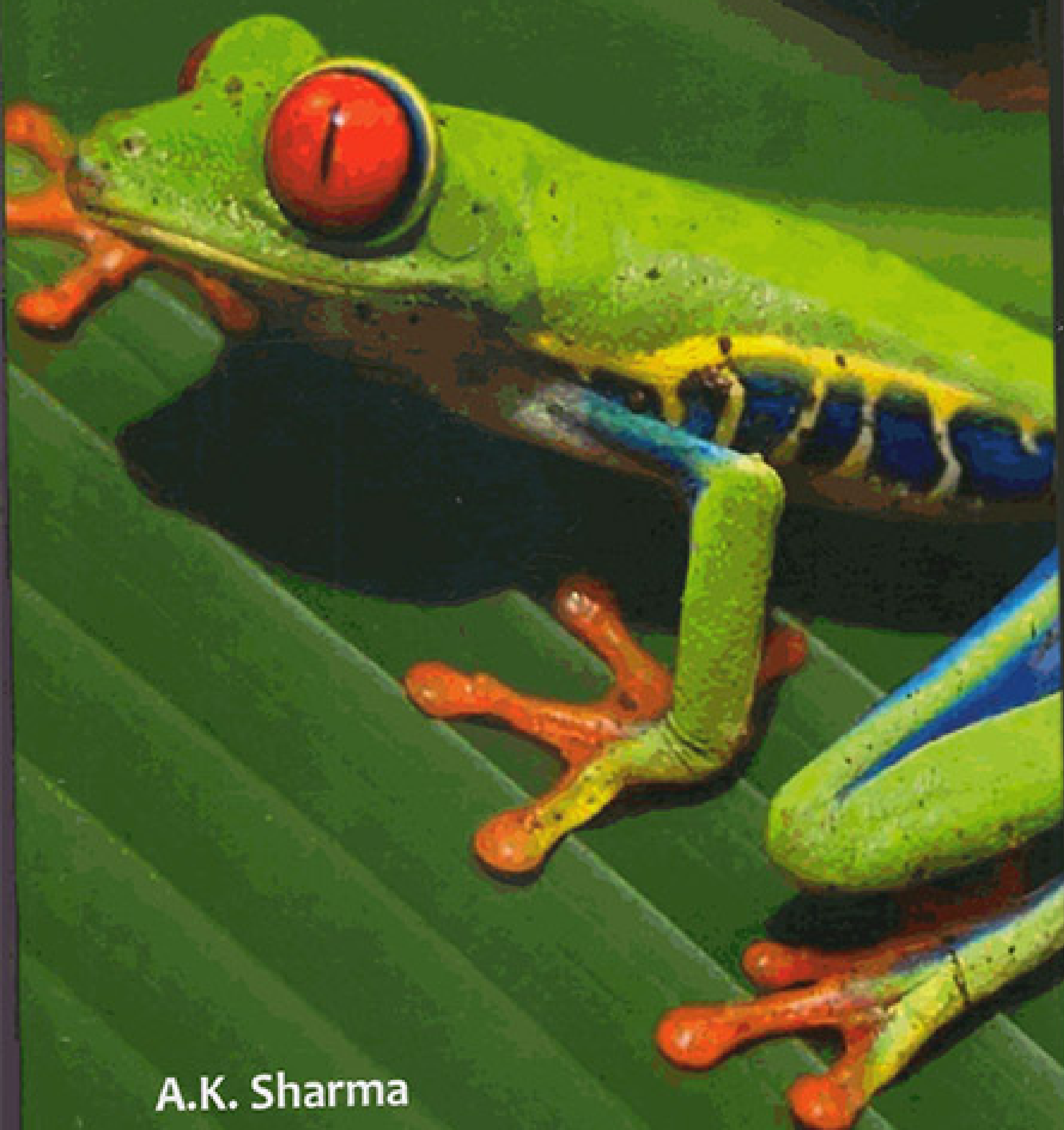
Research Methodology and Techniques in

Zoology



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Research Methodology and Techniques in Zoology

