



LABORATORY MANUAL AND WORKBOOK FOR BIOLOGICAL ANTHROPOLOGY

Engaging with Human Evolution

K. Elizabeth Soluri
Sabrina C. Agarwal



LABORATORY MANUAL AND WORKBOOK FOR BIOLOGICAL ANTHROPOLOGY: **ENGAGING WITH HUMAN EVOLUTION**

K. ELIZABETH SOLURI COLLEGE OF MARIN

SABRINA C. AGARWAL UNIVERSITY OF CALIFORNIA, BERKELEY



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PREFACE

FOR INSTRUCTORS

Active, Engaging, Flexible

The introductory laboratory in biological anthropology can be an inspiring place. It is exciting to see students interact with materials and concepts that may be entirely novel and unfamiliar to them. Of course, it is a challenging place too, a place with many students who enrolled without foreseeing the scientific content and detail of the course. This was the case when we taught introductory biological anthropology at the University of California, Berkeley, and decided to redesign the laboratory portion of the course in 2005. In doing so we had three overarching goals: (1) we wanted to emphasize active student engagement as a way to strengthen learning and long-term retention of course content, (2) we wanted to help students from diverse backgrounds and with varying degrees of experience in anthropology learn the key information about human biology and evolution, and (3) we wanted the lab manual to be simple for instructors to implement in their classes, whether it is used in pieces or as a whole.

We decided to attack this task, both with creativity and with a research and empirical approach emphasizing constant reassessment and improvement. We began simply by creating weekly lab exercises that corresponded with the topics covered in the course and were based on principles of learning from current pedagogy and cognition literature. Then, we spent the next several years trying these lab assignments in classrooms, tweaking them, and testing them again. We also collected empirical data about student engagement, initial learning, and long-term retention of knowledge from the lab component of the course. The data formed the basis for one of the author's (Soluri) doctoral dissertation, which explicitly examined effective pedagogical methods in biological anthropology instruction. With proof of concept at the initial implementation at UC Berkeley, the exercises, questions, and text were then expanded, tested, and refined in additional classroom environments, including community college courses in the San Francisco Bay area. We wanted to make sure our approach would work with as broad an audience as possible.

As a result, we feel this manual has developed into something unique among biological anthropology laboratory manuals.

1. The manual addresses a wide range of topics relevant to introductory biological anthropology courses,

including genetics and evolutionary theory, skeletal biology and forensic anthropology, primatology, and paleoanthropology. We provide a balanced approach to the topics that gives students a well-rounded foundation in the discipline. We also present concepts, such as modern human variation, that are central to biological anthropology but are often not emphasized in laboratory texts. In doing this, we help students build the most comprehensive biological anthropology skill set possible. Each of the lab exercises has been designed with real students in mind, and their effectiveness has been tested and fine-tuned over many semesters in real classrooms at various institutions.

2. The authors' concern with employing effective pedagogy has resulted in a distinctive text that explicitly emphasizes a student-centered learning experience. The manual applies active learning pedagogy, which emphasizes the importance of students' hands-on involvement in learning. It is ideal for laboratory contexts where the goal is to foster the development of key skills, as well as content knowledge.
3. The text is exceptional in its further emphasis on cooperative pedagogy, which highlights the importance of student teamwork to complete learning tasks. This approach helps students develop the critical thinking and communication skills that aid them in the biological anthropology classroom and beyond. We have designed the manual's exercises and discussions with cooperative pedagogy in mind, and we encourage instructors to have students work in groups when completing the classroom tasks.
4. We have given additional attention to designing a text that is appropriate for a variety of learning environments and types of learners. Therefore, the exercise format is varied throughout the text, offering a range of activities that target particular learning styles. This variation helps each student to connect with the material, no matter what their learning background. It also allows instructors to choose particular activities suitable for the unique student makeup of each class.
5. Although the units and labs are arranged in the order in which the topics are often covered in classrooms, we have designed them to be modular. Units and labs can be taught in any order that suits the instructor's needs.

6. In addition to its topical breadth, the manual is unusual because of the varied professional experience of its authors. Dr. Soluri's research has focused on the pedagogical aspects of teaching biological anthropology, and she has experience teaching biological anthropology lecture and laboratory courses at large 4-year institutions and community colleges in the United States. Dr. Agarwal's research has focused on bioarchaeology and skeletal analysis, and she has experience teaching biological anthropology lecture and laboratory courses at large and small 4-year institutions in the United States and Canada. Together, their collective research and teaching experience results in a well-rounded text that is appropriate for a wide range of college and university classrooms.

