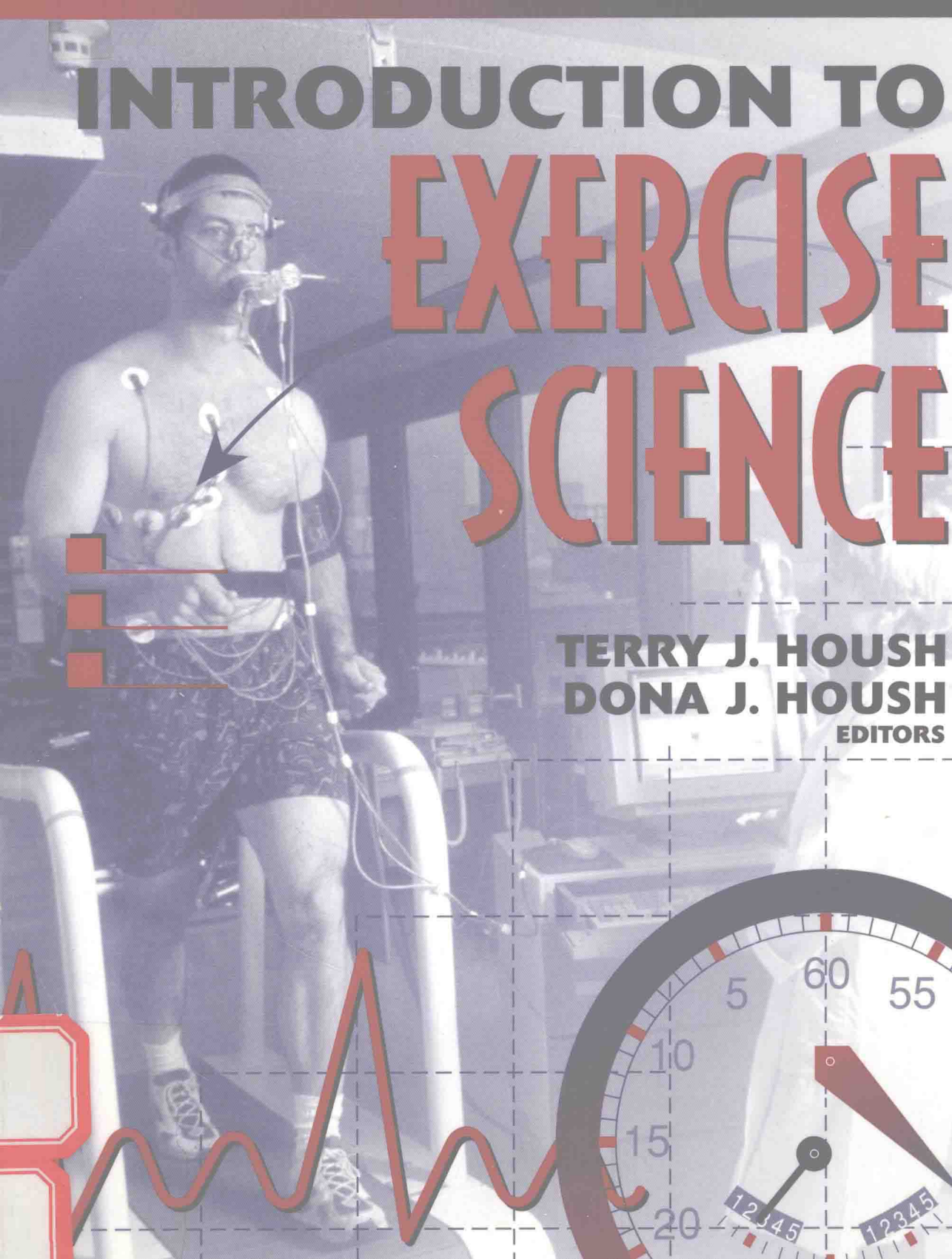
# INTRODUCTION TO EXERCISE SCIENCE

TERRY J. HOUSH
DONA J. HOUSH
EDITORS



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# PREFACE

*Introduction to Exercise Science* is designed to introduce undergraduate students to such aspects of the discipline as the areas of study, technology, certifications, professional associations, and career opportunities. It also helps students develop an appreciation for the history, as well as current and future trends in exercise science. This textbook is not designed as an in-depth exposure to the individual areas of study (i.e., anatomy, biomechanics etc.) within exercise science and, therefore, each chapter identifies prominent and timely lines of inquiry without exhaustive reviews of the primary literature.

