Chapter 01
Lecture Outline

See separate PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.
Introduction

• Anatomy and physiology (A & P) are about human structure and function—the biology of the human body
• A & P form a foundation for advanced study in health care, exercise physiology, pathophysiology, and other related fields
• This chapter introduces: the history of A & P, human evolution, central concepts in physiology, ways to understand medical terminology
The Scope of Anatomy and Physiology

• Expected Learning Outcomes
  – Define *anatomy* and *physiology* and relate them to each other.
  – Describe several ways of studying human anatomy.
  – Define a few subdisciplines of human physiology.
Anatomy—The Study of Form

• Examining structure of the human body
  – Inspection
  – Palpation
  – Auscultation
  – Percussion

• Cadaver dissection
  – Cutting and separating human body tissues to reveal tissue relationships

• Comparative anatomy
  – Study of multiple species to learn about form, function, and evolution
Anatomy—The Study of Form

- **Exploratory surgery**
- **Medical imaging**
  - Viewing the inside of the body without surgery
  - **Radiology**—branch of medicine concerned with imaging
- **Gross anatomy**
  - Study of structures that can be seen with the naked eye
- **Histology (microscopic anatomy)**
  - Examination of tissues with microscope
- **Histopathology**
  - Microscopic examination of tissues for signs of disease
- **Cytology**
  - Study of structure and function of cells
- **Ultrastructure**
  - View detail under electron microscope
Physiology—The Study of Function

• **Subdisciplines**
  – Neurophysiology (physiology of nervous system)
  – Endocrinology (physiology of hormones)
  – Pathophysiology (mechanisms of disease)

• **Comparative physiology**
  – Study of different species to learn about body functions
  – Basis for much of our understanding of human physiology and the development of new drugs and medical procedures
The Origins of Biomedical Sciences

• Expected Learning Outcomes
  – Give examples of how modern biomedical science emerged from an era of superstition and authoritarianism.
  – Describe the contributions of some key people who helped to bring about the transformation.
Greek and Roman Legacy

• Hippocrates
  – Greek physician; “Father of medicine”
  – Established a code of ethics (Hippocratic Oath)
  – Urged physicians to seek natural causes of disease rather than attributing them to acts of the gods and demons

• Aristotle
  – Believed diseases had supernatural or physical causes
    • Called supernatural causes of disease theologi
    • Called natural causes for disease physiologi
    • This gave rise to the terms physician and physiology
  – Believed complex structures were built from simpler parts
Greek and Roman Legacy

• Claudius Galen
  – Physician to Roman gladiators
  – Did animal dissections because use of cadavers was banned
  – Saw science as a method of discovery
  – Teachings were adopted as dogma in Europe in Middle Ages
The Birth of Modern Medicine

• Maimonides (Moses ben Maimon)
  – Jewish physician who wrote 10 influential medical texts
  – Was physician to Egyptian sultan, Saladin

• Avicenna (Ibn Sina) from Muslim world
  – “The Galen of Islam”
  – Combined both Galen and Aristotle’s findings with original discoveries
  – Wrote *The Canon of Medicine*, used in medical schools for 500 years
The Birth of Modern Medicine

Illustrations from (a) Avicenna and (b) Vesalius

Figure 1.1
The Birth of Modern Medicine

- **Andreas Vesalius**
  - Catholic Church relaxed restrictions on dissection of cadavers
  - Performed his own dissections rather than having the barber-surgeons dissect
  - Published first atlas of anatomy, *De Humani Corporis Fabrica (On the Structure of the Human Body)* in 1543

- **William Harvey**
  - Early physiologist—contributions represent the birth of experimental physiology
  - Published book *De Motu Cordis (On the Motion of the Heart)* in 1628
  - Realized blood flows out from heart and back to it again
    - Some credit also given to Michael Servetus for this
The Birth of Modern Medicine

