

ELEMENTS OF BIOLOGICAL SCIENCE

THIRD
EDITION



William T. Keeton
Carol Hardy McFadden

NORTON

INTERNATIONAL
STUDENT EDITION

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CORNELL UNIVERSITY

Elements of Biological Science

THIRD EDITION

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PREFACE

Biological science can and should be one of the most stimulating subjects a college student encounters. Nothing else, after all, has such immediate personal relevance as the phenomenon of life; and biological science, as the study of life, sheds light on what every individual experiences in himself and observes around him. Given the inherent excitement of the subject, there is no excuse for an introductory biology course to be dull.

A textbook for today's students must do justice to the newer areas of biological science without neglecting the older that provide the foundation upon which the new rests. I have tried for an accurate and honest picture of the current state of our knowledge (and ignorance) in each of the major areas, without prejudice to any one of them; thus such topics as cellular ultrastructure, photosynthesis and respiration, molecular genetics, and developmental biology have been carefully examined, but not at the expense of "whole organism" and population biology.

The above paragraphs by William T. Keeton, in the prefaces to the first and second editions, are equally appropriate today. My objective has been to maintain the integrity of Dr. Keeton's approach in this edition,

while at the same time introducing a number of important changes that will suit the needs of today's students. Fortunately, Dr. Keeton was able to begin this revision before his untimely death, and I have had the benefit of his special insight and experience.

My own teaching experience with *Elements of Biological Science* led me to believe that the third edition should be more than a shortened version of Dr. Keeton's longer book, *Biological Science*. Hence, though many of the most important revisions of the latter have been preserved in *Elements*, users of the new edition will find in virtually every chapter changes that reflect the needs of students of a shorter course. A survey of the opinions of users of the previous edition of *Elements*, though it yielded many conflicting responses, helped to establish a general framework for the revision. Nothing, after all, can replace the experience of teachers in the classroom and a healthy respect for the complexities of teaching a diverse and complicated subject to first-year students. I thank the many teachers who took the time to advise us through that questionnaire.

Like the third edition of *Biological Science*, *Elements* now places new emphasis on weak bonds and

their role in biological processes. Introduced early in Chapter 2, weak bonds are used throughout, to explain such phenomena as protein conformation, regulation of enzyme activity, nucleic acid structure, the special properties of water, and membrane structure. Discussions of many topics have been added or updated in this edition; among them are the fluid-mosaic model of the cell membrane, the chemiosmotic hypothesis, the concept of parental investment, altruistic behavior, the cell cycle, the function of guard cells, gas exchange in birds, the immune response, cancer, the gradualist versus the punctuated-equilibrium concept of speciation, the mechanism of gene action, and (particularly) recombinant DNA technology. Some more specialized topics from *Biological Science* have been omitted, abbreviated, or simplified to meet the needs of the students who take a short survey course. *Elements* continues to be designed for those who teach a two-quarter or one-semester course, and for those who merely want a less extensive text than *Biological Science*.

Elements divides the more lengthy, complicated chapters of *Biological Science* into two, sometimes three, smaller chapters. For example, basic chemistry is now presented in two chapters ("Some Simple Inorganic Chemistry" and "Some Simple Organic Chemistry"), since students seem to want their chemistry in bite-sized chunks; the topic of energy transformations has been given like treatment for similar reasons. For a number of topics, such as nutrient procurement and internal transport, this approach means that plants and animals are now treated in separate chapters. An immediate advantage of these changes is increased flexibility for teachers who do not follow the topical sequence of the book. It is now easier, in courses that present metabolism before photosynthesis, for instance, or that separate plant and animal physiology, to make assignments in the text without asking students to stop reading in mid-chapter. But despite the division of chapters along plant and animal lines, *Elements* retains the original philosophy of stressing the similarity in diversity; it discusses the problems faced by all forms of life—plant, animal, or microbe—and compares alternative "solutions" to these problems. Cells are now discussed in two chapters, but we have retained one of the most significant advantages of Keeton's approach: an examination of the cell membrane serves as a conceptual introduction to the biology of subcellular structures.

Though *Elements of Biological Science* is a survey of organismal biology, it places emphasis on some topics of particular human social significance. Among these are the digestion of lactose by adults, thromboembolic and hypertensive disease, trisomy, diet and atherosclerosis, the effects of vitamin A deficiency,

the mode of action of neurological drugs, and the differences between red and white skeletal muscle and their implications for human activity.

A clean, readable page layout allows a synchrony of text and illustrations lacking in many other books. Ruth Mandel, our photo editor, has spent many hours ferreting out new photos. I am grateful to her for these, and for her efforts in laying out the text. Spectacular color photos, chosen for sound pedagogical reasons, are now interspersed throughout. Line art has been carefully re-evaluated for the needs of the short course; many captions have been rewritten to provide additional interpretation of complex subjects. As before, the drawings and diagrams are largely the work of Paula DiSanto Bensadoun, and they continue to clarify difficult concepts and to provide useful visual summaries.

A variety of study and teaching aids accompany this textbook. For the first time, a summary—"Concepts in Brief"—is included at the end of each chapter. This tests student recall of major concepts by providing a brief synopsis of important points. In addition, a complete glossary and an exceptionally thorough index are included at the end of the book. Also, for the first time, a teacher's manual and a study guide accompany the text. The teacher's manual provides practical teaching suggestions and references, and includes a test bank of exam questions drawn from many years of class testing. The study guide details key concepts, objectives, and suggested readings, and provides the student with a series of study questions to test mastery of the material.

I have had considerable help from a number of individuals in the preparation of this edition. Joseph Calvo, Carolyn Eberhard, Jean Hardy, Barbara Keeton, John Kramer, Robert Turgeon, Jerry Waldvogel, and the students in Cornell's Biology 101–102, Biology 105–106, and Biology 109–110 have all contributed in some way.

Special appreciation is due to all the people at W. W. Norton who worked with me, and especially to James Jordan, whose advice and encouragement kept me going. His suggestions contributed enormously to improving the presentation of this text. I also owe particular thanks to Esther Jacobson, whose watchful eye and careful attention to detail saved me from innumerable errors and inconsistencies. It has been a pleasure to work with so many fine people.

Finally, I thank the late William T. Keeton, who made biology the most exciting and vital part of my academic life. I hope that this book will be a suitable memorial to him.

Carol Hardy McFadden
Ithaca, New York

Elements of Biological Science

APPENDIX: A CLASSIFICATION OF LIVING THINGS

The classification given here is one of many in current use. Some other systems recognize more or fewer divisions and phyla, and combine or divide classes in a variety of other ways; but compared with the large areas of agreement, the differences between the various classifications are minor.

Botanists have traditionally used the term “division” for the major groups that zoologists have called phyla. In classifications recognizing only two or three kingdoms, this difference in terminology causes little difficulty, because usage can be consistent within each kingdom. But when a kingdom Protista is recognized, as it is here, consistency is achieved only at the expense of violating well-established usage. The Protista contain some plantlike or funguslike groups traditionally called divisions and some animal-like groups traditionally called phyla. These usages we have respected.

Most classes within a division or phylum are listed here, but where there is only one class it is not named. For some classes (e.g. Insecta and Mammalia) orders are given too. Except for a few extinct groups of particular evolutionary importance (e.g. Placodermi), only groups with living representatives are included. A few of the better-known genera are mentioned as examples in each of the taxons.

Whenever possible, an estimate (a very rough one) of the number of living species is provided for higher taxons.