This textbook is divided into two parts: Introduction and Areas of Study in Exercise Science. Part I includes chapters entitled An Introduction to Exercise Science and History of Exercise Science, while Part II includes chapters on Anatomy, Athletic Training: The Profession, Biomechanics, Exercise Physiology, Exercise and Sport Nutrition, Exercise and Sport Psychology, Measurement in Exercise Science, and Motor Control and Motor Learning. Each chapter in Part II provides information on the specific area of study including a brief history, health and sports performance-related issues, technology, professional associations, employment opportunities, glossary of terms, study questions, an abstract of research, and suggested readings.

## Chapter 1: An Introduction to Exercise Science

Chapter 1 provides basic information about exercise science. It defines exercise and science and provides a working definition of exercise science as "how and why the human body responds to physical activity." It also describes the coursework typically included in an undergraduate major in exercise science and provides examples from four universities presently involved in training undergraduate exercise science students. Furthermore, this chapter synopsizes the Basic Standards for the Professional Preparation in Exercise Science 1995 prepared by the Applied Exercise Science Council of the National Association for Sport and Physical Education (NASPE) of the American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD).

## Chapter 2: History of Exercise Science

In Chapter 2, Herbert deVries provides a historical foundation for the understanding of exercise science. To fully appreciate the current and future trends in the field it is important to know how exercise science developed. Chapter 2 discusses the influence of medical doctors as pioneers in exercise science as well as factors that contributed to the emergence of exercise science as a unique field of study. This chapter also identifies important scientists from the United States and Europe who influenced the development of exercise science and describes selected classic research studies which added to our understanding of

the effects of exercise training. Finally, Dr. deVries provides a perspective on the divergence between exercise science and the applied, professional area of physical education pedagogy (teacher training).

## Chapter 3: Anatomy

An understanding of human anatomy is essential to the development of knowledge in exercise science. In Chapter 3, Glen Johnson discusses the basic science area of anatomy. This chapter provides a brief history of anatomy and defines the subspecialties of gross anatomy, cytology, histology, comparative anatomy, developmental anatomy, and pathological anatomy. Furthermore, Dr. Johnson ties the study of anatomy to exercise science by relating it to research in growth and development, body composition, and the cellular adaptations to training.

## Chapter 4: Athletic Training: The Profession

Chapter 4 addresses issues in Athletic Training. In this chapter, Ronald Pfeiffer includes a description of the profession, the National Athletic Trainer's Association (NATA) Board of Certification examination, and employment opportunities. Athletic training provides a unique opportunity for exercise science professionals to combine work in the area of sports performance with health-related, clinical careers. The national certification process is highly structured and Dr. Pfeiffer outlines the expectations for professionals in athletic training.

## Chapter 5: Biomechanics

Chapter 5 on biomechanics is co-authored by Daniel Blanke and Nick Stergiou from the University of Nebraska-Omaha. Biomechanics has many applications in exercise science and this chapter outlines various sports performance and health-related aspects. In addition, a number of new technologies are discussed in Chapter 5 which are used for in-depth analyses of human movement. Furthermore, as the chapter indicates, there are many interesting employment opportunities for students with knowledge and skills in biomechanics.

## Chapter 6: Exercise Physiology

Exercise physiology is central to an understanding of exercise science. In Chapter 6, Joseph Weir describes many areas of basic and applied research. Exercise physiologists have a number of employment opportunities in academia as well as the private sector. Furthermore, professional organizations such as the American College of Sports Medicine (ACSM) and National Strength and Conditioning Association (NSCA) provide certifications that include topics in exercise physiology which supplement the formal college and university training for exercise science students.

