Chapter 1
Major Themes in A/P
Major Themes of Anatomy and Physiology

- Form and Function
- The Scientific Method
- Hierarchy of Complexity
- Homeostasis
- Regulation of Homeostasis
- Components of a Feedback Loop
Anatomy - The Study of Form (Structure)

- **Examining structure of the Human Body**
  - inspection
  - palpation
  - auscultation
  - Percussion

- **Cadaver dissection**
  - cutting and separation of tissues to reveal their relationships

- **Comparative anatomy**
  - study of more than one species in order to examine structural similarities and differences
  - analyze evolutionary trends
Anatomy - The Study of Form

- **Gross Anatomy**
  - study of structures that can be seen with the naked eye

- **Cytology**
  - study of structure and function of cells

- **Histology (microscopic anatomy)**
  - examination of cells with microscope

- **Ultrastructure**
  - the molecular detail seen in electron microscope

- **Histopathology**
  - microscopic examination of tissues for signs of disease
Physiology - The Study of Function

• **Subdisciplines**
  - neurophysiology (physiology of nervous system)
  - endocrinology (physiology of hormones)
  - pathophysiology (mechanisms of disease)

• **Comparative Physiology**
  - limitations on human experimentation
  - study of different species to learn about bodily function
    • animal surgery
    • animal drug tests
  - basis for the development of new drugs and medical procedures
Scientific Method

- **Francis Bacon**, in England, and **Rene Descartes**, in France

  - philosophers who invented **new habits of scientific thought** in 1600s

  - sought systematic way of seeking similarities, differences, and trends in nature

  - drawing useful generalizations from observable facts

  - How we solve problems.

  - How we find truth.
The Scientific Method

• **A Proof in Science Requires**
  - reliable observations
  - tested and confirmation // repeatedly
  - not falsified by any credible observation

• **In science, all truth is tentative // “proof beyond a reasonable doubt”**

• **Falsifiability //** if we claim something is scientifically true, then we must be able to specify what evidence it would take to prove it wrong

• **Scientific Method’s Goal //** set standards for truth

• **Two Different Approaches to the Scientific Method (See Next Slide Two Slides)**
Inductive Method

• Described by Francis Bacon
  
  – making numerous observations until one becomes confident in drawing generalizations and predictions from them
  
  – knowledge of anatomy obtained by this method
Hypothetico-Deductive Method

- **Physiological knowledge** gained by this method
- Quest for truth is guided by investigator’s observation which leads to a **question**
- Investigator formulates a **hypothesis**- an educated guess // speculation or possible answer to the question

  - **characteristics of a good hypothesis**
    - consistent with what is already known
    - testable and possibly falsifiable with evidence

- **Hypothesis** - to suggest a method for answering questions /// written as ‘If-Then’ statements
Scientific Method / Deductive Method

1. Make observations that generate questions
2. Formulate hypotheses to explain events
3. Design studies, perform tests, and collect data
4. Analyze data and draw conclusions based on the results
5. Share results with peers (report findings)
6. Conduct more research, the results of which may confirm or refute previous findings
• Observation: My flashlight doesn’t work.

• Question: What’s wrong with my flashlight?

• Hypothesis: The flashlight’s batteries are dead.

• Prediction: If I replace the batteries, the flashlight will work.

• Experiment: I replace the batteries with new ones.

• Predicted Effect: The flashlight should work.
Facts, Laws and Theories

• **Scientific fact** // information that can be independently verified by a trained person

• **Law of nature**
  
  – generalization about the predictable way matter and energy behave (e.g. gravity)
    
    • results from inductive reasoning and repeated observations
    
    • written as verbal statements or mathematical formulae

• **Theory** // an explanatory statement or set of statements derived from facts, laws, and confirmed hypotheses (e.g. evolution)
  
  • summarizes what we know
  
  • suggests direction for further study
People who do not study science often misuse common scientific terms. This includes our policy-makers. This ignorance often makes communication between scientists and policy makers confusing and all too often results unfortunately in bad public policy.

Case Study

What is Evolution?

Is it a hypothesis or a theory?

What is Creationism? (a theory or a belief system)
• **Organism** is composed of **organ systems**
• **Organ Systems** composed of **organs**
• **Organs** composed of **tissues**
• **Tissues** composed of **cells**
• **Cells** composed of **organelles**
• **Organelles** composed of **macromolecules**
• **Macromolecules** composed of **molecules**
• **Molecules** composed of **atoms**
Hierarchy of Complexity

- **Organism** – a single, complete individual
- **Organ System** – human body made of 11 organ systems
- **Organ** – structure composed of two or more tissue types that work together to carry out a particular function
- **Tissue** – a mass of similar cells and cell products that form discrete region of an organ and performs a specific function
- **Cells** – the smallest units of an organism that carry out all the basic functions of life
  - **Cytology** – the study of cells and organelles
- **Organelles** – microscopic structures in a cell that carry out its individual functions
- **Molecules** – make up organelles and other cellular components
  - **macromolecules** – proteins, carbohydrates, fats, DNA
- **Atoms** – the smallest particles of matter with unique chemical identities
The body’s organ systems and their major functions.