KINGDOM MONERA

DIVISION SCHIZOMYCETES. Bacteria* (1,400)

- CLASS MYCOPLASMATA. *Mycoplasma*, *Acholeplasma*
 CLASS RICKETTSIAE. *Rickettsia*, *Coxiella*
 CLASS CHLAMYDIAE. *Chlamydia*
 CLASS ACTINOMYCETES. *Streptococcus*, *Staphylococcus*,
Arthrobacter, *Actinomyces*, *Streptomyces*
 CLASS EUBACTERIA. *Escherichia*, *Rhizobium*, *Spirillum*,
Salmonella, *Nitrosomonas*, *Serratia*, *Thiocystis*
 CLASS MYXOBACTERIA. *Myxococcus*, *Chondromyces*
 CLASS SPIROCHETES. *Leptospira*, *Spirocheta*, *Treponema*

DIVISION CYANOBACTERIA. Blue-green bacteria (1,800). *Gloeocapsa*, *Microcystis*, *Oscillatoria*, *Nostoc*, *Scytonema*

DIVISION PROCHLOROPHYTA. *Prochloron*

KINGDOM PROTISTA

SECTION PROTOPHYTA: Algal protists

DIVISION EUGLENOPHYTA. Euglenoids (800). *Euglena*, *Eutreptia*, *Phacus*, *Colacium*

DIVISION CHRYSOPHYTA

- CLASS CHRYSOPHYCEAE. Golden-brown algae (650). *Chrysamoeba*,
Chromulina, *Synura*, *Mallomonas*
 CLASS HAPTOPHYCEAE (or Prymnesiophyceae). Haptophytes and
 coccolithophores. *Isochrysis*, *Prymnesium*, *Phaeocystis*,
Coccolithus, *Hymenomonas*
 CLASS XANTHOPHYCEAE. Yellow-green algae (360). *Botrydiopsis*,
Halosphaera, *Tribonema*, *Botrydium*
 CLASS EUSTIGMATOPHYCEAE. Eustigmatophytes. *Pleurochloris*,
Visheria, *Pseudocharaciopsis*
 CLASS CHLOROMONADOPHYCEAE. Chloromonads. *Gonyostomum*,
Reckertia
 CLASS BACILLARIOPHYCEAE. Diatoms (10,000). *Pinnularia*,
Arachnoidiscus, *Triceratium*, *Pleurosigma*

DIVISION PYRROPHYTA. Dinoflagellates (1,000). *Gonyaulax*, *Gymnodinium*, *Ceratium*, *Gloeodinium*

DIVISION CRYPTOPHYTA. Cryptomonads. *Cryptomonas*, *Chroomonas*, *Chilomonas*, *Hemiselmis*

SECTION PROTOMYCOTA: Fungal protists

DIVISION HYPHOCHYTRIDIOMYCOTA. Hyphochytrids (25). *Rhizidiomyces*

DIVISION CHYTRIDIOMYCOTA. Chytrids (1,000). *Olpidium*, *Rhizophydium*, *Diplophlyctis*, *Cladochytrium*

*There is no generally accepted classification for bacteria at the higher taxon level. One recent classification divides the bacteria into 17 distinct divisions, some without formal names. Another important classification assigns them to 19 "parts," most without formal names. The classification used here, recognizing seven classes, is a conservative one.

SECTION GYMNOAMYCOTA: Slime molds

DIVISION PLASMODIOPHOROMYCOTA. Plasmodiophores (or endoparasitic slime molds). *Plasmodiophora*, *Spongospora*, *Woronina*

DIVISION LABYRINTHULOMYCOTA. Net slime molds. *Labyrinthula*

DIVISION ACRASIOMYCOTA. Cellular slime molds (26). *Dictyostelium*, *Polysphondylium*

DIVISION MYXOMYCOTA. True slime molds (400). *Physarum*, *Hemitrichia*, *Stemonitis*

SECTION PROTOZOA: Animal-like protists

PHYLUM MASTIGOPHORA

- CLASS ZOOFLAGELLATA. "Animal" flagellates (5,000).
Trypanosoma, *Calonympha*, *Chilomonas*, *Trichonympha*
 CLASS OPALINATA.† Opalinids (200). *Opalina*, *Zelleriella*

PHYLUM SARCODINA (or Rhizopoda). Pseudopodal protozoans (11,500)

- CLASS RHIZOPODEA. Naked and shelled amoebae,
 foraminiferans. *Amoeba*, *Pelomyxa*, *Entamoeba*, *Arcella*,
Globigerina, *Textularia*
 CLASS ACTINOPODEA. Radiolarians, heliozoans, acantharians.
Aulacantha, *Acanthometron*, *Actinosphaerium*, *Actinophrys*

PHYLUM SPOROZOA. Sporulation protozoans (3,600)

- CLASS TELOSPOREA. *Monocystis*, *Gregarina*, *Eimeria*, *Toxoplasma*,
Plasmodium
 CLASS PIROPLASMEA. *Babesia*, *Theileria*

PHYLUM CNIDOSPORA. Cnidosporians (1,100)

- CLASS MYXOSPOREA. *Myxobolus*, *Myxidium*, *Ceratomyxa*
 CLASS MICROSPOREA. *Nosema*, *Thelohania*, *Pleistophora*

PHYLUM CILIATA (or Ciliophora). Ciliates (6,000). *Paramecium*, *Stentor*, *Vorticella*, *Spirostomum*

KINGDOM PLANTAE

DIVISION CHLOROPHYTA. Green algae (7,000). *Chlamydomonas*, *Volvox*, *Ulothrix*, *Spirogyra*, *Oedogonium*, *Ulva*

DIVISION CHAROPHYTA. Stoneworts (300). *Chara*, *Nitella*, *Tolypella*

DIVISION PHAEOPHYTA. Brown algae (1,500). *Sargassum*, *Ectocarpus*, *Fucus*, *Laminaria*

DIVISION RHODOPHYTA. Red algae (4,000). *Nemalion*, *Polysiphonia*, *Dasya*, *Chondrus*, *Batrachospermum*

†The opalinids are sometimes placed in the Ciliata, because they have cilia instead of flagella, but they lack the other diagnostic characters of Ciliata. It must be admitted, however, that they do not fit well in the Mastigophora either.

DIVISION BRYOPHYTA (23,600)

- CLASS HEPATICAE. Liverworts. *Marchantia*, *Conocephalum*, *Riccia*, *Porella*
 CLASS ANTHOCEROTAE. Hornworts. *Anthoceros*
 CLASS MUSCI. Mosses. *Polytrichum*, *Sphagnum*, *Mnium*

DIVISION TRACHEOPHYTA. Vascular plants

Subdivision Psilopsida. *Psilotum*, *Tmesipteris*

Subdivision Lycopsidea. Club mosses (1,500). *Lycopodium*, *Phylloglossum*, *Selaginella*, *Isoetes*, *Stylites*

Subdivision Sphenopsida. Horsetails (25). *Equisetum*

Subdivision Pteropsida. Ferns (10,000). *Polypodium*, *Osmunda*, *Dryopteris*, *Botrychium*, *Pteridium*

Subdivision Spermpsida. Seed plants

CLASS PTERIDOSPERMAE. Seed ferns. No living representatives

CLASS CYCADAEE. Cycads (100). *Zamia*

CLASS GINKGOAE (1). *Ginkgo*

CLASS CONIFERAEE. Conifers (500). *Pinus*, *Tsuga*, *Taxus*, *Sequoia*

CLASS GNETEAE (70). *Gnetum*, *Ephedra*, *Welwitschia*

CLASS ANGIOSPERMAE. Flowering plants

SUBCLASS DICOTYLEDONEAE. Dicots (225,000). *Magnolia*, *Quercus*, *Acer*, *Pisum*, *Taraxacum*, *Rosa*, *Chrysanthemum*, *Aster*, *Primula*, *Ligustrum*, *Ranunculus*