## Chapter 7: Exercise and Sport Nutrition

Proper nutrition is important for optimal health as well as successful sports performance. In Chapter 7, Joan Eckerson includes information about nutrition as it relates to chronic disease and athletic performance. In addition, nutritional supplements as ergogenic aids are discussed. In terms of employment opportunities, there is a growing trend towards combining formal training in nutrition with exercise science to meet the needs of health clubs and wellness centers.

## Chapter 8: Exercise and Sport Psychology

In Chapter 8, Richard Schmidt provides information regarding various aspects of exercise and sport psychology. Exercise psychology deals with factors related to motivation, exercise initiation, adherence, and compliance as well as the psychological changes associated with exercise training. Sport psychology includes factors which limit as well as enhance the ability to perform athletic events. Dr. Schmidt also discusses ways in which sports participation can enhance psychological growth and development.

## Chapter 9: Measurement in Exercise Science

Measurement theory and procedures have many applications in exercise science. In Chapter 9, Dale Mood explores the roles of measurement in exercise science. In addition to the assessment of cognitive, physical, and psychological aspects of human performance, measurement also includes issues related to statistical procedures and computer applications.

## Chapter 10: Motor Control and Motor Learning

In Chapter 10, David Sherwood provides basic information concerning the psychological and neurological theories underlying motor control and motor learning. The applications of these theories have implications for health-related fields such as physical therapy and rehabilitation as well as sports performance. Basic knowledge of motor learning and control is valuable for allied health professionals as well as athletes.

This textbook includes contributions from four generations of exercise scientists. Herbert A. deVries, Emeritus Professor at the University of Southern California, is truly a pioneer in the study of exercise and its relationship to sports performance and health across the life span. In 1986, we were at Portland State University, Portland, Oregon. A faculty member, Mike Tichy asked whether we would be interested in helping with a research project organized by Herb at PSU. It turned out that Mike and Herb attended undergraduate school together at East Stroudsburg University in Pennsylvania and were lifelong friends. It was to our great benefit to have the opportunity to assist Herb with that initial project. Since then, we have remained friends and Herb comes to the University of Nebraska-Lincoln

periodically to continue our research on electromyography and muscle fatigue. We were very fortunate to be in the right place at the right time in 1986 and it has been our personal and professional pleasure to work with Dr. deVries for over 12 years now.

Glen O. Johnson, and Dale P. Mood attended graduate school together at the University of Iowa in the late 1960s. They have continued their friendships over the years, and we were fortunate to persuade them to contribute to this textbook. We were also fortunate to have Glen as a doctoral advisor at the University of Nebraska-Lincoln. It was through Glen that we were introduced to Dale and have greatly enjoyed attending professional conferences together such as the annual meeting of the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD).

Joan M. Eckerson and Joseph P. Weir earned their doctoral degrees at the University of Nebraska-Lincoln in the early 1990s. Glen O. Johnson, Terry J. Housh and Richard J. Schmidt were doctoral advisors for Joan and Joe and the succession of exercise scientists will continue with their students.

Editing this textbook has also given us the opportunity to further develop existing friendships as well as make new ones. In this regard, it has been our pleasure to work with Daniel J. Blanke and Nick Stergiou from the University of Nebraska-Omaha, Ronald P. Pfeiffer from Boise State University, and David E. Sherwood from the University of Colorado-Boulder.

One of the true joys of academic life is the long-term associations with students and colleagues who have similar professional interests. It is our hope that the collective insights of the four generations of exercise scientists represented in this textbook will contribute to the professional development of future generations of exercise scientists.

We thank the following reviewers for their helpful suggestions: John Hauth, East Stroudsburg University; Gary Liguori, University of Wyoming; Lori Dewald, Shippensburg University; Andrew Kozar, University of Tennessee–Knoxville; Robert Behnke, Indiana State University; B. Sue Graves, Florida Atlantic University; and Susan Barnd, University of Wisconsin–LaCrosse.

# Introduction to Exercise Science

# CONTENTS

CHAPTER

# 1 An Introduction to Exercise Science

TERRY J. HOUSH

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## What Is Exercise Science?