Organization and Pedagogy

Four flexible units. Our text covers a range of biological anthropology topics in sixteen chapters, or labs. The labs are equally distributed into four units, or parts. The first unit (Labs 1–4) focuses on genetics and evolutionary theory. It places biological anthropology in the context of anthropology and science more generally, and it provides information about what evolution is and how it works. The second unit (Labs 5–8) focuses on modern humans. It gives an introduction to the major bones of the human skeleton and teaches some of the skills and methods used by forensic anthropologists. This unit also examines issues of modern human variation and adaptation. The third unit (Labs 9–12) focuses on primatology. It reviews issues of biological classification and highlights similarities and differences in primate anatomy and behavior. The final unit (Labs 13–16) focuses on paleoanthropology. It traces our fossil history from the first primates to modern humans.

As noted earlier, although the units and labs are arranged in the order in which the topics are often covered in classrooms, we have designed them to be modular, and they can be taught in any order. For courses that have fewer class meetings, labs can be combined or eliminated as necessary. For courses that have more class meetings, labs can be divided across multiple class days. Each lab can be treated as a separate entity, allowing the instructor maximum flexibility in scheduling and lesson planning.

Chapter organization. Within each lab, there are four primary subsections. The first is the **text section**, providing a written overview of the content for the lab. It can be assigned as reading that reviews course information or introduces it for the first time. The text sections are written in a simple and

easy-to-follow format, and they are supported with diagrams, images, and realistic examples to better elucidate points. At the end of the text section of certain labs, we present more advanced concepts that instructors might want to make optional; this material is called out with the heading **Exploring Further**. The second section is a list of **concept review questions**. These questions target foundational knowledge and are designed to reinforce the learning of basic factual content. They are a good review of the reading portion of the chapter, and they can be assigned as homework to be completed before class or as pre-lab questions to be completed at the start of class. The third section includes a set of **five to ten lab exercises** (depending on the type of content covered and length of the exercises). Instructors can choose to assign all of the exercises in a lab or only a sample, depending on their classroom needs. The exercises emphasize active and cooperative pedagogy and are designed to target higher levels of learning, such as comprehension and analysis. Instructors with access to casts and skeletal elements can easily integrate their own teaching collection with the manual exercises. Instructors who do not have access to casts, or who have gaps in their teaching collection, can direct their students to the images provided in the lab appendices. The final section consists of a list of **critical thinking questions** and tasks. This material often targets the highest levels of learning, such as synthesis and evaluation. It provides students with a review of lab content and a chance to think critically about that content. Instructors can assign this material as follow-up questions completed alongside in-class exercises or outside the classroom. Instructors can also use critical thinking questions and concept review questions as exam questions.

Art and photo program. Biological anthropology is a visual discipline and we have tried to illustrate this text in the best possible manner. Every chapter has multiple large and detailed figures and photographs. In most cases, to help students understand the general size of what we picture, we have included scales based on direct measurements of specimens or measurements provided in scientific literature. We strive for accuracy in our drawings and represent many drawings of bones and fossils with an almost three-dimensional appearance. The text has been laid out in a step-by-step manner with use of white space and a double-column design that promotes easy scanning of pages. We provide a map and geological time line on the inside front and back covers.

Tear-out worksheets. All worksheets are designed to be torn out and submitted by students with plenty of room for

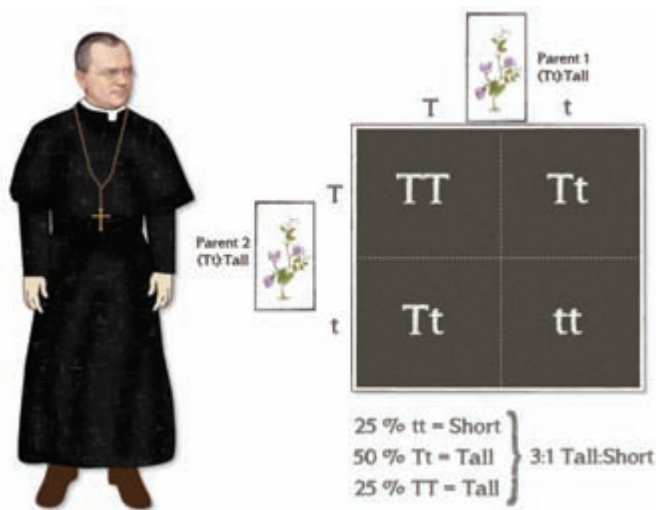
answers. Space for student identification is on every page to aid in grading. Some instructors might also like their students to use the three-hole punch version of this manual. This lets students easily retain worksheets in a binder as they are returned.