- **Robert Hooke**
  - Made many improvements to compound microscope—two lenses: ocular lens (eyepiece) and objective lens (near specimen)
    - Invented specimen stage, illuminator, coarse and fine focus controls
    - His microscopes magnified only 30X
    - First to see and name “cells”
  - Published first comprehensive book of microscopy (*Micrographia*) in 1665

Figure 1.2

(a) Courtesy of the Armed Forces Institute of Pathology; b: ©Corbis-Bettmann
The Birth of Modern Medicine

- **Antony van Leeuwenhoek**
  - Invented a simple (single-lens) microscope with great magnification to look at fabrics (200X)
  - Published his observations of blood, lake water, sperm, bacteria from tooth scrapings, and many other things
The Birth of Modern Medicine

- Matthias Schleiden and Theodor Schwann
  - Examined wide variety of specimens
  - Concluded that “all organisms were composed of cells”
  - First tenet of cell theory
    - Considered to be perhaps the most important breakthrough in biomedical history
    - All functions of the body are interpreted as effects of cellular activity
Scientific Method

• Expected Learning Outcomes
  – Describe the inductive and hypothetico–deductive methods of obtaining scientific knowledge.
  – Describe some aspects of experimental design that help to ensure objective and reliable results.
  – Explain what is meant by hypothesis, fact, law, and theory in science.
Scientific Method

• **Francis Bacon, in England, and René Descartes, in France**
  – Philosophers who invented new habits of scientific thought—a creative, objective process
  – Sought systematic way of seeking similarities, differences, and trends in nature and drawing useful generalizations from observable facts

• **Governments of England and France**
  – Established academies of science that still exist today

• **Science and scientific methods**
  – Set standards for truth
The Inductive Method

• Described by Francis Bacon
  – Making numerous observations until one becomes confident in drawing generalizations and predictions
  – Knowledge of anatomy obtained by this method

• Proof in science
  – Reliable observations, repeatedly confirmed
  – Not falsified by any credible observation

• In science, all truth is tentative
  – “Proof beyond a reasonable doubt”
The Hypothetico–Deductive Method

• Most **physiological knowledge** gained by this method
• Investigator formulates a **hypothesis**—an educated speculation or possible answer to the question
  – Good hypotheses are consistent with what is already known and are testable
• **Falsifiability**—if we claim something is scientifically true, we must be able to specify what evidence it would take to prove it wrong
Experimental Design

- **Sample size**
  - Number of subjects in a study

- **Controls**
  - Control group resembles treatment group but does not receive treatment

- **Psychosomatic effects**
  - Effects of subject’s state of mind on her or his physiology
  - Tested by giving *placebo* to control group

- **Experimenter bias**
  - Avoided with *double-blind study*

- **Statistical testing**
  - Provides statement of probability that treatment was effective
Peer Review

• Critical evaluation by other experts in the field
  – Done prior to funding or publication
  – Done by using verification and repeatability of results

• Ensures honesty, objectivity, and quality in science
Facts, Laws, and Theories

- **Scientific fact**
  - Information that can be independently verified

- **Law of nature**
  - Generalization about the way matter and energy behave
    - Results from inductive reasoning and repeated observations
    - Written as verbal statement or mathematical formula

- **Theory**
  - An explanatory statement or set of statements derived from facts, laws, and confirmed hypotheses
    - Summarizes what we know
    - Suggests directions for further study
Human Origins and Adaptations

• Expected Learning Outcomes
  – Explain why evolution is relevant to A & P.
  – Define *evolution* and *natural selection*.
  – Describe human characteristics that can be attributed to earlier, tree-dwelling primates.
  – Describe human characteristics that evolved later in connection with upright walking.
Human Origins and Adaptations

• Charles Darwin
  – *On the Origin of Species by Means of Natural Selection* (1859)—“the book that shook the world”
  – *The Descent of Man* (1871)—human evolution and relationship to other animals
Evolution, Selection, and Adaptation

• Evolution
  – Change in genetic composition of population of organisms
    • Example: development of bacterial resistance to antibiotics

