The Golden Mouse

The Golden Mouse

Ecology and Conservation

Edited by

Gary W. Barrett
University of Georgia, Athens, GA, USA

George A. Feldhamer
Southern Illinois University, Carbondale, IL, USA

Springer

Editors
Dr. Gary W. Barrett
University of Georgia
Eugene P. Odum School of Ecology
Athens, GA 30602-2202
gbarrett@uga.edu

Dr. George A. Feldhamer
Southern Illinois University
Department of Zoology
Carbondale, IL 62901-6511
feldhamer@zoology.siu.edu

ISBN: 978-0-387-33665-7 e-ISBN: 978-0-387-33666-4

Library of Congress Control Number: 2007924492

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

To Kagen Michael and Brittnee Paige
May you always love wildlife and appreciate
the search for Nature's treasures

GWB

To Carla, Andy, and Carrie
As always

GAF

Foreword

The golden mouse (*Ochrotomys nuttalli*) of the southeastern United States and a diagnostic species of the Austroriparian biotic province exhibits a number of distinctive features in its morphology, physiology, behavior, life history, and ecology. The bright ochraceous color of the upper parts, from which its generic name is derived, contrasts sharply with the more muted pelage coloration of other species of native rats and mice of eastern North America. More fundamental morphological features, including skull and dental characteristics, anatomy of the male reproductive tract, and sperm morphology, also clearly differentiate *Ochrotomys* from other rodent genera. With the exception of the tree and flying squirrels, the golden mouse also is arguably the most arboreal small mammal in eastern North America. Although it might nest on the ground beneath the leaf litter, it frequently constructs conspicuous globular aboveground nests in shrubs or trees, often in hanging vines, such as honeysuckle and greenbrier. Its semi-aboreal habits are reflected in such features of its morphology as a semi-prehensile tail, well-developed plantar tubercles, and strong abdominal musculature. A low basal metabolic rate and tendency to become lethargic at high environmental temperatures are presumably physiological adaptations to reduce heat stress experienced from inhabiting arboreal nests exposed to high summer temperatures. Certain behavioral features such as a tendency of adults to "freeze" when disturbed and the relatively rapid growth and development and low exploratory tendencies of the young also appear to be adaptations for arboreal activity.

Since it was first made known to science by Harlan in 1832, the golden mouse has been the subject of numerous studies dealing with various aspects of its taxonomy, biology, ecology, and behavior. The present volume represents the first attempt to compile and synthesize this substantial body of information. Hopefully, it will not only provide a valuable summary of current knowledge of the golden mouse, but will also reveal what we do not know about the species and thus serve as a stimulus for further research on this distinctive and attractive small mammal.

James N. Layne

Preface

When we hear the familiar phrase *charismatic mammalian megafauna*, we immediately envision large, powerful carnivores like lions and grizzly bears, or sleek graceful ungulates like deer and antelope. However, we rarely, if ever, hear about charismatic mammalian *microfauna* such as rodents. In fact, most people consider small, cryptic rodents as nothing more than vectors of disease, crop depredators, or prey for larger and much more interesting mammals. Yet, many rodent species serve as critical models for medical or ecological research, are valuable as furbearers and sustenance, are important in the pet trade, or possess novel and compelling life history characteristics. In terms of fascinating life history, the subject of this volume—the golden mouse (*Ochrotomys nuttalli*)—has few equals. For example, it exhibits unique patterns of behavior related to bioenergetics, nest building, coexistence with sympatric species of small mammals, and potential longevity. A fairly rare species throughout its geographic range, the golden mouse usually inhabits areas with very thick, dense understory vegetation where it builds softball-sized arboreal nests, as well as ground nests more typical of woodland mice. During certain times of the year, several golden mice might communally occupy large arboreal nests termed shelter/communal nests. In addition to their intriguing life history characteristics, the strikingly radiant golden color of their fur makes them a particularly intriguing and appealing component of the small mammal fauna.