Instructor Supplements (wwnorton.com/instructors)

Instructor's solutions manual and chapter guidelines. The entire lab manual is supplemented by special instructor material that gives instructors the information they need to implement the manual in their courses. It presents guidelines for the exercises, including information about materials needed and the approximate length of time suggested for each activity. It also provides instructors with answers to all concept review questions, exercises, and critical thinking questions.

Image set. Every image, table, and chart from the book is available for download.

LMS coursepacks. Special LMS coursepacks contain versions of selected labs designed to work in your LMS. These facilitate on-line submission of exercises for distance and blended learning students (note that students must have the lab manual for access to images). The coursepack also contains the introductory Concept Review quiz for each chapter, and access to Norton's animation and video resource for biological anthropology.



Low-priced versions and bundle discounts. This manual is available in a discounted three-hole punch version, as

well as an inexpensive electronic version for your distance learning students. Discounted bundle prices are also available to keep costs reasonable for students. Please contact your W. W. Norton representative for more information.

FOR STUDENTS

This book is designed to engage you in an exploration of human biology and evolution. The evolution of our species is a vast and complex topic that is studied by biological anthropologists around the world who seek to understand who we are as a species, how we came to be this way, and where we may be headed from here. Biological anthropologists tackle these issues using a range of research questions and methods, and we will investigate these different forms of analysis throughout the text. Each lab in the book includes text that introduces important content information, questions that can be used to test your comprehension of the material, exercises that ask you to think and act like an anthropologist, and critical thinking questions that ask you to combine all of this knowledge in complex and new ways. There is no set order to the labs, and your instructor may choose to present the labs in any order. No matter where you start or finish, the labs will combine to provide a broad picture of the human species and our evolutionary history.

To facilitate your learning, we engage you as active participants. You will complete tasks, answer questions, and think critically about the information presented. You will get the chance to practice some of the comparative and analytical skills used by biological anthropologists, and you will likely begin seeing yourself in a whole new light because of it. We provide you with up-to-date information about major topics in biological anthropology, so that you are gaining the most accurate and current knowledge possible. We also describe issues and examples that are interesting and relevant to your real life. We supply you with high quality photos and drawings of skeletons, fossils, and living animals to illustrate key points and anatomical features throughout the text. Your instructor may then give you access to additional materials, such as skeletal elements and fossil casts, to supplement what you see and learn in the book.

By the end of this book and course, you will be thinking and applying analytical skills like a biological anthropologist. You will have learned more about yourself, your place in the world, and your evolutionary history, and you will be armed with this knowledge as you continue life in and outside of anthropology classrooms.