• Natural selection
  – How evolution works
  – \textbf{Selection pressures}—forces that promote reproductive success of some individuals more than others
    • Example: predators
  – \textbf{Adaptations}—inherited features of anatomy and physiology that evolved in response to pressures and that enable organism to succeed
    • Example: better camouflage
Evolution, Selection, and Adaptation

• Closest relative to human: chimpanzee
  – Difference of only 1.6% in DNA structure

• Study of evolutionary relationships
  – Help us chose animals for biomedical research (the animal model)
  – Rats and mice used extensively due to cost and ethical issues involved with using chimpanzees
Our Basic Primate Adaptations

- **Primates**—order of mammals to which humans, monkeys, and apes belong

- **Early primates were arboreal (tree-dwelling)**
  - Mobile shoulders—better movement among branches
  - Opposable thumbs and prehensile hands—grasp branches and manipulate objects
  - Forward-facing eyes with stereoscopic vision—depth perception
  - Color vision—find ripe fruit
  - Large brain—memory allowing efficient food finding
Our Basic Primate Adaptations
Walking Upright

• **Bipedalism**—standing and walking on two legs
  – Helps spot predators; carry food, tools, infants

• **Adaptations for bipedalism**
  – Skeletal and muscular modifications
  – Changes to family structure
Walking Upright

- **Australopithecus**—bipedal primate genus lived more than 3 million years ago
- **Homo genus** appeared 2.5 million years ago
  - Taller, larger brain volume, tool-making
- **Homo erectus** appeared 1.8 million years ago
  - Migrated from Africa to parts Asia
- **Homo sapiens** originated in Africa 200,000 years ago
- **Evolutionary medicine** traces some of our diseases to differences between modern and prehistoric environments
Human Structure

• **Expected Learning Outcomes**
  – List the levels of human structure from the most complex to the simplest.
  – Discuss the value of both reductionistic and holistic viewpoints to understanding human form and function.
  – Discuss the clinical significance of anatomical variation among humans.
The Hierarchy of Complexity

- **Organism** composed of **organ systems**
- **Organ systems** composed of **organs**
- **Organs** composed of **tissues**
- **Tissues** composed of **cells**
- **Cells** composed of **organelles**
- **Organelles** composed of **molecules**
- **Molecules** composed of **atoms**
The Hierarchy of Complexity

• **Reductionism**—large, complex systems can be understood by studying their simpler components
  – Essential to scientific thinking

• **Holism**—“emergent properties” of the whole organism cannot be predicted from the properties of the separate parts
  – Humans are more than the sum of their parts
Anatomical Variation

- No two humans are exactly alike
  - Anatomy books show most common organization of structures
  - Some individuals lack certain muscles
  - Some individuals have an atypical number of vertebrae
  - Some individuals have an atypical number of certain organs (for example, kidneys)
  - Some individuals show *situs inversus*—left-right reversal of organ placement
Anatomical Variation

Figure 1.5

Normal

Pelvic kidney

Horseshoe kidney

Variations in branches of the aorta

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Human Function

• Expected Learning Outcomes
  – State characteristics distinguishing living organisms from nonliving objects.
  – Explain the importance of physiological variations.
  – Define *homeostasis* and explain why this concept is central to physiology.
  – Define *negative feedback*, give an example of it, and explain its importance to homeostasis.
  – Define *positive feedback* and give examples of its beneficial and harmful effects.
  – Define *gradient* and describe some examples.
Characteristics of Life

- **Organization**—living things exhibit a higher level of organization than nonliving things
- **Cellular composition**—living matter is always compartmentalized into one or more cells
- **Metabolism**—sum of all internal chemical change: anabolism (synthesis) and catabolism (digestion)
- **Responsiveness**—ability to sense and react to stimuli (irritability or excitability)
- **Movement**—of organism and/or of substances within the organism
Characteristics of Life