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Preface

Zoology is the scientific study of the characteristics and classification of animals. It is one of the branches of biology, and therefore it is also referred to as animal biology. There are several sub-branches within this field, including ethology, zoography, and anthrozoology. Additionally, zoologists often specialize in the study of specific types of animals. For instance, an ornithologist studies birds, while a mammologist studies mammals. As zoology is a very interdisciplinary subject, there are a number of related fields, including taxonomy, paleontology, and evolutionary biology. Although the study of animal life is ancient, its scientific incarnation is relatively modern. This mirrors the transition from natural history to biology at the start of the nineteenth century. Since Hunter and Cuvier, comparative anatomical study has been associated with morphography shapins the modern areas of zoological investigation: anatomy, physiology, histology, embryology, teratology and ethology. Modern zoology first arose in German and British universities. In Britain, Thomas Henry Huxley was a prominent figure. His ideas were centred on the morphology of animals. Many consider him the greatest comparative anatomist of the latter half of the nineteenth century. Similar to Hunter, his courses were composed of lectures and laboratory practical classes in contrast to the previous format of lectures only.

Zoologists are scientists who study animals. They may work in laboratories, or do field research. The methods are many and various. At the heart, they cover the structure, function, ecology and evolution of animals. The structure is investigated by dissection, and microscopic examination. The function is investigated by observation and experiment. Palaeontology supplies information about extinct animals. Zoologists may be employed by universities, museums, or by zoos. Some zoologists choose to focus on the study of how humans and animals interact. This is called anthrozoology, and can include the study of how animals were domesticated, how humans think about animals, and the bonds formed between humans and animals. It's often connected with studies of animal rights, ethology, and psychology. Other researchers in anthrozoology focus on veterinary medicine, or on how animals can be used in therapy for humans.

Studying a wide range of animals is providing enormous insight to understanding some of the issues in general biology and can have very unexpected spin-off benefits in medical and engineering areas.

—Editor

Chapter 1

Introduction

Zoology refers to the scientific study of the animals. It involves the detailed examining and analysis of their behaviour, structural formations, physiology, classification and distribution on planet earth.

History

Ancient History to Darwin

The history of zoology traces the study of the animal kingdom from ancient to modern times. Although the concept of *zoology* as a single coherent field arose much later, the zoological sciences emerged from natural history reaching back to the works of Aristotle and Galen in the ancient Greco-Roman world. This ancient work was further developed in the Middle Ages by Muslim physicians and scholars such as Albertus Magnus. During the Renaissance and early modern period, zoological thought was revolutionized in Europe by a renewed interest in empiricism and the discovery of many novel organisms.

Prominent in this movement were Vesalius and William Harvey, who used experimentation and careful observation in physiology, and naturalists such as Carl Linnaeus and Buffon who began to classify the diversity of life and the fossil record, as well as the development and behaviour of organisms. Microscopy revealed the previously unknown world of microorganisms, laying the groundwork for cell theory. The growing importance of natural theology, partly a response to the rise of mechanical philosophy, encouraged the growth of natural history (although it entrenched the argument from design).

Over the 18th and 19th centuries, zoology became an increasingly professional scientific discipline. Explorer-naturalists such as Alexander von Humboldt investigated the interaction between organisms and their environment, and the ways this relationship depends on geography, laying the foundations for biogeography, ecology and ethology. Naturalists began to reject essentialism and consider the importance of extinction and the mutability of species. Cell theory provided a new perspective on the fundamental basis of life.

Post-Darwin

These developments, as well as the results from embryology and paleontology, were synthesized in Charles Darwin's theory of evolution by natural selection. In 1859, Darwin placed the theory of organic evolution on a new footing, by his discovery of a process by which organic evolution can occur, and provided observational evidence that it had done so.