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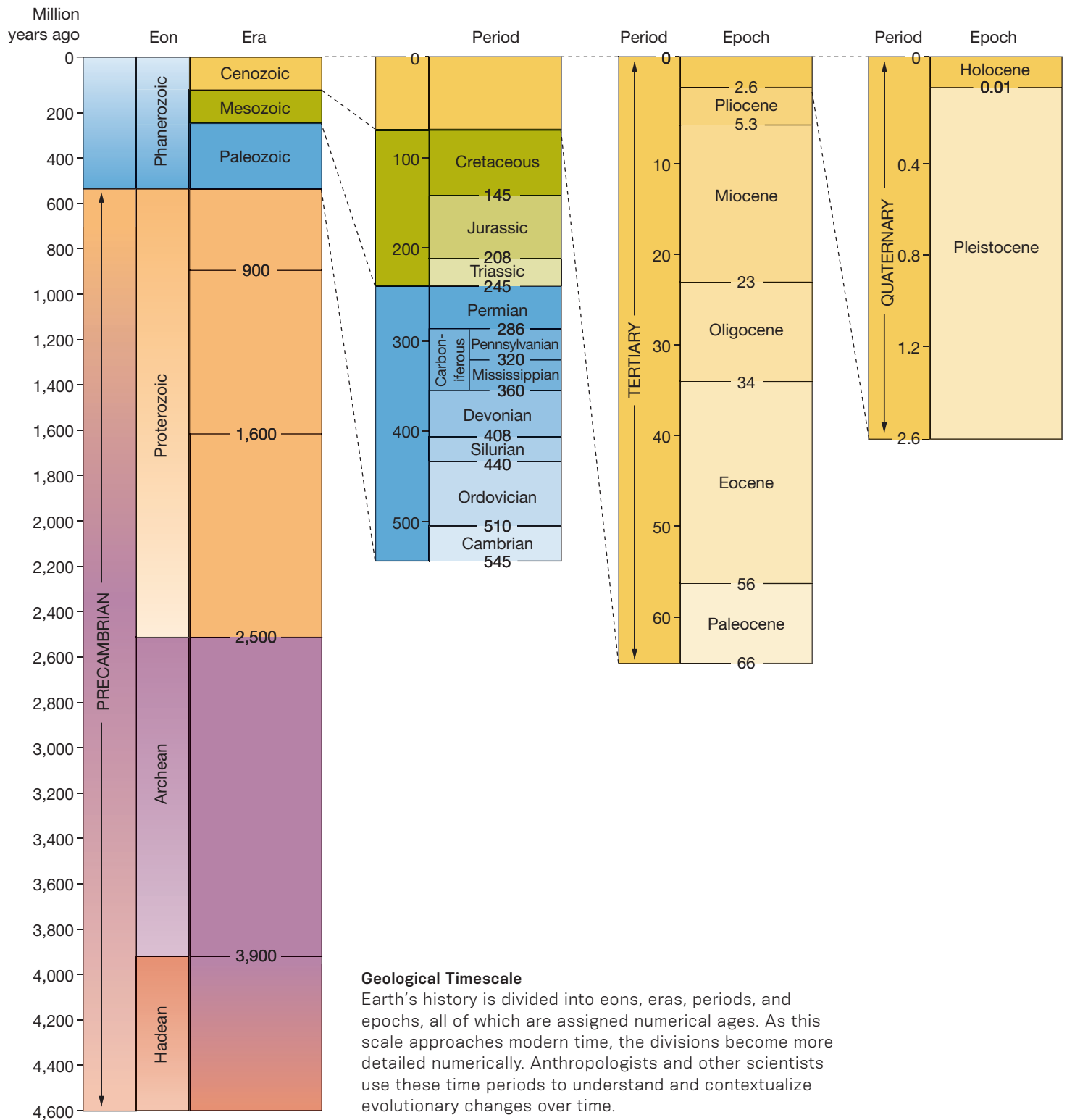
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**LABORATORY MANUAL AND WORKBOOK FOR BIOLOGICAL
ANTHROPOLOGY: ENGAGING WITH HUMAN EVOLUTION**