SUBCLASS MONOCOTYLEDONEAE. Monocots (50,000). *Lilium*, *Tulipa*, *Poa*, *Elymus*, *Triticum*, *Zea*, *Ophrys*, *Yucca*, *Sabal*

KINGDOM FUNGI

DIVISION OOMYCOTA. Water molds, white rusts, downy mildews (400). *Saprolegnia*, *Phytophthora*, *Albugo*

DIVISION ZYGOMYCOTA. Conjugation fungi (250)

CLASS ZYGOMYCETES. *Rhizopus*, *Mucor*, *Phycomyces*, *Choanephora*, *Entomophthora*

CLASS TRICHOMYCETES. *Stachylina*

DIVISION ASCOMYCOTA. Sac fungi (12,000)

CLASS HEMIASCOMYCETES. Yeasts and their relatives. *Saccharomyces*, *Schizosaccharomyces*, *Endomyces*, *Eremascus*, *Taphrina*

CLASS PLECTOMYCETES. Powdery mildews, fruit molds, etc. *Erysiphe*, *Podosphaera*, *Ceratocystis*

CLASS PYRENOMYCETES. *Sordaria*, *Neurospora*, *Chaetomium*, *Xylaria*, *Hypoxylon*

CLASS DISCOMYCETES. *Sclerotinia*, *Trichoscyphella*, *Rhytisma*, *Xanthoria*, *Pyronema*

CLASS LABOULBENIOMYCETES. *Herpomyces*, *Laboulbenia*

CLASS LOCULOASCOMYCETES. *Cochliobolus*, *Pyrenophora*, *Leptosphaeria*, *Pleospora*

DIVISION BASIDIOMYCOTA. Club fungi (15,000)

CLASS HETEROBASIDIOMYCETES. Rusts and smuts. *Ustilago*, *Urocystis*, *Puccinia*, *Phragmidium*, *Melampsora*

CLASS HOMOBASIDIOMYCETES. Toadstools, bracket fungi, mushrooms, puffballs, stinkhorns, etc. *Coprinus*, *Marasmius*, *Amanita*, *Agaricus*, *Lycoperdon*, *Phallus*

DIVISION FUNGI IMPERFECTI. Imperfect fungi (15,000)

Animal pathogens. *Blastomyces*, *Candida*, *Histoplasma*, *Microsporium*, *Trichophyton*

Plant pathogens. *Alternaria*, *Fusarium*, *Verticillium*

Other. *Aspergillus*, *Penicillium*

KINGDOM ANIMALIA**SUBKINGDOM PARAZOA**

PHYLUM PORIFERA. Sponges (5,000)

CLASS CALCAREA. Calcareous (chalky) sponges. *Scypha*, *Leucosolenia*, *Sycon*, *Grantia*

CLASS HEXACTINELLIDA. Glass sponges. *Euplectella*, *Hyalonema*, *Monoraphis*

CLASS DEMOSPONGIAE. *Spongilla*, *Euspongia*, *Axinella*

CLASS SCLEROSPONGIAE. Coralline sponges. *Ceratoporella*, *Stromatospongia*

SUBKINGDOM AGNOTOZOA

PHYLUM PLACOZOA (1). *Trichoplax*

PHYLUM MESOZOA (50)

CLASS DICYEMIDA. *Dicyema*, *Pseudicyema*, *Conocyema*

CLASS ORTHONECTIDA. *Rhopalura*

SUBKINGDOM METAZOA**SECTION RADIATA**

PHYLUM COELENTERATA (or Cnidaria)

CLASS HYDROZOA. Hydrozoans (3,700). *Hydra*, *Obelia*, *Gonionemus*, *Physalia*

CLASS SCYPHOZOA. Jellyfishes (200). *Aurelia*, *Pelagia*, *Cyanea*

CLASS ANTHOZOA. Sea anemones and corals (6,100). *Metridium*, *Pennatula*, *Gorgonia*, *Astrangia*

PHYLUM CTENOPHORA. Comb jellies (90)

CLASS TENTACULATA. *Pleurobrachia*, *Mnemiopsis*, *Cestum*, *Velamen*

CLASS NUDA. *Beroe*

SECTION PROTOSTOMIA

PHYLUM PLATYHELMINTHES. Flatworms (10,000)

CLASS TURBELLARIA. Free-living flatworms. *Planaria*, *Dugesia*, *Leptoplana*

CLASS TREMATODA. Flukes. *Fasciola*, *Schistosoma*, *Prosthogonimus*

CLASS CESTODA. Tapeworms. *Taenia*, *Dipylidium*, *Mesocestoides*

PHYLUM GNATHOSTOMULIDA (100). *Gnathostomula*, *Haplognathia*

PHYLUM NEMERTINA (or Rhynchocoela). Proboscis worms (650)

CLASS ANOPLA. *Tubulanus*, *Cerebratulus*

CLASS ENOPLA. *Amphiporus*, *Prostoma*, *Malacobdella*

PHYLUM ACANTHOCEPHALA. Spiny-headed worms (500). *Echinorhynchus*, *Gigantorhynchus*

PHYLUM ASCHELMINTHES

CLASS ROTIFERA. Rotifers (1,700). *Asplanchna*, *Hydatina*, *Rotaria*

CLASS GASTROTRICHA (200). *Chaetonotus*, *Macrodasy*

CLASS KINORHYNCHA (or Echinodera) (100). *Echinoderes*, *Semnoderes*

CLASS NEMATODA. Round worms (12,000). *Ascaris*, *Trichinella*, *Necator*, *Enterobius*, *Ancylostoma*, *Heterodera*

CLASS NEMATOMORPHA. Horsehair worms (230). *Gordius*, *Paragordius*, *Nectonema*

PHYLUM ENTOPROCTA (60). *Urnatella*, *Loxosoma*, *Pedicellina*

PHYLUM PRIAPULIDA (8). *Priapulius*, *Halicryptus*

PHYLUM ECTOPROCTA (or Bryozoa). Bryozoans, moss animals (4,000)

CLASS GYMNOLEAEMATA. *Paludicella*, *Bugula*

CLASS PHYLACTOLAEMATA. *Plumatella*, *Pectinatella*

PHYLUM PHORONIDA (15). *Phoronis*, *Phoronopsis*

PHYLUM BRACHIOPODA. Lamp shells (300)

CLASS INARTICULATA. *Lingula*, *Glottidia*, *Discina*

CLASS ARTICULATA. *Magellania*, *Neothyris*, *Terebratula*

PHYLUM MOLLUSCA. Molluscs

CLASS AMPHINEURA

SUBCLASS APLACOPHORA. Solenogasters (250). *Chaetoderma*, *Neomenia*, *Proneomenia*

SUBCLASS POLYPLACOPHORA. Chitons (600). *Chaetopleura*, *Ischnochiton*, *Lepidochiton*, *Amicula*

CLASS MONOPLACOPHORA (6). *Neopilina*

CLASS GASTROPODA. Snails and their allies (univalve molluscs) (40,000). *Helix*, *Busycon*, *Crepidula*, *Haliotis*, *Littorina*, *Doris*, *Limax*

CLASS SCAPHOPODA. Tusk shells (350). *Dentalium*, *Cadulus*

CLASS BIVALVIA. Bivalve molluscs (7,500). *Mytilus*, *Ostrea*, *Pecten*, *Mercenaria*, *Teredo*, *Tagelus*, *Unio*, *Anodonta*

CLASS CEPHALOPODA. Squids, octopuses, etc. (600). *Loligo*, *Octopus*, *Nautilus*