*Exercise* is defined as "the performance of any physical activity for the purpose of conditioning the body, improving health, or maintaining fitness, or as a means of therapy for correcting a deformity or restoring the organs and bodily functions to a state of health" (13). *Science* is "a systematic attempt to establish theories to explain observed phenomena and the knowledge obtained through these efforts" (13). Simply stated, *exercise science* is concerned with how and why the human body responds to physical activity. From this generic description, it is clear that exercise science is a very diverse field of study that encompasses many areas of inquiry. For example, the simple act of walking can be viewed from many different perspectives. An anatomist can describe the muscles involved in walking. An exercise physiologist may study how the systems of the body respond to the stress of walking, and a

biomechanist can apply the laws of physics to examine the efficiency of each stride. An exercise psychologist may be interested in what motivates the subject to walk, and a sports nutritionist can describe how the food that we eat is used to supply the energy for the walk.

Furthermore, each of these exercise scientists can study how we respond during an exercise bout (acute responses to exercise) or how we adapt to exercise training (chronic responses to exercise). For example, an exercise physiologist may find that as we begin to walk our cardiovascular and pulmonary systems respond to the demands of the activity by increasing our heart rates and ventilatory rates. These are examples of acute responses to exercise. On the other hand, if we change from a sedentary life-style and begin to walk regularly, our cardiovascular and pulmonary systems become more efficient, which results in reduced heart rates and ventilatory responses to exercise. These improvements in physical fitness are examples of chronic responses to exercise. It is likely that as a student of exercise science, you will discover that even simple acts of physical activity, such as walking, can be more complex and thought provoking than they initially appear. This, however, is the exciting challenge of studying exercise science and learning how and why the human body responds to physical activity.

## What Do Exercise Scientists Study?

Two primary areas of inquiry for exercise scientists are (1) the health-related aspects of physical activity and (2) sports performance. Recent research has provided valuable information concerning various aspects of the relationship between physical activity and health (4–6, 8–12, 14–16, 18). For example, exercise epidemiologists have found compelling evidence to suggest that an active life-style reduces the risk of developing diseases such as coronary heart disease (CHD) and some forms of cancer (4, 6, 9). Furthermore, studies indicate that disease risk factors can be favorably modified with appropriate exercise and dietary interventions (3, 5, 15, 18). Recent studies have also found that exercise can affect the immune system and potentially influence the risk of developing infectious diseases (11, 14). The total picture regarding the health-related benefits of physical activity, however, is far from complete. For example, perhaps the greatest public impact from exercise science research is the study of how low to moderate levels of exercise improve health and well-being throughout the life-span (2, 3, 8, 15, 18). We still know very little about how much exercise is needed to reduce the risk of developing specific diseases. Thus, with our present level of knowledge we are limited in the ability to provide "safe and effective" exercise prescriptions for various age groups (4). Future generations of exercise scientists will carry on these important lines of research.

Exercise scientists also study factors related to the improvement of sports performance. The study of sports performance includes a wide range of diverse areas, such as (but not limited to) the growth and development of young athletes, the nutritional needs of adult athletes, biomechanical analysis of Olympic athletes, and the psychological characteristics of Masters age-group athletes. Applied research involving the development and application of training techniques for athletes is a primary interest of strength and conditioning coaches associated with universities and professional teams. In addition, athletic trainers often study methods of preventing athletic injuries and rehabilitating athletes injured in competition or

practice. Clearly, there are many opportunities for exercise scientists with regard to the development and application of knowledge related to sports performance.

## Academic Programs in Exercise Science

Most current academic programs in exercise science in colleges and universities grew out of the applied, professional discipline of physical education, which in the 1960s encompassed various aspects of sports, fitness, and physical activity (17). Today, however, physical education majors are usually preparing to teach in elementary and secondary schools. On the other hand, exercise science is normally a nonteaching option. At many universities, exercise science has replaced physical education teacher preparation as the largest undergraduate major in departments such as Kinesiology, Health and Human Performance, and Health, Physical Education, and Recreation (17).