In this volume, we bring together zoologists, ecologists, behaviorists, parasitologists, artists, and other authorities to contribute their expertise to an investigation and a better understanding of the golden mouse. Each author brings his or her experience and insights from being directly involved with ongoing research related to the golden mouse and related species of small mammals. We have attempted to produce a concise, scholarly work based on past and current research that will be useful to students and professionals in mammalogy, ecology, and wildlife biology, as well as general readers interested in natural history. We use the golden mouse as the focal species to explore conceptual issues in ecology across levels of organization (individual, population, community, ecosystem, and landscape), integrating reductionist and holistic ecological science.

Chapter 1 provides an overview of the golden mouse explaining why a levels-of-organization approach is used to organize information and to suggest future

investigations in order to better understand this unique species. Following an historical perspective, examples are presented to introduce early chapters in the book based on the levels-of-organization concept. Latter chapters focus on ecological processes (e.g., regulation, energetics, and behavior) that transcend these levels of organization.

At the individual level (Chapter 2), we discuss natural history, taxonomy, evolution, and systematics of the golden mouse. We then move to the population level (Chapter 3), where growth, population dynamics, and population genetics are described for this species. At the community level (Chapter 4), topics such as coexistence, competitive interactions, and the benefits of semiarboreal living are discussed. Natural and anthropogenic perturbations, secondary succession, and the impact of various forestry practices on ecosystem dynamics that affect golden mice are discussed in Chapter 5. At the landscape level (Chapter 6), we discuss riparian habitats as possible landscape corridors, landscape fragmentation, and patch quality relative to what is known about golden mice and identify questions yet to be addressed.

Chapters 7–10 discuss such transcending processes as rarity, energetics, behavior, and parasitism. For example, the status of the golden mouse as a relatively rare species and conservation and management practices related to this species are outlined in Chapter 7. A discussion describing why the golden mouse represents a model species to better understand mechanisms of energetic efficiency is presented in Chapter 8. Because of its diverse patterns of nest construction and unusual nesting behavior, the authors in Chapter 9 suggest that the golden mouse be considered an ecological (*oikos*) engineer. Chapter 10 summarizes the ectoparasites found on golden mice and the relationship of golden mice to vector-borne diseases.

Finally, the authors place and discuss golden mice within the larger perspective of landscape aesthetics (Chapter 11). In Chapter 12 the editors of this volume present future investigative challenges and outline important questions yet to be addressed. We hope by demonstrating how a relatively small mammal species can be investigated using this approach—unlike a taxon such as *Peromyscus*—will help to define future areas of research and will promote future integrative studies across all levels of organization. We also hope that undergraduates, graduate students, working professionals, and interested laypersons will agree that the golden mouse is a worthy standard bearer for, and prime example of, the most charismatic of mammalian microfauna.

Gary W. Barrett
George A. Feldhamer

Acknowledgments

We thank Janet Slobodien, Editor, Life Sciences, Springer for her support of the book since its conception. We also thank Felix Portnoy, Production Editor, Springer for his coordination of the production of this book. We express our appreciation to Joseph Piliero, Design Manager, Springer, for the evocative cover design of this book. Naturally, special thanks are extended to the contributors of each of the following chapters. Special thanks are also due to Andrea Zlabis, Brookfield Zoological Park, Chicago, Illinois for sharing her experience and for providing photographs of the golden mouse exhibit in "The Swamp" area located at the Zoological Park; to Joy Richardson, Barrow County School System, Georgia, for directing our attention to the books on Poppy, the golden mouse; and to Thomas Luhring, Anita Morzillo, Tim Carter, Terry Barrett, and James Layne for their photographs that appear in this book. We are grateful to James Layne for providing the Foreword for the book. We are especially grateful to Terry Barrett for her time, effort, and knowledge regarding numerous editorial suggestions and the selection of photographs and graphics used throughout the text. The invaluable assistance of Lisa Russell, Environmental Studies Program, Southern Illinois University Carbondale (SIUC), in several phases of this project is gratefully acknowledged. Thanks are also extended to Jonathan Gray, Department of Speech Communication at SIUC, and James Layne, Archbold Biological Station, Lake Placid, Florida, for their contributions as reviewers. We acknowledge Margaret Adamic, Contracts Administrator Publishing, Corporate Legal, Disney Publishing Worldwide, for archival research pertaining to and assistance in obtaining permissions for the ©Disney Enterprises, Inc. images shown in this volume.