PHYLUM POGONOPHORA. Beard worms (100). *Siboglinum*, *Lamellisabella*, *Oligobranchia*, *Polybrachia*

PHYLUM SIPUNCULIDA (250). *Sipunculus*, *Phascolosoma*, *Dendrostomum*

PHYLUM ECHIUIROIDA (80)

CLASS ECHIURIDA. *Echiurus*, *Urechis*, *Ikeda*

CLASS SACTOSOMATIDA. *Sactosoma*

PHYLUM ANNELIDA. Segmented worms

CLASS POLYCHAETA (including Archiannelida). Sandworms, tubeworms, etc. (5,400). *Nereis*, *Chaetopterus*, *Aphrodite*, *Diopatra*, *Arenicola*, *Hydroides*, *Sabella*

CLASS OLIGOCHAETA. Earthworms and many freshwater annelids (3,100). *Tubifex*, *Enchytraeus*, *Lumbricus*, *Dendrobaena*

CLASS HIRUDINEA. Leeches (300). *Trachelobdella*, *Hirudo*, *Macrobdella*, *Haemadipsa*

PHYLUM ONYCHOPHORA (65). *Peripatus*. *Peripatopsis*

PHYLUM TARDIGRADA. Water bears (300). *Echiniscus*, *Macrobiotus*

PHYLUM PENTASTOMIDA. Tongue worms (60). *Cephalobaena*, *Linguatula*

PHYLUM ARTHROPODA

Subphylum Trilobita. No living representatives

Subphylum Chelicerata

CLASS EURYPTERIDA. No living representatives

CLASS XIPHOSURA. Horseshoe crabs (4). *Limulus*

CLASS ARACHNIDA. Spiders, ticks, mites, scorpions, whipscorpions, daddy longlegs, etc. (55,000). *Archaearenea*, *Latrodectus*, *Argiope*, *Centruroides*, *Chelifer*, *Mastigoproctus*, *Phalangium*, *Ixodes*

CLASS PYCNOGONIDA. Sea spiders (500). *Nymphon*, *Ascorhynchus*

Subphylum Mandibulata

CLASS CRUSTACEA (26,000). *Homarus*, *Cancer*, *Daphnia*, *Artemia*, *Cyclops*, *Balanus*, *Porcellio*

CLASS CHILOPODA. Centipeds (3,000). *Scolopendra*, *Lithobius*, *Scutigera*

CLASS DIPLOPODA. Millipeds (8,000). *Narceus*, *Apheloria*, *Polydesmus*, *Julus*, *Glomeris*

CLASS PAUROPODA (300). *Pauropus*

CLASS SYMPHYLA (130). *Scutigera*

CLASS INSECTA. Insects (900,000)

ORDER COLLEMBOLA. Springtails. *Isotoma*, *Achorutes*, *Neosminthurus*, *Sminthurus*

ORDER PROTURA. *Acerentulus*, *Eosentomon*

ORDER DIPLURA. *Campodea*, *Japyx*

ORDER THYSANURA. Bristletails, silverfish, firebrats. *Machilis*, *Lepisma*, *Thermobia*

ORDER EPHEMERIDA. Mayflies. *Hexagenia*, *Callibaetis*, *Ephemerella*

ORDER ODONATA. Dragonflies, damselflies. *Archilestes*, *Lestes*, *Aeshna*, *Gomphus*

ORDER ORTHOPTERA. Grasshoppers, crickets, walking sticks, mantids, cockroaches, etc. *Schistocerca*, *Romalea*, *Nemobius*, *Megaphasma*, *Mantis*, *Blatta*, *Periplaneta*

ORDER ISOPTERA. Termites. *Reticulitermes*, *Kaloterms*, *Zootermopsis*, *Nasutitermes*

ORDER DERMAPTERA. Earwigs. *Labia*, *Forficula*, *Prolabia*

ORDER EMBIARIA (or Embiidina or Embioptera). *Oligotoma*, *Anisembia*, *Gynembia*

ORDER PLECOPTERA. Stoneflies. *Isoperla*, *Taeniopteryx*, *Capnia*, *Perla*

ORDER ZORAPTERA. *Zorotypus*

ORDER CORRODENTIA. Book lice. *Ectopsocus*, *Liposcelis*, *Trogium*

ORDER MALLOPHAGA. Chewing lice. *Cuculotogaster*, *Menacanthus*, *Menopon*, *Trichodectes*

ORDER ANOPLURA. Sucking lice. *Pediculus*, *Phthirus*, *Haematopinus*

ORDER THYSANOPTERA. Thrips. *Heliothrips*, *Frankliniella*, *Herclothrips*

ORDER HEMIPTERA. True bugs. *Belostoma*, *Lygaeus*, *Notonecta*, *Cimex*, *Lygus*, *Oncopeltus*

ORDER HOMOPTERA. Cicadas, aphids, leafhoppers, scale insects, etc. *Magicalcica*, *Circulifer*, *Psylla*, *Aphis*, *Saissetia*

ORDER NEUROPTERA. Dobsonflies, alderflies, lacewings, mantispids, snakeflies, etc. *Corydalus*, *Hemerobius*, *Chrysopa*, *Mantispa*, *Agulla*

ORDER COLEOPTERA. Beetles, weevils. *Copris*, *Phyllophaga*, *Harpalus*, *Scolytus*, *Melanotus*, *Cicindela*, *Dermestes*, *Photinus*, *Coccinella*, *Tenebrio*, *Anthonomus*, *Conotrachelus*

ORDER HYMENOPTERA. Wasps, bees, ants, sawflies. *Cimbex*, *Vespa*, *Glypta*, *Scolia*, *Bembix*, *Formica*, *Bombus*, *Apis*

ORDER MECOPTERA. Scorpionflies. *Panorpa*, *Boreus*, *Bittacus*

ORDER SIPHONAPTERA. Fleas. *Pulex*, *Nosopsyllus*, *Xenopsylla*, *Ctenocephalides*

ORDER DIPTERA. True flies, mosquitoes. *Aedes*, *Asilus*, *Sarcophaga*, *Anthomyia*, *Musca*, *Chironomus*, *Tabanus*, *Tipula*, *Drosophila*

ORDER TRICHOPTERA. Caddisflies. *Limnephilus*, *Rhyacophila*, *Hydropsyche*

ORDER LEPIDOPTERA. Moths, butterflies. *Tinea*, *Pyrausta*, *Malacosoma*, *Sphinx*, *Samia*, *Bombyx*, *Heliothis*, *Papilio*, *Lycaena*

SECTION DEUTEROSTOMIA

PHYLUM CHAETOGNATHA. Arrow worms (60). *Sagitta*, *Spadella*

PHYLUM ECHINODERMATA

CLASS CRINOIDEA. Crinoids, sea lilies (630). *Antedon*, *Ptilocrinus*, *Comactinia*

CLASS ASTEROIDEA. Sea stars (1,600). *Asterias*, *Ctenodiscus*, *Luidia*, *Oreaster*

CLASS OPHIUROIDEA. Brittle stars, serpent stars, basket stars, etc. (2,000). *Asteronyx*, *Amphioplus*, *Ophiotrix*, *Ophioderma*, *Ophiura*

CLASS ECHINOIDEA. Sea urchins, sand dollars, heart urchins (860). *Cidaris*, *Arbacia*, *Strongylocentrotus*, *Echinanthus*, *Echinarachnius*, *Moiria*

CLASS HOLOTHUROIDEA. Sea cucumbers (900). *Cucumaria*, *Thyone*, *Caudina*, *Synapta*

PHYLUM HEMICHORDATA (90)

CLASS ENTEROPNEUSTA. Acorn worms. *Saccoglossus*, *Balanoglossus*, *Glossobalanus*

CLASS PTEROBRANCHIA. *Rhabdopleura*, *Cephalodiscus*

PHYLUM CHORDATA. Chordates

Subphylum Urochordata (or Tunicata). Tunicates (2,000)

CLASS ASCIDIACEA. Ascidians or sea squirts. *Ciona*, *Clavelina*, *Molgula*, *Perophora*

CLASS THALIACEA. *Pyrosoma*, *Salpa*, *Doliolum*

CLASS LARVACEA. *Appendicularia*, *Oikopleura*, *Fritillaria*

Subphylum Cephalochordata. Lancelets, amphioxus (30).