- **Homeostasis**—maintaining relatively stable internal conditions
- **Development**—differentiation and growth
- **Reproduction**—producing copies of themselves; passing genes to offspring
- **Evolution of a population**—changes in genes
Physiological Variation

• Sex, age, diet, weight, physical activity

• Typical physiological values
  – Reference man
    • 22 years old, 154 lb, light physical activity
    • Consumes 2,800 kcal/day
  – Reference woman
    • Same as man except 128 lb and 2,000 kcal/day

• Failure to consider variation can lead to overmedication of elderly or medicating women on the basis of research done on men
Homeostasis and Negative Feedback

• **Homeostasis**—the ability to detect change, activate mechanisms that oppose it, and thereby maintain relatively stable internal conditions

• **Claude Bernard (1813–78)**
  – Noted fairly constant internal conditions despite changing external conditions (for example, temperature)

• **Walter Cannon (1871–1945)**
  – Coined the term **homeostasis**

• **Negative feedback** allows for dynamic equilibrium within a limited range around a **set point**
  – The body senses a change and “negates” or reverses it

• **Loss of homeostatic control causes illness or death**
Homeostasis and Negative Feedback

- Because feedback mechanisms alter the original changes that triggered them, they are called feedback loops.
Homeostasis and Negative Feedback

- **Homeostasis in body temperature**
  - If too warm, vessels dilate in the skin and sweating begins (heat-losing mechanism)
  - If too cold, vessels in the skin constrict and shivering begins (heat-gaining mechanism)
Homeostasis and Negative Feedback
Homeostasis and Negative Feedback

- **Receptor**—structure that senses change in the body (e.g., stretch receptors above heart that monitor blood pressure)

- **Integrating (control) center**—control center that processes the sensory information, “makes a decision,” and directs the response (e.g., cardiac center of the brain)

- **Effector**—cell or organ that carries out the final corrective action to restore homeostasis (e.g., the heart)
Positive Feedback and Rapid Change

• **Self-amplifying cycle**
  – Leads to greater change in the same direction
  – Feedback loop is repeated—change produces more change

• **Normal way of producing rapid changes**
  – Examples include: childbirth, blood clotting, protein digestion, and generation of nerve signals

• **Can sometimes be dangerous**
  – Example: vicious circle of runaway fever
Positive Feedback and Rapid Change

1. Fetus’ head pushes against cervix
2. Nerves send signals to brain
3. Brain stimulates pituitary to secrete oxytocin
4. Oxytocin stimulates uterine contraction
5. Fetus’ head applies more pressure to cervix and cycle repeats, strengthens

Figure 1.8
Gradients and Flow

- **Gradient**—a difference in chemical concentration, charge, temperature, or pressure between two points

- **Matter and energy tend to flow down gradients**
  - Example: blood flows from a place of higher pressure to a place of lower pressure
  - Movement in the opposite direction is “up the gradient”
  - Movement in this direction requires spending metabolic energy

Figure 1.9(a)

Figure 1.9(b)
Gradients and Flow

- Chemicals flow down concentration gradients
- Charged particles flow down electrical gradients
- Heat flows down thermal gradients

Figure 1.9 (c), (d), (e)
The Language of Medicine

• **Expected Learning Outcomes**
  – Explain why modern anatomical terminology is so heavily based on Greek and Latin.
  – Recognize eponyms when you see them.
  – Describe the efforts to achieve an internationally uniform anatomical terminology.
  – Break medical terms down into their basic word elements.
  – State some reasons why the literal meaning of a word may not lend insight into its definition.
  – Relate singular noun forms to their plural and adjectival forms.
  – Discuss why precise spelling is important in anatomy and physiology.
The History of Anatomical Terminology