We are indebted to numerous students (both undergraduate and graduate) from Miami University of Ohio and the Eugene P. Odum School of Ecology, University of Georgia, who over the past several decades have provided assistance in the field. Many of these individuals have gone on to become professionals in fields such as law, medicine, business, and academia. This list includes, but is not limited to, Molly Anderson, Jill Auburn, Jennifer Blesh, Susan Brewer, Megan Casey, Jennifer Chastant, Cory Christopher, Daniel Crawford, Scott Davis, Brett Dietz, Janet Ford, Tara Gancos, Laura Gibbes, Patricia Gregory, Lauren Hall, Steve Harper, Chad Jennison, Melissa Jewell, Ryan Klee, Barbara Knuth, Chris Lucia, Thomas Luhring, Anika Mahoney, Mark Maly, Kelli Meek, Maura O'Malley, Cayce

Payton, John Peles, Bill Peterjohn, Kevin Postma, Alison Pruett, Luis Rodas, Jeff Ryan, Chris Schmidt, Steve Shivers, Scott Springer, Matthew Shuman, Ryan Stander, Karen Stueck, Christopher Williams, Michelle Williams, and Sabrina Willis. Many of these individuals conducted independent research on the golden mouse as undergraduates and had their findings published in professional peer-reviewed journals. Likewise, we drew on the work of several SIUC graduate students whose thesis research involved aspects of the golden mouse, including: Dean Corgiat, Chelsea DeBay, Kathy Furtak-Maycroft, Anita Morzillo, and David Wagner. Witnessing the academic growth and success of these individuals is one of the highlights of our careers as educators.

Contents

Section 3 Transcending Processes

Section 4 New Perspectives and Future Challenges

Contributors

Gary W. Barrett
Eugene P. Odum School of Ecology, University of Georgia, Athens, GA 30602

Terry L. Barrett
120 Riverbottom Circle, Athens, GA 30606

Guy N. Cameron
Department of Biological Sciences, University of Cincinnati, Cincinnati, OH 45221

Donald W. Linzey
Department of Biology, Wytheville Community College, 1000 East Main Street, Wytheville, VA 24382

Thomas M. Luhring
Eugene P. Odum School of Ecology, University of Georgia, Athens, GA 30602

Anita T. Morzillo
US EPA, 200 SW 35th Street, Corvallis, OR 97333

John D. Peles
Penn State University-McKeesport, 207 Ostermayer Laboratory, McKeesport, PA 15132

Cory C. Christopher
Department of Biological Sciences, University of Cincinnati, Cincinnati, OH 45221

Lance A. Durden
Department of Biology, Georgia Southern University, Statesboro, GA 30460

George A. Feldhamer
Department of Zoology, Southern Illinois University, Carbondale, IL 62901

James N. Layne
Archbold Biological Station, Lake Placid, FL 33852

Robert K. Rose
Department of Biological Sciences, Old Dominion University, Norfolk, VA 23529

Steven W. Seagle
Department of Biology, Appalachian State University, 572 Rivers Street, Boone, NC 28606

Jerry O. Wolff
Department of Biological Sciences, St. Cloud State University, 720 Fourth Avenue South, St. Cloud, MN 56301