Branchiostoma, *Asymmetron*

Subphylum Vertebrata. Vertebrates

CLASS AGNATHA. Jawless fishes (50). *Cephalaspis*,* *Pteraspis*,* *Petromyzon*, *Entosphenus*, *Myxine*, *Eptatretus*

*Extinct.

CLASS PLACODERMI. No living representatives

CLASS CHONDRICHTHYES. Cartilaginous fishes (625). *Squalus*, *Hyporion*, *Raja*, *Chimaera*

CLASS OSTEICHTHYES. Bony fishes (30,000)

SUBCLASS SARCOPTERYGII

ORDER CROSSOPTERYGII (or Coelacanthiformes). Lobe-fins. *Latimeria*

ORDER DIPNOI (or Dipteriformes). Lungfishes. *Neoceratodus*, *Protopterus*, *Lepidosiren*

SUBCLASS BRACHIOPTERYGII. Bichirs. *Polypterus*

SUBCLASS ACTINOPTERYGII. Higher bony fishes. *Amia*, *Cyprinus*, *Gadus*, *Perca*, *Salmo*

CLASS AMPHIBIA (2,600)

ORDER ANURA. Frogs and toads. *Rana*, *Hyla*, *Bufo*

ORDER URODELA. Salamanders. *Necturus*, *Triturus*, *Plethodon*, *Ambystoma*

ORDER APODA. *Ichthyophis*, *Typhlonectes*

CLASS REPTILIA (6,500)

ORDER CHELONIA. Turtles. *Chelydra*, *Kinosternon*, *Clemmys*, *Terrapene*

ORDER RHYNCHOCEPHALIA. Tuatara. *Sphenodon*

ORDER CROCODYLIA. Crocodiles and alligators. *Crocodylus*, *Alligator*

ORDER SQUAMATA. Snakes and lizards. *Iguana*, *Anolis*, *Sceloporus*, *Phrynosoma*, *Natrix*, *Elaphe*, *Coluber*, *Thamnophis*, *Crotalus*

CLASS AVES. Birds (8,600). *Anas*, *Larus*, *Columba*, *Gallus*, *Turdus*, *Dendroica*, *Sturnus*, *Passer*, *Melospiza*

CLASS MAMMALIA. Mammals (4,100)

SUBCLASS PROTOTHERIA

ORDER MONOTREMATA. Egg-laying mammals. *Ornithorhynchus*, *Tachyglossus*

SUBCLASS THERIA. Marsupial and placental mammals

ORDER MARSUPIALIA. Marsupials. *Didelphis*, *Sarcophilus*, *Notoryctes*, *Macropus*

ORDER INSECTIVORA. Insectivores (moles, shrews, etc.). *Scalopus*, *Sorex*, *Erinaceus*

ORDER DERMOPTERA. Flying lemurs. *Galeopithecus*

ORDER CHIROPTERA. Bats. *Myotis*, *Eptesicus*, *Desmodus*

ORDER PRIMATES. Lemurs, monkeys, apes, humans. *Lemur*, *Tarsius*, *Cebus*, *Macacus*, *Cynocephalus*, *Pongo*, *Pan*, *Homo*

ORDER EDENTATA. Sloths, anteaters, armadillos. *Bradypus*, *Myrmecophagus*, *Dasyurus*

ORDER PHOLIDOTA. Pangolin. *Manis*

ORDER LAGOMORPHA. Rabbits, hares, pikas. *Ochotona*, *Lepus*, *Sylvilagus*, *Oryctolagus*

ORDER RODENTIA. Rodents. *Sciurus*, *Marmota*, *Dipodomys*, *Microtus*, *Peromyscus*, *Rattus*, *Mus*, *Erethizon*, *Castor*

ORDER CETACEA. Whales, dolphins, porpoises. *Delphinus*, *Phocaena*, *Monodon*, *Balaena*

ORDER CARNIVORA. Carnivores. *Canis*, *Procyon*, *Ursus*, *Mustela*, *Mephitis*, *Felis*, *Hyaena*, *Eumetopias*

ORDER TUBULIDENTATA. Aardvark. *Orycteropus*

ORDER PROBOSCIDEA. Elephants. *Elephas*, *Loxodonta*

ORDER HYRACOIDEA. Coney. *Procapra*

ORDER SIRENIA. Manatees. *Trichechus*, *Halicore*

ORDER PERISSODACTYLA. Odd-toed ungulates. *Equus*, *Tapirella*, *Tapirus*, *Rhinoceros*

ORDER ARTIODACTYLA. Even-toed ungulates. *Pecari*, *Sus*, *Hippopotamus*, *Camelus*, *Cervus*, *Odocoileus*, *Giraffa*, *Bison*, *Ovis*, *Bos*

GLOSSARY

The Glossary gives brief definitions of the most important recurrent terms used in the text, excluding taxonomic designations. For fuller definitions, consult the index, where italicized page numbers refer you to explanations of key terms in context.

Of the basic units of measurement, some are tabulated on p. A8, others have their own alphabetical entries.

Interalphabetized with the vocabulary are the main prefixes and combining forms used in biology. You will notice that, while they are generally of Greek or Latin origin, many of them have acquired a new meaning in biology (examples: *blasto-*, *-cyte*, *caryo-*, *-plasm*). Familiarity with these forms will make it easier for you to learn and remember the numerous terms in which they are incorporated.

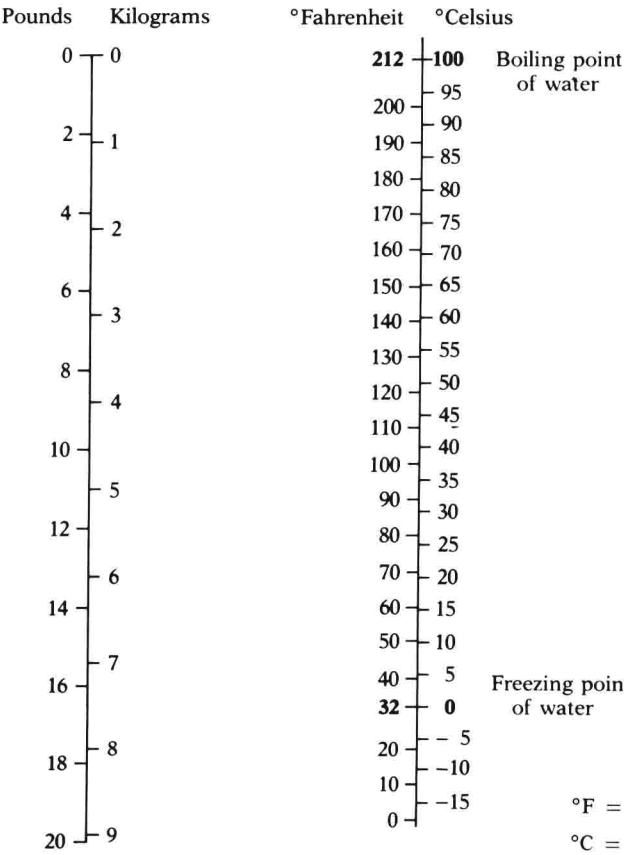
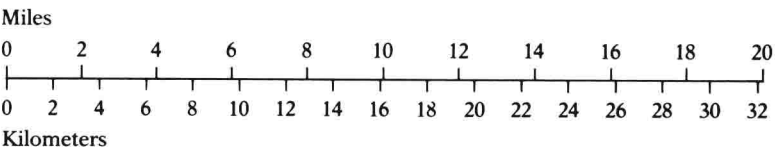
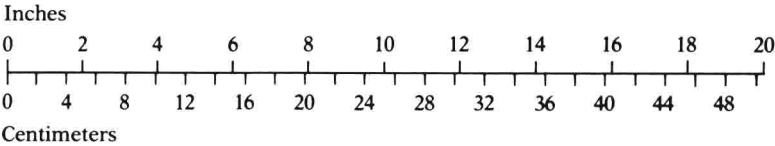
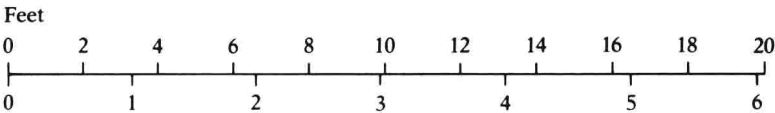
TABLE 1 Standard prefixes of the metric system