Darwin gave new direction to morphology and physiology, by uniting them in a common biological theory: the theory of organic evolution. The result was a reconstruction of the classification of animals upon a genealogical basis, fresh investigation of the development of animals, and early attempts to determine their genetic relationships. The end of the 19th century saw the fall of spontaneous generation and the rise of the germ theory of disease, though the mechanism of inheritance remained a mystery. In the early 20th century, the rediscovery of Mendel's work led to the rapid development of genetics by Thomas Hunt Morgan and his students, and by the 1930s the combination of population genetics and natural selection in the "neo-Darwinian synthesis".

Research

Structural: Cell biology studies the structural and physiological properties of cells, including their behaviour, interactions, and environment. This is done on both the microscopic and molecular levels, for single-celled organisms such as bacteria as well as the specialised cells in multicellular organisms such as humans. Understanding the structure and function of cells is fundamental to all of the biological sciences. The similarities and differences between cell types are particularly relevant to molecular biology.

Anatomy considers the forms of macroscopic structures such as organs and organ systems.

Physiological

Physiology studies the mechanical, physical, and biochemical processes of living organisms by attempting to understand how all of the structures function as a whole. The theme of "structure to function" is central to biology. Physiological studies have traditionally been divided into plant physiology and animal physiology, but some principles of physiology are universal, no matter what particular organism is being studied.

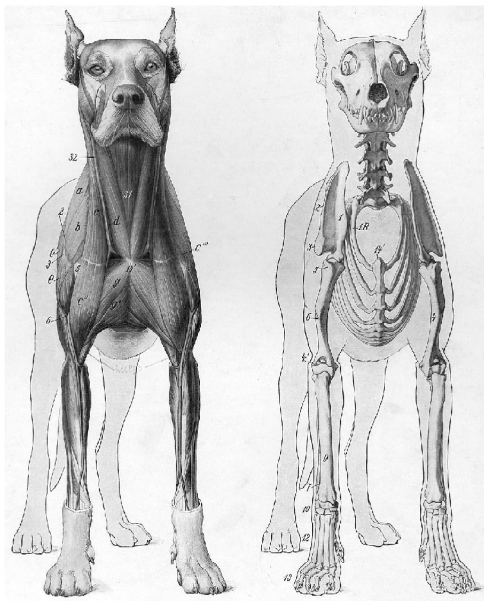

Figure: *Animal anatomical engraving from* Handbuch der Anatomie der Tiere für Künstler.

For example, what is learned about the physiology of yeast cells can also apply to human cells. The field of animal physiology extends the tools and methods of human physiology to non-human species. Physiology studies how for example nervous, immune, endocrine, respiratory, and circulatory systems, function and interact.

Evolutionary

Evolutionary research is concerned with the origin and descent of species, as well as their change over time, and includes scientists from many taxonomically oriented disciplines. For example, it generally involves scientists who have special training in particular organisms such as mammalogy, ornithology, or herpetology, but use those organisms as systems to answer general questions about evolution.

Evolutionary biology is partly based on paleontology, which uses the fossil record to answer questions about the mode and tempo of evolution, and partly on the developments in areas such as population genetics and evolutionary theory. In the 1980s, developmental biology re-entered evolutionary biology from its initial exclusion from the modern synthesis through the study of evolutionary developmental biology. Related fields often considered part of evolutionary biology are phylogenetics, systematics, and taxonomy.

Systematics

Scientific classification in zoology, is a method by which zoologists group and categorize organisms by biological type, such as genus or species. Biological classification is a form of scientific taxonomy. Modern biological classification has its root in the work of Carolus Linnaeus, who grouped species according to shared physical characteristics. These groupings have since been revised to improve consistency with the Darwinian principle of common descent. Molecular phylogenetics, which uses DNA sequences as data, has driven many recent revisions and is likely to continue to do so. Biological classification belongs to the science of zoological systematics.