(a) Integumentary System
Forms the external body covering, and protects deeper tissues from injury. Synthesizes vitamin D, and houses cutaneous (pain, pressure, etc.) receptors and sweat and oil glands.
(b) **Skeletal System**

Protects and supports body organs, and provides a framework the muscles use to cause movement. Blood cells are formed within bones. Bones store minerals.
Skeletal muscles

(c) Muscular System
Allows manipulation of the environment, locomotion, and facial expression. Maintains posture, and produces heat.
(d) **Nervous System**
As the fast-acting control system of the body, it responds to internal and external changes by activating appropriate muscles and glands.
Endocrine System

Glands secrete hormones that regulate processes such as growth, reproduction, and nutrient use (metabolism) by body cells.
Cardiovascular System

Blood vessels transport blood, which carries oxygen, carbon dioxide, nutrients, wastes, etc. The heart pumps blood.
(g) Lymphatic System/Immunity
Picks up fluid leaked from blood vessels and returns it to blood. Disposes of debris in the lymphatic stream. Houses white blood cells (lymphocytes) involved in immunity. The immune response mounts the attack against foreign substances within the body.
Respiratory System

Keeps blood constantly supplied with oxygen and removes carbon dioxide. The gaseous exchanges occur through the walls of the air sacs of the lungs.
(i) **Digestive System**

Breaks down food into absorbable units that enter the blood for distribution to body cells. Indigestible foodstuffs are eliminated as feces.
(j) **Urinary System**

Eliminates nitrogenous wastes from the body. Regulates water, electrolyte and acid-base balance of the blood.
(k) Male Reproductive System
Overall function is production of offspring. Testes produce sperm and male sex hormone, and male ducts and glands aid in delivery of sperm to the female reproductive tract. Ovaries produce eggs and female sex hormones. The remaining female structures serve as sites for fertilization and development of the fetus. Mammary glands of female breasts produce milk to nourish the newborn.

(l) Female Reproductive System
Overall function is production of offspring. Testes produce sperm and male sex hormone, and male ducts and glands aid in delivery of sperm to the female reproductive tract. Ovaries produce eggs and female sex hormones. The remaining female structures serve as sites for fertilization and development of the fetus. Mammary glands of female breasts produce milk to nourish the newborn.
Examples of interrelationships among body organ systems.
Two Different Ways to Look at the Hierarchy of Complexity

• **Reductionism**
  
  – theory that a large, complex system such as the human body can be understood by studying its simpler components
  – first espoused by Aristotle
  – highly productive approach
  – essential to scientific thinking

• **Holism**
  
  – there are ‘emergent properties’ of the whole organism that cannot be predicted from the properties of the separate parts
  – humans are more than the sum of their parts
  – complementary theory to reductionism
Homeostasis

- **Homeostasis** – the body’s ability to detect change, activate mechanisms that oppose it, and thereby maintain relatively stable internal conditions

- **Claude Bernard (1813-78)**
  - constant internal conditions regardless of external conditions /// internal body temperature ranges from 97 to 99 degrees F (38 C) despite variations in external temperature

- **Walter Cannon (1871-1945)**
  - coined the term ‘**Homeostasis**’
  - state of the body fluctuates (**dynamic equilibrium**) within limited range around a **set point**
  - **Negative feedback mechanisms** keeps variable close to the set point

- Loss of homeostatic control causes illness or death
Negative Feedback Loop

- Body senses a change and activates mechanisms to reverse it - dynamic equilibrium

1. Room temperature falls to 66°F (19°C)
2. Thermostat activates furnace
3. Heat output
4. Room temperature rises to 70°F (21°C)
5. Thermostat shuts off furnace
6. Room cools down
Negative Feedback, Set Point

- Room temperature does not stay at set point of 68 degrees -- it only averages 68 degrees

- Similar graph for blood glucose concentration over time (70 to 100 mg/dl blood sugar vs time)
Negative Feedback in Human Thermoregulation

- Brain senses change in blood temperature
  - if too warm, vessels dilate (vasodilation) in the skin and sweating begins (heat losing mechanisms)
  - if too cold, vessels in the skin constrict (vasoconstriction) and shivering begins (heat gaining mechanism)
Negative Feedback Control of Blood Pressure

- Sitting up in bed causes a drop in blood pressure in the head and upper thorax.

- **Baroreceptors** in the arteries near the heart alert the cardiac center in the brainstem.

- **Cardiac center** sends nerve signals that increase the heart rate and return the blood pressure to normal.

