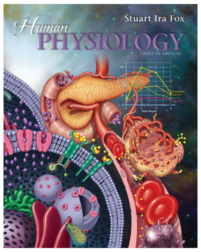
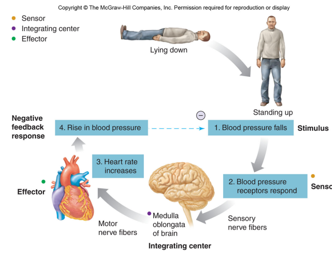


Chapter 1

The Study of Body Function

Lecture PowerPoint

I. Introduction to Physiology



What Is Physiology?

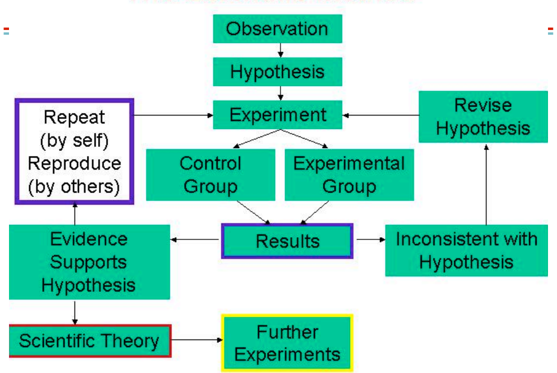
- Study of biological functions: how the body works
  - Concerns the **normal** functions of cells, tissues, organs, and systems
  - Emphasizes mechanisms
  - Is derived from scientific experiments

The Scientific Method

- Steps:
  - Make observations.
  - Form a hypothesis.
    - The hypothesis must be testable.
  - Design and conduct experiments or make more observations.
  - Analyze the data.

  Results must be replicated many times before a conclusion is accepted. Several verified hypotheses may become a general theory.

The Scientific Method



Measurements, Controls, and Statistics

- Good physiological research requires:
  - Quantifiable measurements
  - An experimental group and a control group
  - Statistical analysis
  - Review and publication by a peer-reviewed journal

Developing Pharmaceuticals

- Basic research is conducted for years before a drug is ever given to a person.
- Research begins by studying the effects of a chemical on cells in vitro (in a culture dish).
- Next, studies are done in animals (usually rats and mice) to see if the same effects occur in vivo (in a living creature) and if there are any toxic side effects.
  - For these trials, many rats and mice are genetically modified to be susceptible to particular diseases.
  - Animal trials may take several years.

Developing Pharmaceuticals

- Phase I clinical trials test the drug on healthy human volunteers to test for side effects, rates of passage, dosage, etc.
- Next the drug goes into phase II clinical trials to test its effectiveness on people with the particular disease.
- Phase III clinical trials are conducted on a large number of people to include both sexes, many age groups and ethnicities, and people with more than the one health condition. From here the FDA can approve the drug for sale.
- Phase IV trials test other applications for the drug.

II. Homeostasis and Feedback Control

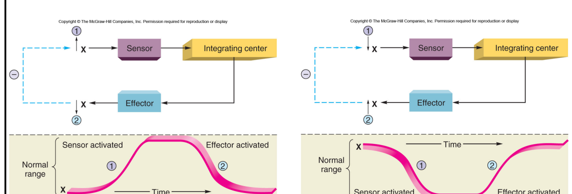
Homeostasis

- Term coined by Walter Cannon in 1932
- Homeostasis is constancy of the internal environment.
- The main purpose of our physiological mechanisms is to maintain homeostasis.
- Deviation from homeostasis indicates disease.
- Homeostasis is accomplished most often by negative feedback loops.

Negative Feedback Loops

- Involve:
  - *Sensors* in the body to detect change and send information to the:
  - *Integrating center,* which assesses change around a set point. The integrating center then sends instructions to an:
  - *Effector,* which can make the appropriate adjustments.

Negative Feedback Loops



Negative Feedback Loops

- Body temperature:
  - Sensors in the brain detect deviation from 37ºC. Another part of the brain assesses this as actionable, and effectors (sweat glands) are stimulated to cool the body.
  - Once the body is cool, sensors alert the integrating center, and sweat glands are inhibited.
  - The end result regulates the entire process. Production of the end product shuts off or down-regulates the process. This is why it is called a negative feedback loop.

Antagonistic Effectors

- Homeostasis is often maintained by opposing effectors that move conditions in opposite directions.
  - This maintains conditions within a certain normal range, or dynamic constancy.
  - When you are hot, you sweat; when you are cold, you shiver. These are antagonistic reactions.

Antagonistic Effectors

Figure 1.3

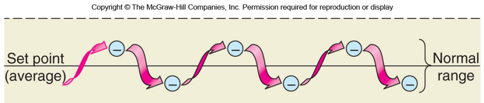
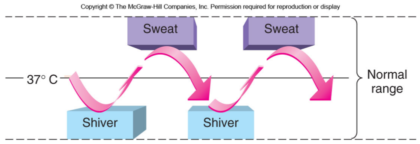


Figure 1.4



Quantitative Measurements

- A knowledge of normal ranges aids in diagnosing diseases and in assessing the effects of drugs and other treatments in experiments.