Many scientists now consider the five-kingdom system outdated. Modern alternative classification systems generally start with the three-domain system: Archaea (originally Archaebacteria); Bacteria (originally Eubacteria); Eukaryota (including protists, fungi, plants, and animals) These domains reflect whether the cells have nuclei or not, as well as differences in the chemical composition of the cell exteriors.

Further, each kingdom is broken down recursively until each species is separately classified. The order is: Domain; Kingdom; Phylum; Class; Order; Family; Genus; Species. The scientific name of an organism is generated from its genus and species. For example, humans are listed as *Homo sapiens*. *Homo* is the genus, and *sapiens* the species. When writing the scientific name of an organism, it is proper to capitalize the first letter in the genus and put all of the species in lowercase. Additionally, the entire term may be italicized or underlined.

The dominant classification system is called the Linnaean taxonomy. It includes ranks and binomial nomenclature. The classification, taxonomy, and nomenclature of zoological organisms is administered by the International Code of Zoological Nomenclature, and International Code of Nomenclature of Bacteria for animals and bacteria, respectively. The classification of viruses, viroids, prions, and all other sub-viral agents that demonstrate biological characteristics is conducted by the International Code of Virus classification and nomenclature. However, several other viral classification systems do exist.

A merging draft, BioCode, was published in 1997 in an attempt to standardize nomenclature in these areas, but has yet to be formally adopted. The BioCode draft has received little attention since 1997; its originally planned implementation date of January 1, 2000, has passed unnoticed. However, a 2004 paper concerning the cyanobacteria does advocate a future adoption of a BioCode and interim steps consisting of reducing the differences between the codes. The International Code of Virus Classification and Nomenclature (ICVCN) remains outside the BioCode.

Ethology

Ethology is the scientific and objective study of animal behaviour. The focus of ethology is on animal behaviour under natural conditions, as opposed to behaviourism, which focuses on behavioural response studies in a laboratory setting. Ethologists have been particularly concerned with the evolution of behaviour and the understanding of behaviour in terms of the theory of natural selection. In one sense, the first modern ethologist was Charles Darwin, whose book, *The Expression of the Emotions in Man and Animals,* influenced many future ethologists.

Biogeography studies the spatial distribution of organisms on the Earth, focusing on topics like plate tectonics, climate change, dispersal and migration, and cladistics.

Branches of Zoology

Although the study of animal life is ancient, its scientific incarnation is relatively modern. This mirrors the transition from natural history to biology at the start of the nineteenth century. Since Hunter and Cuvier, comparative anatomical study has been associated with morphography shapins the modern areas of zoological investigation: anatomy, physiology, histology, embryology, teratology and ethology. Modern zoology first arose in German and British universities. In Britain, Thomas Henry Huxley was a prominent figure. His ideas were centred on the morphology of animals. Many consider him the greatest comparative anatomist of the latter half of the nineteenth century. Similar to Hunter, his courses were composed of lectures and laboratory practical classes in contrast to the previous format of lectures only.

Gradually zoology expanded beyond Huxley's comparative anatomy to include the following sub-disciplines:

- Zoography, also known as *descriptive zoology*, describes animals and their habitats

- Comparative anatomy studies the structure of animals.
- Animal physiology
- Behavioural ecology
- Ethology studies animal behaviour.
- Invertebrate Zoology.
- Vertebrate Zoology.
- Comparative Zoology.
- The various taxonomically oriented disciplines such as mammalogy, herpetology, ornithology and entomology identify and classify species and study the structures and mechanisms specific to those groups.

Related fields:

- Evolutionary biology: Development of both animals and plants is considered in the articles on evolution, population genetics, heredity, variation, Mendelism, reproduction.
- Molecular Biology studies the common genetic and developmental mechanisms of animals and plants
- Palaeontology
- Systematics, cladistics, phylogenetics, phylogeography, biogeography and taxonomy classify and group species via common descent and regional associations.