About the Editors

Gary W. Barrett is Odum Chair of Ecology in the Eugene P. Odum School of Ecology at the University of Georgia. Until 1994, he was Distinguished Professor of Ecology at Miami University, Oxford, Ohio, where he founded the Institute of Environmental Sciences and the Ecology Research Center. From 1994 through 1996 he was the director of the Eugene P. Odum School of Ecology at the University of Georgia. He is the author or coauthor of 6 books and over 170 publications in professional journals. He was Ecology Program Director with the National Science Foundation from 1981 to 1983 and has served on or chaired numerous committees within the American Society of Mammalogists, American Institute of Biological Sciences, International Association for Landscape Ecology, International Association for Ecology, and National Research Council of the National Academy of Sciences. Barrett is a fellow of the American Association for the Advancement of Science (1990). He served as chair of the Applied Ecology Section of the Ecological Society of America (1985–1987), president of the United States Regional Association of the International Association for Landscape Ecology (1988–1990), president of the Association for Ecosystem Research Centers (1995–1996), and president of the American Institute of Biological Sciences (1998). He received the AIBS Presidential Citation Award in 2000 in recognition of leadership and contributions to the biological sciences and the prestigious Distinguished Landscape Ecologist Award in 2001 from the United States Regional Association of the International Association for Landscape Ecology. Barrett was the recipient of the Excellence in Undergraduate Mentoring Award at the University of Georgia in 2005.

George A. Feldhamer is Professor of Zoology and Director of the Environmental Studies Program at Southern Illinois University at Carbondale (SIUC). His research has focused exclusively on mammalian populations, ecology, and management; biology of introduced cervids; and threatened and endangered species, with funding from state and federal management agencies. He has published in numerous professional journals. He was associate editor for forest biology and ecology for the *Journal of Forest Research* (1997–2004) and the *Wildlife Society Bulletin* (1993–1995). He is senior editor of *Wild Mammals of North America: Biology, Management, and Conservation* (2003) and coauthor of *Mammals of the National Parks: Conserving America's Wildlife and Parklands* (2005), both published by John Hopkins University Press. He is senior author of the textbook *Mammalogy: Adaptation, Diversity, Ecology* (1999; 2003) published by McGraw-Hill. He has 30 years of experience in teaching upper-division mammalogy courses, and a game mammal management course at SIUC and the University of Maryland. In 2000, Feldhamer was named Outstanding Teacher in the College of Science at SIUC.

Section 1
Introduction

1
The Golden Mouse: A Levels-of-Organization Perspective

Gary W. Barrett

> *Who else had known and admired golden mice? Theodore Roosevelt, twenty-sixth president of the United States, knew of them. "As a boy I worked in the museum and . . . remember skinning some rather reddish white-footed mice I thought were golden mice, and was disappointed to find they were not."* (Terres 1966:98)

A Personal History Perspective

I vividly recall the first time I observed a golden mouse (*Ochrotomys nuttalli*) in the field. It was the summer in 1965 while conducting my doctoral dissertation research at the University of Georgia (UGA). My dissertation research was the first major investigation conducted at HorseShoe Bend (HSB) Experimental Site located in Clarke County, latitude 33º57′N and longitude 83º23′W, near Athens, Georgia. HSB is a 35-acre (14.1-ha) research site created by a meander of the North Oconee River (see Barrett 1968, Blesh and Williams 2003, Hendrix 1997 for detailed descriptions of the site). This ecosystem-level investigation focused on the effects of a carbamate insecticide (Sevin) on small mammal populations in semi-enclosed grassland ecosystems later published in *Ecology* (Barrett 1968). At HSB, the undergrowth outside of the 0.4-ha enclosures and along the North Oconee River contained an abundance of Chinese privet (*Ligustrum sinense*), Japanese honeysuckle (*Lonicera japonica*), and greenbrier (*Smilax* sp.) within a bottomland forest community. One afternoon during the 1960s, while hiking through this mixed hardwood and thicket-type plant community, I came upon a globular nest. I had never seen a nest like this during my childhood while living on a farm in southern Indiana. I assumed it was a bird nest of which I was not yet familiar. Out of curiosity, I touched the nest with a stick and out from the nest appeared the most beautiful small mammal that I had ever observed. This docile animal stopped on a limb in the sun to groom. Its rich golden pelage remains vivid in my mind to this day. I returned to the nest site the next day with a pair of long forceps to live capture (by its tail) and identify this beautiful small mammal species. I found it interesting to observe a small mammal residing in bushes, rather than in open fields, such as the deer mice (*Peromyscus maniculatus*) that I had livetrapped in a red clover (*Trifolium pratense*) field while conducting research