• About 90% of our current medical terms come from 1,200 Greek and Latin roots reflecting ancient past
• The Renaissance brought progress but confusion
  – Same structures named differently in varied countries
  – Some structures named after people (eponyms)
• 1895: Anatomists established worldwide naming conventions
  – Rejected eponyms; used unique Latin names
• 1998: *Terminologia Anatomica* (TA)
  – Provided Latin names and English equivalents
  – Adopted by anatomists in over 50 countries
Analyzing Medical Terms

- **Terminology based on word elements**
  - Lexicon of 400 word elements can be found on the inside back cover of textbook

- **Scientific terms**
  - One **root (stem)** with core meaning
  - **Combining vowels** join roots into a word
  - **Prefix** and/or **suffix** may modify meaning of root word

- **Acronyms**—pronounceable words formed from first letter, or first few letters, of series of words
  - Example: PET scan
Plural, Adjectival, and Possessive Forms of Medical Terms

• Plural forms vary
  – Examples: cortex–cortices, corpus–corpora

• Adjectival form of a term can appear different than noun form
  – Example: Brachium (n.): arm vs. brachii (adj.): of the arm

• Adjective often follows noun it modifies
  – Example: Biceps brachii
## Plural, Adjectival, and Possessive Forms of Medical Terms

TABLE 1.1
Singular and Plural Forms of Some Noun Terminals

<table>
<thead>
<tr>
<th>Singular Ending</th>
<th>Plural Ending</th>
<th>Examples</th>
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<tbody>
<tr>
<td>-a</td>
<td>-ae</td>
<td>axilla, axillae</td>
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<td>calyx, calyces</td>
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Pronunciation

- Simple pronunciation guides for many terms are given in the text when terms are first introduced

- Pronunciation guides are also available online through Anatomy & Physiology Revealed
The Importance of Precision

• Be precise in use and spelling of terms

• Many terms are spelled similarly but have very different meanings

• Health-care professions demand precision in order to maintain patient safety
Review of Major Themes

• **Unity of form and function**
  – Anatomy and physiology complement each other and cannot be divorced from one another

• **Cell theory**
  – All structure and function result from the activity of cells

• **Evolution**
  – The human body is a product of evolution

• **Hierarchy of complexity**
  – Human structure can be viewed as a series of levels of complexity

• **Homeostasis**
  – The purpose of most normal physiology is to maintain stable conditions within the body

• **Gradients and flow**
  – Matter and energy tend to flow down gradients
Medical Imaging

• Radiography (X-rays)
  – William Roentgen’s discovery in 1885
  – Penetrate tissues to darken photographic film beneath the body
  – Dense tissue appears white
  – Over half of all medical imaging

Figure 1.10a
Medical Imaging

- Radiopaque substances
  - Injected or swallowed
  - Fills hollow structures
    - Blood vessels
    - Intestinal tract

Figure 1.10b

(b) Cerebral angiogram
©Custom Medical Stock Photo, Inc.
Medical Imaging

- **Computed tomography (CT scan)**
  - Formerly called a CAT scan
  - Low-intensity X-rays and computer analysis
    - Slice-type image
    - Increased sharpness of image

Figure 1.10c
Medical Imaging

- **Positron emission tomography (PET) scan**
  - Assesses metabolic state of tissue
  - Distinguishes tissues most active at a given moment
  - Mechanics—inject radioactively labeled glucose
    - Positrons and electrons collide
    - Gamma rays given off
    - Detected by sensor
    - Analyzed by computer
    - Image color shows tissues using the most glucose at that moment
    - Damaged tissues appear dark

Figure 1.10d
Medical Imaging

- **Magnetic resonance imaging (MRI)**
  - Superior quality to CT scan
  - Best for soft tissue
  - Mechanics
    - Alignment and realignment of hydrogen atoms with magnetic field and radio waves
    - Varying levels of energy given off used by computer to produce an image

Figure 1.10e
Medical Imaging

- **Sonography**
  - Second oldest and second most widely used
  - **Mechanics**
    - High-frequency sound waves echo back from internal organs
  - Avoids harmful X-rays
    - Obstetrics
    - Image not very sharp

Figure 1.11