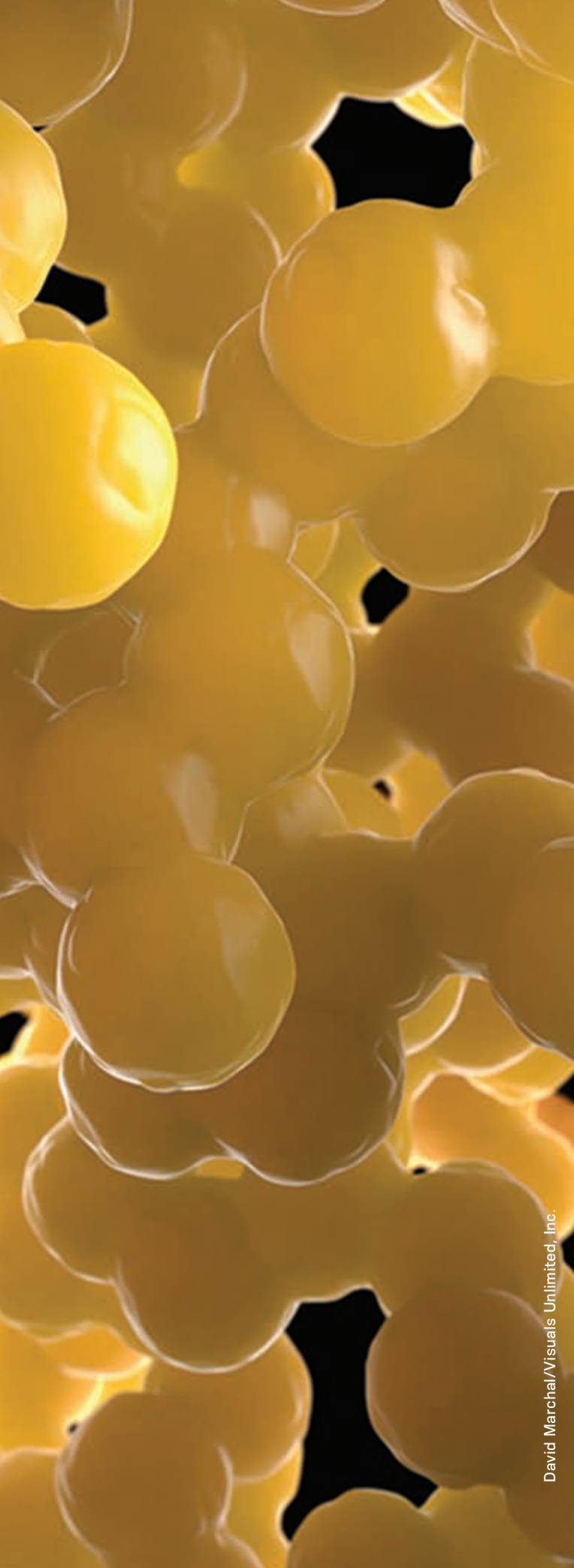


PART ONE



GENETICS AND EVOLUTIONARY THEORY

The genetic code for an organism is stored in its DNA. This DNA is coiled with proteins to form chromosomes. Humans have 23 pairs of chromosomes.



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LAB 1: BIOLOGICAL ANTHROPOLOGY AND THE SCIENTIFIC METHOD

WHAT TOPICS ARE COVERED IN THIS LAB?

- An introduction to the discipline of anthropology
- A discussion of the four fields of anthropology
- A closer consideration of the field of biological anthropology
- A review of science and the scientific method
- An overview of the role of scientific inquiry in biological anthropology research

LAB 2: GENETICS

WHAT TOPICS ARE COVERED IN THIS LAB?

- An introduction to the cell parts related to processes of evolution and inheritance
- A look at the importance of cell division for evolution
- A review of DNA replication and protein synthesis

LAB 3: INHERITANCE

WHAT TOPICS ARE COVERED IN THIS LAB?

- An overview of Gregor Mendel's research with pea plants
- A consideration of the relationship between dominant and recessive alleles
- A review of genotypes and phenotypes
- An introduction to the production and interpretation of Punnett squares and pedigree diagrams
- A discussion of Mendelian and non-Mendelian traits
- An examination of the ABO blood group in humans to illuminate complex relationships of dominance and recessiveness in real life

LAB 4: FORCES OF EVOLUTION

WHAT TOPICS ARE COVERED IN THIS LAB?

- An introduction to the concept of evolution
- A discussion of the role of genetic recombination in evolution
- A review of the primary forces of evolution (mutation, natural selection, genetic drift, and gene flow)
- A consideration of how to determine when evolution is happening, using the Hardy-Weinberg equilibrium



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Biological anthropologists address a wide range of research topics related to humans and our evolutionary history. This research often includes time in the laboratory and time in the field.

Lab Learning Objectives

By the end of this lab, students should be able to:

- describe the discipline of anthropology in general, and compare the four fields of anthropology.
- discuss the similarities and differences between the subfields of biological anthropology.
- explain the scientific method and define "scientific theory."
- discuss how biological anthropologists draw on science and scientific techniques in their work.

LAB 1

Biological Anthropology and the Scientific Method

In Germany, a group of researchers examines modern and ancient human DNA to understand human population movements in the past. Meanwhile, researchers in Ethiopia excavate the fossil remains of some of our relatives who went extinct roughly 4 million years ago. In California, a researcher analyzes 7,000-year-old bones for evidence of changes in bone density related to both biological sex and gender differences during life. At the same time, researchers in Borneo observe orangutans using probing tools to fish for the insects they eat. What do all of these people have in common? They are all conducting biological anthropology research. What does it mean to be a biological anthropologist? What topics do biological anthropologists study? In this lab, we explore answers to these questions.

anthropology the study of people

context the time, space, environment, historical circumstances, and cultural practices within which a subject of anthropological investigation is situated

holistic approach research approach that emphasizes the importance of all aspects of the study subject and requires a consideration of context to gain an understanding of the broader picture

comparative approach research approach that emphasizes the importance of comparisons across cultures, times, places, species, etc.

cultural anthropology the study of the cultural life of living people, including their cultural practices, beliefs, economics, politics, gender roles, etc.; also called social anthropology

INTRODUCTION

We begin this lab with an overview of the discipline of anthropology. We discuss the four fields of anthropology, and we pay particular attention to how biological anthropology relates to the other fields of anthropology. We outline the subfields of biological anthropology and consider how they overlap and vary. We also explore science more generally, discussing the scientific method and its role in scientific research. We conclude by examining how biological anthropologists employ the scientific method in their work.