Fauna

Figure: *Australian and New Zealand Fauna. This image was likely first published in the first edition (1876–1899) of the Nordisk familjebok.*

Fauna is all of the animal life of any particular region or time. The corresponding term for plants is *flora*. Flora, fauna and other forms of life such as fungi are collectively referred to as biota.

Zoologists and paleontologists use *fauna* to refer to a typical collection of animals found in a specific time or place, e.g. the "Sonoran Desert fauna" or the "Burgess Shale fauna".

Paleontologists sometimes refer to a sequence of faunal stages, which is a series of rocks all containing similar fossils.

Subdivisions of Fauna

Cryofauna: *Cryofauna* are animals that live in, or very close to, ice.

Cryptofauna: *Cryptofauna* are animals that are rarely seen and may be extinct or mythological.

Infauna: *Infauna* are benthic organisms that live within the bottom substratum of a body of water, especially within the bottom-most oceanic sediments, rather than on its surface. Bacteria and microalgae may also live in the interstices of bottom sediments. In general infaunal animals become progressively smaller and less abundant with increasing water depth and distance from shore, whereas bacteria show more constancy in abundance, tending toward one billion cells per millilitre of interstitial seawater.

Epifauna: *Epifauna*, also called *epibenthos*, are aquatic animals that live on the bottom substratum as opposed to within it, that is, the benthic fauna that live on top of the sediment surface at the seafloor.

Macrofauna: *Macrofauna* are benthic or soil organisms which are retained on a 0.5mm sieve. Studies in the deep sea define macrofauna as animals retained on a 0.3mm sieve to account for the small size of many of the taxa.

Megafauna: *Megafauna* are large animals of any particular region or time. For example, Australian megafauna.

Meiofauna: *Meiofauna* are small benthic invertebrates that live in both marine and fresh water environments. The term *Meiofauna* loosely defines a group of organisms by their size, larger than microfauna but smaller than macrofauna, rather than a taxonomic grouping. One environment for meiofauna is between grains of damp sand.

In practice these are metazoan animals that can pass unharmed through a 0.5 – 1 mm mesh but will be retained by a 30 – 45 ìm mesh, but the exact dimensions will vary from researcher to researcher.

Whether an organism passes through a 1 mm mesh also depends upon whether it is alive or dead at the time of sorting.

Mesofauna: *Mesofauna* are macroscopic soil invertebrates such as arthropods or nematodes. Mesofauna are extremely diverse; considering just the springtails (Collembola), as of 1998, approximately 6,500 species had been identified.

Microfauna: *Microfauna* are microscopic or very small animals (usually including protozoans and very small animals such as rotifers).

Other: Other terms include *avifauna*, which means "bird fauna" and *piscifauna* (or *ichthyofauna*), which means "fish fauna".

Branches of Zoology

- Acarology
- Anthrozoology
- Arachnology
- Batrachology
- Cetology
- Entomology
- Ethology
- Herpetology
- Ichthyology
- Malacology
- Mammalogy
- Myrmecology
- Neuroethology
- Ornithology
- Paleozoology
- Parasitology
- Protozoology
- Endocrinology
- Nematology
- Helminthology

Animal

Animals are multicellular, eukaryotic organisms of the kingdom Animalia or Metazoa. Their body plan eventually becomes fixed as they develop, although some undergo a process of metamorphosis

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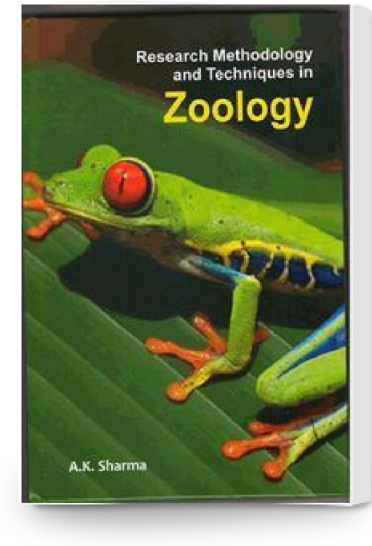

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