kilo- (k)	1,000	10^3
deci- (d)	0.1	10^{-1}
centi- (c)	0.01	10^{-2}
milli- (m)	0.001	10^{-3}
micro- (μ)	0.000001	10^{-6}
nano- (n)	0.000000001	10^{-9}

TABLE 2 Common units of length, weight, and liquid capacity

kilometer (km)	1,000 m	0.62137 mile
meter (m)		39.37 inches
centimeter (cm)	0.01 m	0.39 inch
millimeter (mm)	0.001 m	0.039 inch
micrometer* (μ m)	10^{-6} m	
nanometer (nm)	10^{-9} m	
angstrom† (\AA)	10^{-10} m	
kilogram (kg)	1,000 g	2.2 pounds
gram (g)		0.035 ounce
milligram (mg)	0.001 g	
microgram (μ g)	10^{-6} g	
liter (l)	1,000 cm ³	1.057 quarts
milliliter (ml)	0.001 l	

*Formerly called micron.
†No longer used; nanometer used instead.



a- Without, lacking.

ab- Away from, off.

abdomen [L *belly*] In mammals, the portion of the trunk posterior to the thorax, containing most of the viscera except heart and lungs. In other animals, the posterior portion of the body.

absolute zero The temperature (-273°C) at which all thermal agitation ceases. The lowest possible temperature.

acellular Not constructed on a cellular basis.

acid [L *acidus* sour] A substance that increases the concentration of hydrogen ions when dissolved in water, that has a pH lower than 7.

ACTH See adrenocorticotrophic hormone.

action potential See potential.

active site In an enzyme, the portion of the molecule that reacts with a substrate molecule.

active transport Movement of a substance across a membrane by a process requiring expenditure of energy by the cell.

ad- Next to, at, toward.

adaptation Any genetically controlled characteristic that increases an organism's fitness, usually by helping the organism to survive and reproduce in the environment it inhabits.

adenosine diphosphate (ADP) A doubly phosphorylated organic compound that can be further phosphorylated to form ATP.

adenosine triphosphate (ATP) A triply phosphorylated organic compound that functions as "energy currency" for organisms.

adipose [L *adeps* fat] Fatty.

ADP See adenosine diphosphate.

adrenal [L *renes* kidneys] An endocrine gland of vertebrates located near the kidneys.

adrenalin A hormone produced by the adrenal medulla that stimulates "fight-or-flight" reactions.

adrenocorticotrophic hormone (ACTH) A hormone produced by the pituitary that stimulates the adrenal cortex.

adsorb [L *sorbēre* to suck up] Hold on a surface.

advanced New, unlike the ancestral condition.

aerobic [L *aer* air] With oxygen.

agonistic [Gk *agōnistēs* combatant] Having to do with attack, escape, or fear.

alcohol Any of a class of organic compounds in which one or more OH groups are attached to a carbon backbone.

alkaline Having a pH of more than 7. See base.

all-, allo- [Gk *allos* other] Other, different.

allele Any of several alternative gene forms at a given chromosomal locus.

allopatric [L *patria* homeland] Having different ranges.

all-or-none The property of responding maximally or not at all.

allosteric Of an enzyme; one that can exist in two or more conformations. *Allosteric control*: control of the activity of an allosteric enzyme by determination of the particular conformation it will assume.

alveolus [L little hollow] A small cavity, especially one of the microscopic cavities that are the functional units of lungs.

amino acid An organic acid carrying an amino group ($-\text{NH}_2$); the building-block compound of proteins.

amnion [Gk *caul*] An extraembryonic membrane that forms a fluid-filled sac containing the embryo in reptiles, birds, and mammals.

amoeboid [Gk *amoibē* change] Amoebalike in the tendency to change shape by protoplasmic flow.

amylase [L *amylum* starch] A starch-digesting enzyme.

an- Without.

anabolism [Gk *ana-* upward; *metabolē* change] The biosynthetic building-up aspects of metabolism.

anaerobic [L *aer* air] Without oxygen.

analogous Of characters in different organisms: similar in function and often in superficial structure but of different evolutionary origins.

anemia A condition in which the blood has lower than normal amounts of hemoglobin or red blood cells.

angio-, -angium [Gk *angeion* vessel] Container, receptacle.

anion A negatively charged ion.

annual A plant that lives for one year or season.

anterior Toward the front end.

antheridium [Gk *anthos* flower] Male reproductive organ of a plant; produces sperm cells.

antibody A protein, produced by the immune system, that destroys or inactivates a particular antigen.

antigen A substance, usually a protein or polysaccharide, that, when injected into a vertebrate, stimulates the organism's immune system to produce antibodies against it.

anus [L ring] Opening at the posterior end of the digestive tract, through which indigestible wastes are expelled.

aorta The main artery of the systemic circulation.

apical At, toward, or near the apex, or tip, of a structure such as a plant shoot.

apo- Away from.

apoplast The network of cell walls and intercellular spaces within a plant body; permits extensive extracellular movement of water within the plant.

arch- [Gk *archein* to begin] Primitive, original.

archegonium [Gk *archegonos* the first of a race] Female reproductive organ of a higher plant; produces egg cells.

archenteron [Gk *enteron* intestine] The cavity in an early embryo that becomes the digestive cavity.

arteriole A small artery.

artery A blood vessel that carries blood away from the heart.

articulation A joint between bones. Articulating surfaces are those formed between bones and joints.

artifact A by-product of scientific manipulation rather than an inherent part of the thing observed.

ascus [Gk *askos* bag] The elongate spore sac of a fungus of the Ascomycota group.

asexual Without sex.

atmosphere (atm) (unit of pressure) The normal pressure of air at sea level: 101,325 newtons per square meter (approx. 14.7 pounds per square inch).

atom [Gk *atomos* indivisible] The smallest unit of an element, not divisible by ordinary chemical means.

atomic mass unit (amu) See dalton.

atomic weight The average weight of an atom of an element relative to C^{12} , an isotope of carbon with six neutrons in the nucleus. The atomic weight of C^{12} has arbitrarily been fixed as 12.