WHAT IS ANTHROPOLOGY?

Anthropology, in the most general sense, refers to the study of people. This can take a variety of forms, including the study of people in the present and people in the past. There are two ideas that are fundamental to all anthropological work. The first idea is the importance of **context**. This includes issues of time, space, unique historical and environmental circumstances, and various culturally specific practices. Context is important to all anthropological work because it shapes what we study. People do not live in a vacuum. Instead, they are inseparable from the context in which they live. For example, if an anthropologist were to fully understand you, they would have to consider your age, where you live, your gender, your life experience, your cultural practices, your family, your place in the broader biological world, and many other factors specific and unique to you. Where you live determines the environmental resources available to you, your food, and possibly your cultural practices. Your cultural practices impact the way you view the world and your place in it. Your biology, such as your sex or age, may impact your place in your culture, and your life experiences often tell the story of all of these factors. It would be impossible to understand you without understanding as much as possible about these other contextual issues. This emphasis on context and how different aspects

of a study subject interrelate and impact one another is often called a **holistic approach**. With a holistic approach, emphasis is placed on seeing the whole picture because anthropology recognizes that numerous factors and contextual issues contribute to what it means to be human.

The second fundamental idea in anthropology is the use of a **comparative approach**. The comparative approach can take many forms, and anthropological comparisons can be the focus of a research project or only a component of a research project. For example, anthropologists often compare different cultural groups, or the same cultural group in different time periods, or people in one region to people in another region, or humans to other species. No matter what anthropologists study, they recognize the importance of considering similarities and differences through comparisons.

Anthropology is unique because it takes into account how people are shaped by their biological and their cultural context, and it explores and compares people in all time periods and regions. Other social sciences, such as psychology and sociology, have minor components of both of these fundamental aspects of anthropology. While many social scientists consider the role of biology and/or culture in human life, most of these disciplines do not emphasize a comparative approach. They study people in the present or people in particular areas of the world. In contrast, anthropological work considers context and employs a broad, comparative perspective.

FOUR FIELDS OF ANTHROPOLOGY

There are generally four fields of anthropology (**FIGURE 1.1**). These four fields are united by the consideration of culture and an emphasis on the comparative approach, but they vary based on what questions they ask and what materials they study. One field of anthropology is called **cultural anthropology** (often called social anthropology in Europe). Cultural anthropologists study cultural practices, beliefs, economics,