for my Master's thesis at Marquette University (Barrett and Darnell 1967). This individual was identified as a golden mouse and that experience, unrelated to my dissertation research at the time, was my initial introduction to *O. nuttalli*. It was also at that time that I read an article in the March–April issue of *Audubon Magazine* entitled "Search for the Golden Mouse" (Terres 1966), which intrigued me. These circumstances served as an early incentive for a continuing interest that would result many years later in this book.

Following the award of my Ph.D. at the University of Georgia in 1967, and after one year on the faculty at Drake University, I joined the faculty at Miami University in Oxford, Ohio in 1968. I soon recognized from geographical distribution maps (see Figure 2.1 in Chapter 2 of this volume) that *O. nuttalli* did not occur in southern Ohio but was present in Kentucky. It appears that the Ohio River has served as a natural barrier and boundary regarding the northern geographic range of this species in that area.

During early December 1973, a group of students accompanied me on what would become a pilgrimage to Lexington, Kentucky to determine if we could locate and live capture golden mice for a bioenergetics feeding study (see Stueck et al. 1977 for details). We met for breakfast with the late Roger W. Barbour to discuss sites in Kentucky where we might capture golden mice. Dr. Barbour, along with William H. Davis, was the author of *The Mammals of Kentucky* (Barbour and Davis 1974). Dr. Barbour informed us, following several muffins and a cup of hot chocolate, that our best bet was to explore an area where he discovered a population of golden mice several years earlier. This area was located in a box canyon near Big Hill, Madison County, Kentucky. Big Hill is located near Berea College, an institution nationally recognized for its high standards of education for students residing in the Appalachian Mountains of Kentucky and nearby states. Interestingly, students from Berea College were living in what I would describe as a large log house at this site. Our trip to Big Hill was very exciting and successful.

For example, six golden mice (four males and two females) were captured in one large communal/shelter nest located in an Eastern red cedar (*Juniperus virginiana*) tree (Stueck et al. 1977). We also learned that it typically took several days for golden mice to enter live traps (live traps set on this 2-day excursion were unsuccessful). Thus, we developed a "new capture method" during future 2-day excursions to central Kentucky and elsewhere. Once we located a globular or shelter nest, we used a stepladder to get an eye-level view of the nest if possible; some nests were too high for this strategy. Fortunately, several nests near ground level did not require a ladder. One individual would climb the ladder and then, very carefully, touch the nest with 12-in (30.5-cm) forceps (specimen forceps, Carolina Science, FR-62-4335). If golden mice were present, an individual would typically appear near the entrance to the nest. Unless one is very careful (patience is a great virtue while collecting golden mice), one or more individuals in the nest might become alarmed and leap to the ground. Those individuals that emerged from the nest, yet stayed in the brush or tree canopy, remained our focus of capture. Persons on the ground also had forceps and observed the movement of golden mice once they exited a nest.

Because golden mice are typically docile (unless unnecessarily frightened once leaving the nest), they most often will move from branch to branch, frequently from tree to tree, using their prehensile-like tail to aid their arboreal patterns of movement (Goodpaster and Hoffmeister 1954, Packard and Garner 1964). Golden mice typically move slowly through the branches or undergrowth, pausing frequently to groom or rest. With a couple of ladders, much patience, and good eyes, eventually investigators will be successful. They reach through the brush and, with long forceps, carefully, but gently, clamp the tail and place the golden mouse into a pillowcase in which the mouse can be handled by the neck to determine its sex. Captured individuals are then placed in plastic cages for transport back to the laboratory. I have hand-captured literally dozens of golden mice in this manner.