ATP See adenosine triphosphate.

auto- Self, same.

autonomic nervous system A portion of the vertebrate nervous system, comprising motor neurons that innervate internal organs and are not normally under direct voluntary control.

autosome [Gk *sōma* body] Any chromosome other than a sex chromosome.

autotrophic [Gk *trophē* food] Capable of manufacturing organic nutrients from inorganic raw materials.

auxin [Gk *auxein* to grow] Any of a class of plant hormones that promote cell elongation and can diffuse into a decapitated plant from an agar block, causing the plant to bend in the dark (Went test).

axon [Gk *axōn* axis] A fiber of a nerve cell that conducts impulses away from the cell body and can release transmitter substance.

bacteriophage [Gk *phagein* to eat] A virus that attacks bacteria, abbrev. phage.

basal At, near, or toward the base (i.e. the point of attachment) of a structure such as a limb.

base (or alkali) A substance that increases the concentration of hydroxyl ions when dissolved in water, that has a pH higher than 7.

basidium The spore-bearing structure of Basidiomycota (club fungi).

bi- Two.

bilateral symmetry The property of having two similar sides, with definite upper and lower surfaces and definite anterior and posterior ends.

binary fission Reproduction by the division of a cell into two essentially equal parts by a nonmitotic process.

bio- [Gk *bios* life] Life, living.

biogenesis [Gk *genesis* source] Origin of living organisms from other living organisms.

biological magnification Increasing concentration of relatively stable chemicals as they are passed up a food chain from initial consumers to top predators.

biomass The total weight of all the organisms, or of a designated group of organisms, in a given area.

biome A major climax plant formation.

biotic Pertaining to life.

blasto- [Gk *blastos* bud] Embryo.

blastocoel [Gk *kōilos* hollow] The cavity of a blastula.

blastopore [Gk *poros* passage] The opening from the cavity of the archenteron to the exterior in a gastrula.

blastula An early embryonic stage in animals, preceding the delimitation of the three principal tissue layers; frequently spherical and hollow.

buffer A substance that binds H^+ ions when their concentration rises and releases them when their concentration falls, thereby minimizing fluctuations in the pH of a solution.

caecum [L *caecus* blind] A blind diverticulum of the digestive tract.

calorie [L *calor* heat] The quantity of energy, in the form of heat, required to raise the temperature of one gram of pure water one degree from 14.5 to 15.5°C. The nutritionists' Calorie (capitalized) is 1,000 calories, or one kilocalorie.

cambium [L *cambiare* to exchange] The principal lateral meristem of vascular plants; gives rise to most secondary tissue.

cAMP See cyclic adenosine monophosphate.

capillarity [L *capillus* hair] The tendency of aqueous liquids to rise in narrow tubes with hydrophilic surfaces.

capillary [L *capillus*] A tiny blood vessel with walls one cell thick, across which exchange of materials between the blood and the tissues takes place; receives blood from arteries and carries it to veins. Also, a similar vessel of the lymphatic system.

carbohydrate Any of a class of organic compounds composed of carbon, hydrogen, and oxygen in a ratio of about two hydrogens and one oxygen for each carbon. Examples: sugar, starch, cellulose.

carboxyl group The $-COOH$ group characteristic of organic acids.

cardiac [Gk *kardia* heart] Pertaining to the heart.

carnivore [L *carnis* of flesh; *vorare* to devour] An organism that feeds on animals.

carotenoid [L *carota* carrot] Any of a group of red, orange, and yellow accessory pigments of plants, found in plastids.

carrying capacity The maximum population that a given environment can support indefinitely.

cartilage A specialized type of dense fibrous connective tissue with a rubbery intercellular matrix.

caryo- [Gk *karyon* kernel] Nucleus.

Casparian strip A lignified and waterproofed thickening in the radial and end walls of endodermal cells of plants.

cata- Down.

catabolism [Gk *katabolē* a throwing down] The degradational breaking-down aspects of metabolism.

catalysis [Gk *katalyein* to dissolve] Acceleration of a chemical reaction by a substance that is not itself permanently changed by the reaction.

catalyst A substance that produces catalysis.

cation A positively charged ion.

caudal [L *cauda* tail] Pertaining to the tail.

cell cycle The cycle of cellular events from one mitosis through the next. Four stages are recognized, of which the last—distribution of genetic material to the two daughter nuclei—is mitosis proper.

cell sap See sap.

cellulose [L *cellula* cell] A complex polysaccharide that is a major constituent of most plant cell walls.

centi- [L *centum* hundred] One hundredth.

central nervous system A portion of the nervous system that contains interneurons and exerts some control over the rest of the nervous system. In vertebrates, the brain and spinal cord.

centri- [L *centrum* center] Center.

centrifugation [L *fugere* to flee] The spinning of a mixture at very high speeds to separate substances of different densities.

centriole A cylindrical cytoplasmic organelle located just outside the nucleus of animal cells and the cells of some lower plants; associated with the spindle during mitosis and meiosis.

centromere [Gk *meros* part] A special region on a chromosome that attaches to a spindle microtubule during mitosis or meiosis.

cephalization [Gk *kephalē* head] Localization of neural coordinating centers and sense organs at the anterior end of the body.

cerebellum [L small brain] A part of the hindbrain of vertebrates that controls muscular coordination.

cerebrum [L brain] Part of the forebrain of vertebrates, the chief coordination center of the nervous system.

character Any structure, functional attribute, behavioral trait, or other characteristic of an organism.

character displacement The rapid divergent evolution in sympatric species of characters that minimize competition and/or hybridization between them.

chemosynthesis Autotrophic synthesis of organic materials, energy for which is derived from inorganic molecules.

chitin [Gk *chitōn* tunic] Polysaccharide that forms part of the hard exoskeleton of insects, crustaceans, and other invertebrates; also occurs in the cell walls of fungi.

chlorophyll [Gk *chlōros* greenish yellow; *phyllon* leaf] The green pigment of plants necessary for photosynthesis.

chloroplast A plastid containing chlorophyll.

chrom-, -chrome [Gk *chrōma* color] Colored; pigment.

chromatid A single chromosomal strand.

chromatography Process of separating substances by adsorption on media for which they have different affinities.

chromosome [Gk *sōma* body] A filamentous structure in the cell nucleus (or nucleoid) along which the genes are located.

cilium [L eyelid] A short hairlike locomotory organelle on the surface of a cell (*pl. cilia*).

cisterna [L cistern] A cavity, sac, or other enclosed space serving as a reservoir.

cistron The genetic unit of function; synonymous with the gene as biochemically defined.

cleavage Division of a zygote or of the cells of an early embryo.

climax (ecological) A relatively stable stage reached in some ecological successions.

cline [Gk *klinein* to lean] Gradual variation, correlated with geography, in a character of a species.

cloaca [L sewer] Common chamber that receives materials from the digestive, excretory, and reproductive systems.

clone [Gk *klōn* twig] A group of cells or organisms derived asexually from a single ancestor and hence genetically identical.

co- With, together.

codon The unit of genetic coding, three nucleotides long.

coel-, -coel [Gk *kōilos* hollow] Hollow, cavity; chamber.

coelom A body cavity bounded entirely by mesoderm.

coenocytic [Gk *koinos* common] Having more than one nucleus in a single mass of cytoplasm.

coenzyme A nonproteinaceous organic molecule that plays an accessory role, but a necessary one, in the catalytic action of an enzyme.

coevolution Two or more organisms evolving, each in response to the other.

coleoptile [Gk *koleon* sheath; *ptilon* feather] A sheath around the young shoot of grasses.

collagen A fibrous protein; the most abundant protein in mammals.

collenchyma [Gk *kolla* glue] A supportive tissue in plants in which the cells usually have thickenings at the angles of the walls.

colloid [Gk *kolla*] A stable suspension of particles that, though larger than in a true solution, do not settle out.