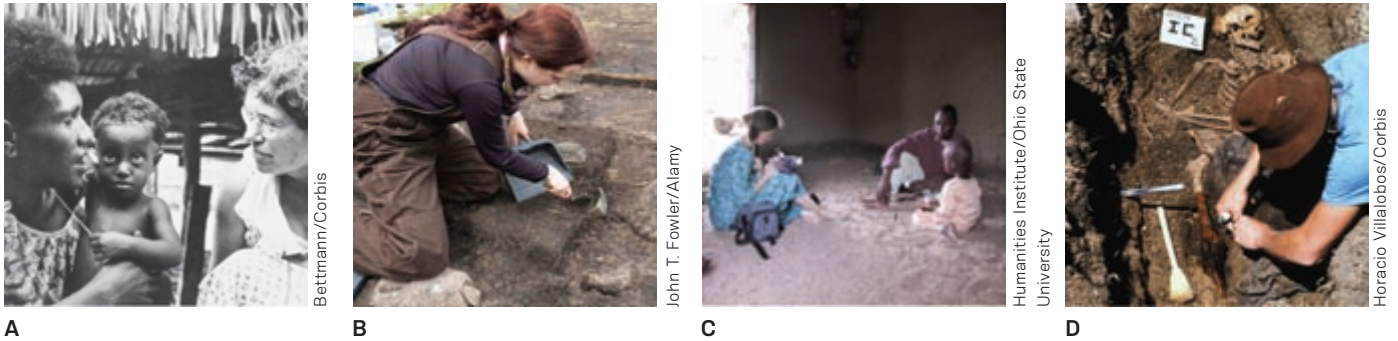


FIGURE 1.1 The Four Fields of Anthropology

All four fields of anthropology emphasize the importance of context and apply a comparative approach, but they differ in the specific aspects of humanity that they study. Cultural anthropologists (A) study the cultural life of living people. Archaeologists (B) study the cultural life of past people by examining their material remains. Linguistic anthropologists (C) study how people make and use language. Biological anthropologists (D) study human evolution, and their methods of analysis may be applied to help criminal investigations.

politics, gender roles, etc.; they traditionally studied non-Western groups, although this is not always the case in the field today. Cultural anthropologists study living (or recently living) peoples. These anthropologists make observations, conduct interviews, and examine things made by the people being studied (their material culture). For example, a cultural anthropologist might study the seasonal rituals practiced by a particular Native American group. The anthropologist would observe the rituals and the times surrounding the rituals to understand the broader cultural context of the practices. The anthropologist might interview the people involved in the ritual and the people who observe the ritual, and the anthropologist might examine the clothing and materials used in the ritual.

A second field of anthropology is **linguistic anthropology**. Linguistic anthropologists study how people make and use language. Again, linguistic anthropologists tend to research living (or recently living) peoples, and they traditionally studied non-Western populations. Like cultural anthropologists, linguistic anthropologists use observations and interviews to collect data about language production and use. They can also use written documents, where available, and recordings of people speaking the language under study. For example, a linguistic anthropologist might study how language is used differently by men and women in an indigenous group in New Guinea. The anthropologist would

observe people talking with people of their same gender and people not of their same gender. The anthropologist might also interview people about who taught them their language, how they talk to their children of different genders, and how they talk to different people in their community. The anthropologist might also listen to recordings of songs made by earlier researchers studying the same group to see if there are differences in men's and women's singing.

A third field of anthropology is **archaeology**. In Europe, archaeology is sometimes treated as a discipline separate from anthropology. In the United States, however, archaeology is considered a subdiscipline of anthropology, and it is sometimes called anthropological archaeology to highlight this categorization. Archaeologists, like cultural anthropologists, study cultural practices, economics, gender roles, and rituals. However, archaeologists focus on people and cultures in the past. Sometimes they study the distant past, tens of thousands of years ago. Sometimes they study the recent past, maybe only a few decades ago. Archaeologists study both Western and non-Western peoples around the world. Unlike cultural and linguistic anthropology, archaeology primarily examines the material remains left by people to understand their practices and way of life. Material remains are things that are made or modified by people and later recovered by an archaeologist. They include things like remnants of houses

linguistic anthropology the study of how people make and use language

archaeology the study of the cultural life of past people, as seen through their material remains such as architecture, bones, and tools

and ritual buildings, human bones and burials, tools, animal bones and charred plant parts, ceramic vessels, personal ornaments, statues, clothing, and sometimes historical documents. If archaeologists were studying what Maya people ate in a community in Mexico 1,000 years ago, they would probably try to recover and examine animal and plant remains from meals, ceramic vessels that held food and beverages, areas of the community that were used for food storage or preparation, and any documents that might help them understand food use.

The fourth field of anthropology is called **biological anthropology**. Biological anthropology is traditionally called physical anthropology, with the term “physical” reflecting a traditional focus on the physical measurement of modern humans. Current trends in the field emphasize methods and theories from biology, such as the growing incorporation of DNA analysis. Thus, while both names are acceptable and continue to be used today, we will use “biological anthropology” to reflect anthropologists’ increasing use of biological techniques.

Biological anthropology is the study of human evolution, including our biology, our close primate relatives, our fossil ancestry, and our current similarities and differences. Biological anthropologists study people today and in the past. They also study nonhuman species, specifically our living primate relatives and our extinct fossil relatives. They examine a wide range of material, including fossils, living primates, skeletons, and DNA. For example, a biological anthropologist studying the primate capacity for language might examine genes that contribute to language production and comprehension. That same anthropologist could also examine the bones of the skeleton related to language production and/or try to train living primates to produce or understand some form of language. The theme that unifies biological anthropology research is an emphasis on evolution.