Occasionally one will locate a large communal/shelter nest containing several individuals. I have personally removed six to eight individual golden mice from large communal nests on several occasions (Jewell et al. 1991, Springer et al. 1981, Stueck et al. 1977). If one is careful, most individuals (one at a time) can be captured with forceps as described earlier. Because golden mice are docile, they can even be manipulated with the forceps (assuming that they have been staring at you from a hole in the nest) and then captured by the tail as they return into the nest.

Several other points of interest should be mentioned when one goes "hunting (alive) golden mice." On numerous excursions, 10–15 globular nests (Figure 1.1)

FIGURE 1.1. Representative globular nest constructed and used by golden mice (*O. nuttalli*). Nests might contain several golden mice at the same time. Photograph by Thomas Luhring.

will be located before one discovers an active nest. Why would a golden mouse allocate energy to constructing numerous seldom-used globular nests, or at least not used throughout the growing season? Could these "extra" nests be constructed to divert or decrease rates of capture by snakes or avian predators? These unknowns provide fertile areas for future research.

Occasionally, especially during winter, one comes upon a large communal/shelter nest (see Chapter 9 of this volume for details). These communal nests frequently contain from four to eight individuals (Barbour 1942, Dietz and Barrett 1992, Stueck et al. 1977). Goodpaster and Hoffmeister (1954) and Packard and Garner (1964) also reported that golden mice commonly are found grouped in arboreal nests in winter, but they are more solitary during summer. Springer et al. (1981) observed natural groupings ranging from two to six individuals per nest in late November 1978. Dietz and Barrett (1992) hand-collected two groups of four individuals each from the same nest in Madison County, Kentucky in December 1988. I have observed that large communal/shelter nests frequently have an abundance of sticks and small limbs in addition to finely shredded bark, grasses, leaves, and feathers typical of globular nests (Linzey 1968, Linzey and Packard 1977).

Another important observation: When one locates an active nest with several mice and is only able to capture one or two individuals out of four or more present, those that escaped will return to the nest overnight. Thus, an investigator will get a second opportunity to collect the remaining individuals from that particular nest. Some decisions require common sense and an understanding of the sample research site. For example, one should not collect all individuals from a particular nest unless it was previously confirmed that there is an abundant population density at the site. On several occasions, experimental animals were returned and released at the site of capture following nesting behavior or bioenergetic studies (Jewell et al. 1991, Knuth and Barrett 1984, Peles et al. 1995, Springer et al. 1981). It should also be noted, but not recommended unless one desires to collect a kin group (Dietz and Barrett 1992), that all individuals in a single nest can be collected simultaneously by carefully trimming most of the vines from around the nest and then quickly placing the nest, including the mice therein, into a pillowcase (my favorite collecting sack). One must be exceedingly careful while clipping the vines and small limbs not to disturb the inhabitants within the nest. Again, *patience is a virtue*.

A final observation: One cannot set 100 live traps for one day and hope the next day to capture *O. nuttalli*. Even if these traps are set on limbs near active nests, I have failed to live trap even a single golden mouse; thus, the reason for the "forceps live-capture" methodology described earlier. When live traps are set overnight in a golden mouse habitat, one can expect to capture at least a few white-footed mice (*Peromyscus leucopus*), perhaps even an Eastern chipmunk (*Tamias striatus*) or a Southern flying squirrel (*Glaucomys volans*). However, golden mice do not readily enter live traps the first couple of nights (see Feldhamer and Maycroft 1992). Perhaps live traps function as foreign novel stimuli, thus impeding their immediate entrance in a freshly set live trap.

FIGURE 1.2. Wooden platform and chamber containing a Sherman live trap situated 5 ft (1.5 m) high on the trunk of a tree used to estimate population abundance of *O. nuttalli*. Photograph by Thomas Luhring.