### Emergence of Academic Programs

Many academic programs in exercise science emerged in response to public concerns about our society's lack of physical fitness and the aerobic fitness movement of the 1960s and 1970s. Even with this increased interest in exercise, a number of studies have shown that people today are generally not very fit or active, which increases the risk of developing a number of diseases (18). This, combined with the results of other studies that have shown that we can improve our health and quality of life through regular physical activity (5, 6, 15), has sparked an interest in understanding the responses of the body to exercise. As the role of exercise in maintaining fitness and healthy life-styles has become better understood, researchers have been able to obtain government as well as private funding to study the health-related aspects of exercise. The increased funding has been, in part, responsible for the development and continuation of programs in exercise science in postsecondary institutions.

### Growth of Academic Programs

Initially, many students are drawn to the undergraduate major in exercise science because they enjoyed athletic participation during childhood and adolescence. The opportunity to study the scientific bases of sport performance is often appealing. Some students also find it interesting to apply the knowledge gained to their own training for competitive athletics or to work with athletes in various settings. Other students major in exercise science because the rigorous scientific coursework prepares them for future careers. The dramatic growth in exercise science programs in colleges and universities in recent years is also due to the diversity of career opportunities available to graduates (Table 1.1).

Undergraduate exercise science programs are frequently used as the foundation for attending professional schools in medicine, physical therapy, chiropractic, occupational therapy, and dentistry, as well as other *allied health* fields. In addition, an exercise science degree is valuable for careers in *corporate or agency fitness* (YMCA, YWCA, Jewish Community Centers, and the like) and in **private consulting**, such as for health clubs. The

**TABLE 1.1 Potential Career Options for Students in Exercise Science**

*Agency and Corporate Fitness*

Young Men's Christian Association (YMCA)
Young Women's Christian Association (YWCA)
Jewish community center
Corporate-sponsored fitness and wellness centers

*Clinical Rehabilitation*

Cardiac rehabilitation
Pulmonary rehabilitation
Athletic trainer

*Preprofessional Schools*

Medicine: allopathic (M.D.) and osteopathic (D.O.)
Physical therapy
Occupational therapy
Physician's assistant
Dentistry
Chiropractic
Optometry

*Private Sector*

Corporate employee or consultant, such as athletic shoe manufacturer or athletic equipment design
Ergonomics consultant, such as insurance claims for worksite injuries
Health club employee or owner
Personal trainer
Strength and conditioning coach for professional team

*Teacher, Researcher, and/or Coach*

University, college, or community college professor
University or college strength and conditioning coach
Athletic team coach
Researcher for institution, such as the Cooper Institute or Olympic Training Center

expansion of fitness facilities by corporations has been driven not only by a desire to provide a valued fringe benefit for employees, but also by research that indicates that the company can benefit economically through reduced health insurance costs and absenteeism when their work force is physically fit and active (7). The need for qualified managers of such facilities has led to the development of exercise science majors at colleges and universities, as well as certification programs through professional organizations such as the American College of Sports Medicine (**ACSM**) and the National Strength and Conditioning Association (NSCA).

The combination of a degree in exercise science and certification from a reputable professional organization increases the likelihood of success in the job market. Another career option for undergraduate exercise science students is to attend graduate school.

Generally, the graduate school options involve advanced preparation for students interested in corporate or agency fitness, specialized training in clinical aspects of exercise science, such as cardiac rehabilitation, or the development of research skills for those interested in teaching and conducting research in university settings.

### The Curriculum

The typical undergraduate exercise science curriculum includes a foundation in the basic sciences, followed by a series of courses related to exercise. Table 1.2 includes examples from Boise State University, Creighton University, University of Colorado–Boulder, and the University of Nebraska–Lincoln. Although there are differences among curricula from various institutions, they generally follow a similar format. For example, the science core usually includes courses in anatomy, biology, chemistry, and physiology. The exercise-related courses often include biomechanics, exercise physiology, laboratory techniques, and sports nutrition.