One of the things that makes biological anthropology research unusual among the sciences is its emphasis on a **biocultural approach**. This approach recognizes that human biology and culture are closely intertwined and need to

be examined and understood simultaneously. Thus, biological anthropologists consider how stone tool use (culture) impacted past diet and dietary adaptations (biology) or how mating preferences (culture) impact current population isolation and human variation (biology).

THE SUBFIELDS OF BIOLOGICAL ANTHROPOLOGY

Within biological anthropology, there are several subfields. Each subfield emphasizes different aspects of human evolution and our place in the world. One subfield can be generally referred to as **human biology**. This is a broad subfield that includes research on human genetics, the impact of evolutionary processes on our species, and variation among humans today. This subfield draws heavily on theories and methods from biology. For example, a researcher in human biology might study the evolution of a particular trait, such as adult lactose tolerance. This researcher could explore the impact of different evolutionary processes in shaping this adaptation. He could also consider genetic evidence for the trait, as well as why this trait might vary in human populations today. Another example of human biology research would be a study of energy demands and nutrition in different human populations. The researcher could observe and interview people in different groups to identify what people eat, how regularly they eat, how they spend their time, and how much energy is required for their lifestyle. The researcher would likely take into account differences in age, gender, and social status that may impact energy demands and nutrition.

Forensic anthropology is an applied area of biological anthropology that has gained popular attention through the television programs *Bones* and *CSI*. Forensic anthropology is related to human biology because it applies methods of skeletal analysis from biology and anatomy to real-world problems. Forensic anthropologists analyze human skeletons as part of legal investigations. When a criminal investigation uncovers

biological anthropology the study of human evolution, including human biology, our close living and extinct relatives, and current similarities and differences within our species; also called physical anthropology

biocultural approach research approach that recognizes the close relationship between human biology and culture and attempts to study these two forces simultaneously

human biology the study of human genetics, variations within our species, and how our species is impacted by evolutionary processes

forensic anthropology the application of knowledge and methods of skeletal analysis to assist in legal investigations



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FIGURE 1.2 Forensic Anthropology

Forensic anthropologists apply methods of human skeletal analysis to aid criminal investigations. They help identify victims and describe circumstances surrounding death, using clues in human skeletal remains.

a victim that is primarily skeletal, with little soft tissue remaining, investigators call on a forensic anthropologist for assistance (FIGURE 1.2). In some cases, forensic anthropologists are asked to help with investigations of war crimes, natural disasters, and other instances that involve the identification of numerous victims. These anthropologists are experts on the human skeleton and use various methods and techniques to help identify victims and to suggest the circumstances surrounding the victims' deaths.

Another subfield of biological anthropology is called **primatology**. Primatology is the study of living primates (FIGURE 1.3). Primatologists study similarities and differences across primate species, and they try to understand how, why, and when various primate traits evolved. Because humans are primates, this work is used to help understand our broader biological context and evolutionary history. Primatologists draw on biological theories and methods, such as DNA analysis and observations of animals in the wild. Primatologists may also design laboratory experiments to test things such as the ability of primates to perform certain problem-solving tasks or learn language. A primatologist might study chimpanzee social interactions in the wild. In doing this, the researcher would stay near a group of chimpanzees for an extended time, observing and documenting chimpanzee behavior in

various social situations, such as sharing food, having sex, and fighting. This type of information could then be used to help us understand human behavior in similar situations today and in the past.

The final subfield of biological anthropology is called **paleoanthropology**. Paleoanthropology is the study of the anatomy and behavior of humans and our biological relatives in the past (FIGURE 1.4). This subfield uses methods of excavation that are similar to those used by archaeologists, and there is often overlap in the evidence used in paleoanthropology and archaeology. However, archaeologists tend to focus on the modern human species, and paleoanthropologists often focus on our ancient extinct relatives, such as Neanderthals. Paleoanthropologists often deal with the more distant past, even as far back as several million years ago. Paleoanthropologists also focus on the analysis of fossilized skeletal remains and sometimes tools and other artifacts that have been well preserved across long periods. For example, a paleoanthropologist might study when we first diverged from other primates.

primatology

the study of living primates, particularly their similarities and differences and why these similarities and differences might exist

paleoanthropology

the study of the anatomy and behavior of humans and our extinct relatives



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FIGURE 1.3 Primatology

Some biological anthropologists, such as Jane Goodall, specialize in primatology.