We have observed, however, that if one places a live trap on a wooden L-shaped platform mounted 5 ft (1.5 m) high on the trunk of a tree (Figure 1.2), then golden mice, as well as white-footed mice, will be more readily captured (Christopher and Barrett 2006). This height is also their most active use of three-dimensional habitat space (Jennison et al. 2006, Pruett et al. 2002).

In summary, for 26 years (1968–1994) while serving on the faculty at Miami University of Ohio, groups of us made several pilgrimages to Big Hill, Kentucky, collecting and observing *O. nuttalli* in their prime habitat. I returned to this site twice with students from the UGA to monitor the abundance of this small mammal species. Unfortunately, on these expeditions only seven golden mice were observed in 2001 and two golden mice in 2005. To my surprise, however, the log house formerly occupied by graduate students from nearby Berea College was discovered to be a tavern where Ulysses S. Grant stayed along his way to Lexington, Kentucky, during the American Civil War (Figure 1.3). In fact, a small cemetery from the American Civil War is located on this site. Thus, not only has this site been prime habitat for golden mice, but also it is now a designated state historic landmark. One frequently learns varied histories while investigating the natural habitat of their favorite species.

Well, so much for the enjoyment of field observations and methodologies developed for collecting one of the unique small mammals in the southeastern United States. Suffice it to say, golden mice represent one of the most unusual small mammals based on their particular bioenergetics, habitat selection, nesting

FIGURE 1.3. Students on a golden mouse-collecting trip in November, 1980, near Big Hill, Madison County, Kentucky (left to right: Barbara Knuth, Mark Maly, Chris Lucia, and Bill Peterjohn). The log house in the background is actually a tavern where Ulysses S. Grant had stayed during the American Civil War. Photograph by Terry L. Barrett.

behavior, and niche relationships. Next, let us turn to the reasons why this book is organized along levels of biological/ecological organization.

Levels-of-Organization Approach

The levels-of-organization concept ranges from the cellular to the ecosphere levels (Figure 1.4). Figure 1.4 also illustrates how 7 ecological processes transcend and integrate these 11 levels of organization (see Barrett et al. 1997 for details). We elected to organize the chapters of this book based on this concept, focusing on the organism/natural history (Chapter 2), population (Chapter 3), community (Chapter 4), ecosystem (Chapter 5), and landscape (Chapter 6) levels. Figure 1.4 also shows seven transcending processes (behavior, development, diversity, energetics, evolution, integration, and regulation) that transcend all levels of organization. These processes are illustrated throughout the book, with some chapters devoted specifically to processes such as energetics, behavior, and evolutionary relationships. This chapter will provide examples to articulate how the golden mouse functions within each of the above levels-of-organization from organism, population, community, ecosystem, to landscape.

As mentioned earlier, select chapters are devoted to the transcending processes as they relate to the golden mouse. For example, Chapter 7 discusses the importance of rarity regarding the evolution, behavior, and dynamics of this