The philosophy underlying the undergraduate exercise science curriculum is that there is a knowledge base that all students should have. In general, this knowledge base is important for all specialized areas of interest, whether it be cardiac rehabilitation, corporate and agency fitness, physical therapy, or medicine. There is also an underlying concept that, in addition to core courses, students should develop the skills and knowledge associated with their specialized area of interest in many ways, including elective courses, practicum experiences, volunteer noncredit activities, work experiences, and/or special training from professional certification programs during their undergraduate preparation. Many students also specialize through postbaccalaureate experiences, such as professional school (physical therapy, medicine, chiropractic, and the like) or graduate school.

## Professional Standards for Exercise Science Programs

The Ad Hoc Committee on Program Accreditation of the Southeast Regional Chapter of the American College of Sports Medicine has developed a document entitled *Guidelines for Professional Preparation in Exercise Science* (available at www.dlu.edu). These guidelines describe the "knowledge, skills, and abilities needed by professionals to function in settings in which exercise is used in prevention of or as a nonpharmacological treatment for various health-related problems" and provide a "minimum foundation upon which other educational/curricular objectives for training Exercise Science professionals can be based." At the undergraduate level (e.g., bachelor's degree), the suggested content areas include Anatomy/Physiology, Biomechanics, Kinesiology, Statistics, Physiology of Exercise, Nutrition/Weight Control, Behavioral Change, Exercise Testing for Normal and Special Populations, Exercise Prescription for Normal and Special Populations, First Aid/Athletic Training (including emergency and safety procedures for facilities), Exercise Leadership for Facilities, Practicum Experience, and Computer Proficiency. In addition to demonstrating competency in the undergraduate content areas, the recommended graduate level (e.g., master's degree) content areas include Research Design and Statistics, Advanced or Clinical

**TABLE 1.2 Examples of Undergraduate Exercise Science Curricula**

**Example 1**
*Undergraduate Exercise Science Emphasis,*
Department of Health, Physical Education, and Recreation, Boise State University, Boise, ID

*Basic Science Courses*
- Human Anatomy and Physiology
- Human Physiology
- Foundations of Physical Science or General Physics
- Cell Biology
- College Chemistry
- College Chemistry Laboratory
- Organic Chemistry
- Organic Chemistry Laboratory
- Nutrition

*Exercise-related Courses*
- Health Education
- Foundations of Physical Education
- Rhythmic Skills and Dance
- Fitness Foundations
- Standard First Aid and CPR
- Applied Anatomy
- Microcomputers in Physical Education
- Internship I
- Human Growth and Motor Learning
- Evaluation in Physical Education
- Exercise Physiology
- Conditioning Procedures
- Kinesiology
- Psychological and Sociological Aspects of Activity
- Health Promotion
- Adapted Physical Education
- Internship II
- Sport and Fitness Activity
- Electives

**Example 2**
*Undergraduate Exercise Science Curriculum,*
Exercise Science Department, Creighton University, Omaha, NE

*Basic Science Courses*
- General Biology I
- General Chemistry
- Human Anatomy

*Exercise-related Courses*
- Beginning Swimming
- First Aid
- Introduction to Athletic Training
- Personalized Weight Training
- Aerobic Dance
- Beginning Tennis or Beginning Racquetball
- Designing a Personalized Fitness Program
- Nutrition for Health and Sports Performance
- Biomechanics
- Exercise Physiology
- Exercise Prescriptions: Their Design and Evaluation
- Basic Statistics and Research Design
- Laboratory Methods and Procedures
- Exercise Leadership and Program Administration
- Directed Independent Study
- Exercise Sciences Practicum

*Specialty Tracks*
- Corporate, Community, and Commercial Fitness
- Business Ethics
- Marketing
- Education
- Management
- Legal Environment
- Business Law

*Athletic Training*
- Practicum I–IV
- Modalities and Rehabilitation
- Selected Topics
- Physiology
- Athletic Training Independent Study

*Physical Therapy*
- Chemistry
- Biology
- Physics
- Physiology
- Philosophy

*Personal Training*
- Certification Independent Study
- All Courses in the Corporate, Community, and Commercial Fitness Track
- Strength and Conditioning
- Certification Independent Study

*Cardiac Rehabilitation*
- Psychology II
- Psychology III
- Education
- Clinical Exercise Testing and Electrocardiogram Interpretation