colon The large intestine.

com- Together.

commensalism [L *mensa* table] A symbiosis in which one party is benefited and the other party receives neither benefit nor harm.

community In ecology, a unit composed of all the populations living in a given area.

competition In ecology, utilization by two or more individuals, or by two or more populations, of the same limited resource; an interaction where both parties are harmed.

condensation reaction A reaction joining two compounds with resultant formation of water.

conditioning The associating, as a result of reinforcement, of a response with a stimulus with which it was not previously associated.

conformation (of a protein) [L *conformatio* symmetrical forming] The three-dimensional pattern according to which the polypeptide chains of a protein coil (secondary structure), fold (tertiary structure), and—if there is more than one chain—fit together (quaternary structure).

conjugation [L *jugare* to join, marry] Process of genetic recombination between two organisms (e.g. bacteria, algae) through a cytoplasmic bridge between them.

connective tissue A type of animal tissue whose cells are embedded in an extensive intercellular matrix; connects, supports, or surrounds other tissues and organs.

contractile vacuole An excretory and/or osmoregulatory vacuole in some cells, which, by contracting, ejects fluids from the cell.

cork [L *cortex* bark] A waterproofed tissue, derived from the cork cambium, that forms at the outer surfaces of the older stems and roots of woody plants; the outer bark or periderm.

corpus luteum [L yellow body] A yellowish structure in the ovary, formed from the follicle after ovulation, that secretes estrogen and progesterone (*pl. corpora lutea*).

cortex [L bark] In plants, tissue between the epidermis and the vascular cylinder of stems and roots. In animals, the outer barklike tissue of some organs, as *cerebral cortex*, *adrenal cortex*, etc.

cotyledon [Gk *kotylē* cup] A "seed leaf," a food-digesting and -storing part of a plant embryo.

covalent bond A chemical bond resulting from the sharing of a pair of electrons.

crossing-over Exchange of parts between two homologous chromosomes.

cross section See section.

cryptic [Gk *kryptos* hidden] Concealing.

cuticle [L *cutis* skin] A waxy layer on the outer surface of leaves, insects, etc.

cyclic adenosine monophosphate (cyclic AMP or cAMP) Compound, synthesized in living cells from ATP, that functions as an intracellular mediator of hormonal action; also plays a part in neural transmission and some other kinds of cellular control systems.

cyst [Gk *kystis* bladder, bag] (1) A saclike abnormal growth. (2) Capsule that certain organisms secrete around themselves and that protects them during resting stages.

-cyte, cyto- [Gk *kytos* container] Cell.

cytochrome Any of a group of iron-containing pigments important in the electron transport of oxidative phosphorylation and photophosphorylation.

cytokinesis [Gk *kinēsis* motion] Division of the cytoplasm of a cell.

cytoplasm All of a cell except the nucleus.

cytosol The relatively fluid, less structured part of the cytoplasm of a cell, excluding organelles and membranous structures.

dalton A unit of mass equal to one twelfth the atomic weight of C^{12} , or 1.66024×10^{-24} gram. Formerly called atomic mass unit (amu).

deamination Removal of an amino group.

deciduous [L *decidere* to fall off] Shedding leaves each year.

dehydration reaction A condensation reaction.

deme [Gk *dēmos* population] A local unit of population of any one species.

dendr-, dendro- [Gk *dendron* tree] Tree; branching.

dendrite A short unsheathed fiber of a nerve cell—often spiny, usually branched and tapering—that receives many synapses and leads impulses toward the cell body.

deoxyribonucleic acid (DNA) A nucleic acid found especially in the cell nucleus—the genetic material.

-derm [Gk *derma* skin] Skin, covering; tissue layer.

di- Two.

dicot A member of a subclass of the angiosperms, or flowering plants, distinguished mainly by the presence of two cotyledons in the embryo; *cf.* monocot.

differentiation The process of developmental change from an immature to a mature form, especially in a cell.

diffusion The movement of dissolved or suspended particles from one place to another as a result of their heat energy (thermal agitation).

digestion Hydrolysis of complex nutrient compounds into their building-block units.

diploid [Gk *diploos* double] Having two of each type of chromosome.

disaccharide A double sugar, i.e. one composed of two simple sugars.

distal [L *distare* to stand apart] Situated away from some reference point (usually the main part of the body).

diverticulum [L *devertere* to turn aside] A blind sac branching off a cavity or canal.

DNA See deoxyribonucleic acid.

dominant (1) Of an allele: exerting its full phenotypic effect despite the presence of another allele of the same gene, whose phenotypic expression it blocks. *Dominant phenotype, dominant character*: one caused by a dominant allele. (2) Of an individual: occupying a high position in the social hierarchy.

dormancy [L *dormire* to sleep] The state of being inactive, quiescent. In plants, particularly seeds and buds, a period in which growth is arrested until environmental conditions become more favorable.

dorsal [L *dorsum* back] Pertaining to the back.

duodenum [From a Latin phrase meaning 12 (*duodecim*) finger's-breadths long] The first portion of the small intestine of vertebrates, into which ducts from the pancreas and gallbladder empty.

ecosystem [Gk *oikos* habitation] The sum total of physical features and organisms occurring in a given area.

ecto- Outside, external.

ectoderm The outermost tissue layer of an animal embryo. Also, tissue derived from the embryonic ectoderm.

effector The part of an organism that produces a response, e.g. muscle, cilium, flagellum.

egg An egg cell or female gamete. Also a structure in which embryonic development takes place, especially in birds and reptiles; consists of an egg cell, various membranes, and often a shell.

electron A negatively charged primary subatomic particle.

electronic charge unit The charge of one electron, or 1.6021×10^{-19} coulomb.

elimination (or defecation) The release of unabsorbed wastes from the digestive tract. *Cf.* excretion.

embryo A plant or animal in an early stage of development; generally still contained within the seed, egg, or uterus.

emulsion [L *emulsus* milked out] Suspension, usually as fine droplets, of one liquid in another.

-enchyma [Gk *parenchein* to pour in beside] Tissue.

end-, endo- Within, inside; requiring.

endergonic [Gk *ergon* work] Energy-absorbing.

endocrine [Gk *krinein* to separate] Pertaining to ductless glands that produce hormones.

endoderm The innermost tissue layer of an animal embryo.

endodermis A plant tissue, especially prominent in roots, that surrounds the vascular cylinder; all endodermal cells have Casparian strips.

endoplasmic reticulum [L *reticulum* network] A system of membrane-bounded channels in the cytoplasm.

endoskeleton An internal skeleton.

endosperm [Gk *sperma* seed] A nutritive material in seeds.

entropy Measure of the disorder of a system.

enzyme [Gk *zymē* leaven] A protein that acts as a catalyst.

epi- Upon, outer.

epicotyl The portion of the axis of a plant embryo above the point of attachment of the cotyledons; forms most of the shoot.

epidermis [Gk *derma* skin] The outermost portion of the skin or body wall of an animal.

episome [Gk *sōma* body] Genetic element at times free in the cytoplasm, at other times integrated into a chromosome.

epithelium An animal tissue that forms the covering or lining of all free body surfaces, both external and internal.

erythrocyte [Gk *erythros* red] A red blood cell, i.e. a blood cell containing hemoglobin.

esophagus [Gk *phagein* to eat] An anterior part of the digestive tract; in mammals it leads from the pharynx to the stomach.

estrogen [L *oestrus* frenzy] Any of a group of vertebrate female sex hormones.

estrous cycles [L *oestrus*] In female mammals, the higher primates excepted, a recurrent series of physiological and behavioral changes connected with reproduction.

estuary That portion of a river that is close to the sea and influenced by marine tides.