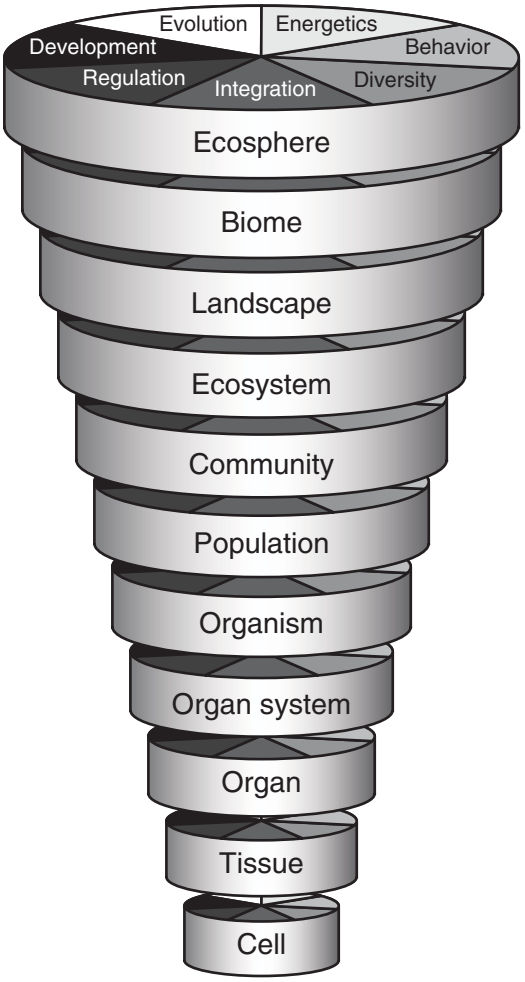

FIGURE 1.4. Model illustrating the levels-of-organization concept. Seven processes transcend and help to integrate levels of organization. Modified after Odum and Barrett 2005, with permission from Brooks/Cole, a division of Thomson Learning.

unique small mammal species. Chapter 8 describes the bioenergetics and energy efficiency of *O. nuttalli* compared to other small mammal species of similar body mass and natural histories. Chapter 9 outlines the unusual nest-building behavior of *O. nuttalli*, illustrating the diversity of nest types constructed and suggesting how these nest types relate to social behavior, ecological energetics, and niche relationships. The authors go so far as to describe the golden mouse as an "ecological *oikos* engineer." Chapter 10 describes the ecology and epidemiology of ectoparasites, bots, and vector-borne diseases associated with golden mice.

Such transcending processes as coevolution, potential role of parasites on golden mouse bioenergetics, and the evolutionary relationship between hosts and parasites in natural ecosystems are discussed. Chapter 10 also illustrates how patterns of movement and use of habitat space affect rates of parasitism in populations of *O. nuttalli* and *P. leucopus* (see Jennison et al. 2006 for details). Chapter 11 is unique in that it introduces a concept of landscape aesthetics in which aesthetics, as an emerging property of natural and cultural landscapes, influences resource recognition, management, conservation, and preservation of species such as the golden mouse. This chapter articulates the process in which the golden mouse has contributed to art, literature, and repositories of American culture and natural history (i.e., curio, museum). Finally, Chapter 12 outlines challenges and research opportunities as related to golden mouse landscape management, population genetics, and intraspecific and interspecific social relationships.

The Golden Mouse and the Levels-of-Organization Concept

Considering the levels-of-organization approach, the golden mouse (or your favorite small mammal species) can be effective in influencing educators, resource managers, and policy makers regarding the management of rare and little understood native species and their role in ecosystem dynamics. One has only to browse in a Barnes and Noble, Borders, or Waldens bookstore or to visit a Bass Pro Shop to realize that greater emphasis is placed on large mammals, such as polar bears (*Ursus maritimus*), timber wolves (*Canis lupus*), white-tailed deer (*Odocoileus virginianus*), and mountain lions (*Puma concolor*) — often referred to as "charismatic megafauna"—than on small mammals. Even intermediate-sized mesocarnivores or mesoomnivores such as raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), bobcats (*Lynx rufus*), and striped skunks (*Mephitis mephitis*) command their share of shelf space, or DVDs. It is rare when a small mammal, such as the golden mouse, shares shelf space or documentary highlights in the bookstore. We hope this volume might help "level the playing field." The chapters that follow in this book will amplify this level-of-organization concept.

Organism Level

At the organismal level of organization one has only to study Figure 1.5 to appreciate the beauty and alert behavior of this unique, nocturnal species. It is not unusual to observe a golden mouse after it leaves its nest, then pausing on a nearby limb to groom. It will sit quietly on such a limb for a long period of time if not disturbed. It is also a time when a mammalogist or ecologist truly appreciates the beauty (rich golden color that is unique among cricetids) and, especially, the docile behavior of golden mice. Linzey and Packard (1977) noted that the golden mouse is unique in its burnished to golden color within the neotomyine–peromyscine group.

Golden mice prefer to live in a variety of habitats, but most frequently they occur in association with heavy undergrowth dominated by greenbrier, Chinese privet