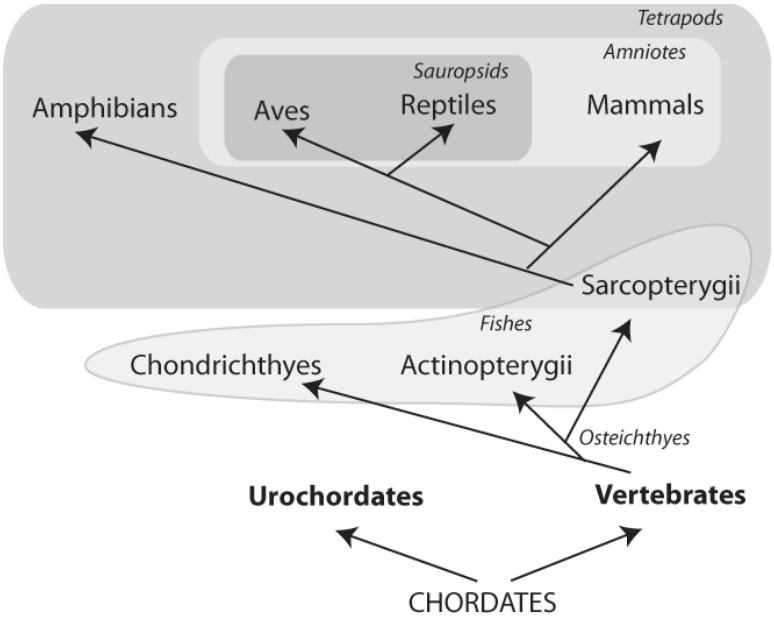

Fig 1.3: Evolution of major chordate classes. Subphyla are represented as bold and superclass as italics. Shaded regions represent clades that are included in the respective superclass.