- Failure of this feedback loop may produce dizziness in the elderly.
Control of Blood Pressure

Blood drains from upper body, creating homeostatic imbalance. Baroreceptors above heart respond to drop in blood pressure. Baroreceptors send signals to cardiac center of brainstem, causing cardiac center to accelerate heartbeat. Blood pressure rises to normal; homeostasis is restored. Person rises from bed.
**Negative Feedback**

**STIMULUS**
Disrupts homeostasis by increasing

**CONTROLLED CONDITION**
Blood pressure

**RECEPTORS**
Baroreceptors in certain blood vessels

**INPUT**
Nerve impulses

**CONTROL CENTER**
Brain

**OUTPUT**
Nerve impulses

**EFFECTORS**
的心
Blood vessels

**RESPONSE**
A decrease in heart rate and the dilation (widening) of blood vessels cause blood pressure to decrease

**Return to homeostasis when the response brings blood pressure back to normal**
3 Components of a Feedback Loop

• **Receptor** - senses change in the body

• **Integrating Center (Control Center)** - control center that processes the sensory information, ‘makes a decision’, and directs the response

• **Effector** – carries out the final corrective action to restore homeostasis
STIMULUS disrupts homeostasis by increasing or decreasing a
CONTROLLED CONDITION that is monitored by
RECEPTORS that send nerve impulses or chemical signals to a
CONTROL CENTER that receives the input and provides nerve impulses or chemical signals to
EFFECTORS that bring about a change or
RESPONSE that alters the controlled condition
Return to homeostasis when the response brings the controlled condition back to normal
Positive Feedback Loops

- Not a common mechanism

- Self-amplifying cycle
  - leads to greater change in the same direction
  - feedback loop is repeated – change produces more change // potentially very dangerous!!!

- Normal way of producing rapid changes
  - occurs with childbirth, blood clotting, protein digestion, fever, and generation of nerve signals
Positive Feedback Loops

1. Head of fetus pushes against cervix
2. Nerve impulses from cervix transmitted to brain
3. Brain stimulates pituitary gland to secrete oxytocin
4. Oxytocin stimulates uterine contractions and pushes fetus toward cervix
Positive Feedback

Contractions of the wall of the uterus force the baby's head or body into the cervix

CONTROLLED CONDITION
Stretching of the cervix

RECEPTORS
Stretch-sensitive nerve cells in the cervix

Input
Nerve impulses

CONTROL CENTER
Brain

Output
Brain interprets input and releases oxytocin

EFFECTORS
Muscles in the wall of the uterus

Contract more forcefully

RESPONSE
Baby's body stretches the cervix more

Increased stretching of the cervix causes the release of more oxytocin, which results in more stretching of the cervix

Interruption of the cycle:
The birth of the baby decreases stretching of the cervix, thus breaking the positive feedback cycle
Harmful Positive Feedback Loop

- Fever > 104 degrees F
  - metabolic rate increases
  - body produces heat even faster
  - body temperature continues to rise
  - further increasing metabolic rate

- Cycle continues to reinforce itself
- Becomes fatal at 113 degrees F
Human Origins & Adaptations

• Charles Darwin
  
  – *On the Origin of Species by Means of Natural Selection* (1859) – ‘book that shook the world’
  
  – *The Ascent of Man* (1871) – human evolution

• The Theory of Natural Selection
  
  – how species originate and change through time
  
  – changed view of “our origin, our nature and our place in the universe”
  
  – increases understanding of human form and function
Evolution & Natural Selection

• **Evolution** = change in genetic composition in a population of an organisms over time
  
  • development of bacterial resistance to antibiotics
  
  • appearance of new strains of AIDS virus

• **Natural Selection** // some individuals within a species have hereditary advantage over their competitors

  • better camouflage // disease resistance // ability to attract mates

  • e.g. polar bears vs brown bears // wolf vs dog

  – produce more offspring, genes more likely to be passed on to next generation

  – **Selection Pressures** – natural forces that promote the reproductive success of some individuals more than others // adaptation
Analyzing Medical Terms

- Terminology based on word elements
  - lexicon of 400 word elements on the inside of the back cover of textbook

- Scientific terms
  - one root (stem) with core meaning
  - combining vowels join roots into a word
  - prefix modifies core meaning of root word
  - suffix modifies core meaning of root word

- Acronyms formed from first letter, or first few letters of series of words // Calmodulin comes from the phrase - calcium modulating protein
# TABLE 1.2

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<th>Plural Ending</th>
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Imaging Technology

Not Learning Objectives
Single-photon-emission computed tomography (SPECT) scan of transverse section of the brain (the almost all green area at lower left indicates migraine attack)
Radiograph of thorax in anterior view

- Vertebral column
- Left clavicle
- Left rib
- Left lung
- Heart
- Diaphragm
Mammogram of female breast showing cancerous tumor (white mass with uneven border)
Bone densitometry scan of lumbar spine in anterior view
Angiogram of adult human heart showing blockage in coronary artery (arrow)
Intravenous urogram showing kidney stone (arrow) in right kidney
Barium contrast x-ray showing cancer of the ascending colon (arrow)
Magnetic resonance image of brain in sagittal section
Computed tomography scan of thorax in inferior view
Sonogram of fetus (Courtesy of Andrew Joseph Tortora and Damaris Soler)
CCTA scan of coronary arteries

- Normal left coronary artery
- Blocked right coronary artery
Positron emission tomography scan of transverse section of brain (circled area at upper left indicates where a stroke has occurred)
Interior view of colon as shown by colonoscopy
Radionuclide (nuclear) scan of normal human liver