Quantitative Measurements

Table 1.2 | **Approximate Normal Ranges for Measurements of Some Fasting Blood Values**

Measurement	Normal Range
Arterial pH	7.35–7.45
Bicarbonate	24–28 mEq/L
Sodium	135–145 mEq/L
Calcium	4.5–5.5 mEq/L
Oxygen content	17.2–22.0 ml/100 ml
Urea	12–35 mg/100 ml
Amino acids	3.3–5.1 mg/100 ml
Protein	6.5–8.0 g/100 ml
Total lipids	400–800 mg/100 ml
Glucose	75–110 mg/100 ml

Positive Feedback

- The end product in a process stimulates the process.
- Positive feedback could not work alone, but it does contribute to many negative feedback loops.
  - For example, if a blood vessel is damaged, a process is begun to form a clot. Once the damage is fixed, clotting ends (negative feedback). However, the process of forming the clot involves positive feedback.
  - The strength of uterine contractions during childbirth is also regulated by a positive feedback loop.

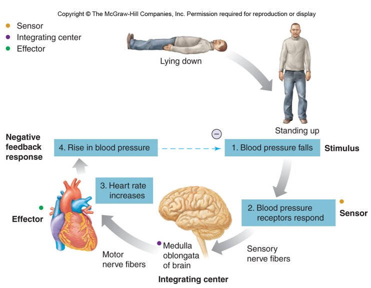
Intrinsic and Extrinsic Regulation

- Regulation of processes within organs can occur in two ways:
  - Intrinsically: Cells within the organ sense a change and signal to neighboring cells to respond appropriately.
  - Extrinsically: The brain (or other organs) regulates an organ using the endocrine or nervous system.

Neural and Endocrine Regulation

- The nervous system “innervates” organs with nerve fibers.
- The endocrine system releases hormones into the blood, which transports them to multiple target organs.

Neural and Endocrine Regulation



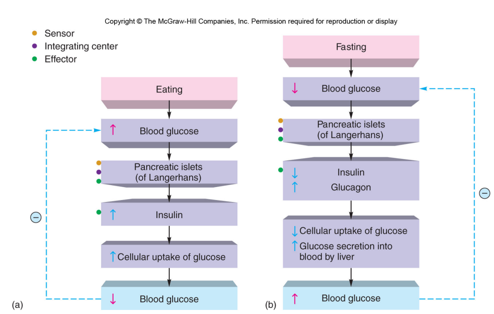
Feedback Control of Hormone Secretions

- Hormones are secreted in response to specific stimuli.
  - An increase in blood sugar results in the release of insulin, which removes sugar from the blood.
- Secretion can be inhibited by its own effects.
  - Decreased blood sugar inhibits the release of insulin.
- This is an example of negative feedback inhibition.

Feedback Control of Hormone Secretions

- Negative feedback inhibition usually involves an antagonist to make sure homeostasis is maintained within normal levels.
  - When blood sugar is low, the hormone glucagon is secreted, which results in a rise in blood sugar.

Feedback Control of Hormone Secretions



III. The Primary Tissues

The Primary Tissues

- Our organs are composed of four major categories of tissues:
  – Muscle tissue
  – Nervous tissue
  – Epithelial tissue
  – Connective tissue
- Each tissue has particular structures and functions that dictate the physiology of the organ.

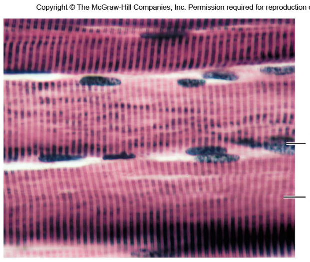
Muscle Tissue

- Specialized for contraction
- The three types are:
  – Skeletal muscle
  – Cardiac muscle
  – Smooth muscle

Skeletal Muscle Tissue

- Voluntary muscle (muscle you can consciously control)
- Associated with bones that are pulled to produce movements
  – The tongue, esophagus, sphincters, and diaphragm are also skeletal muscle.
- Has cells organized in striations

Skeletal Muscle Tissue



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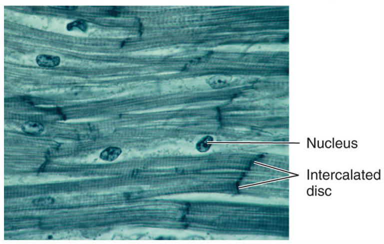
Cardiac Muscle Tissue

- Found only in the heart
- Striated, but very different in structure and action from skeletal muscle.
  – Intercalated discs allow passage of sodium ions between cells.

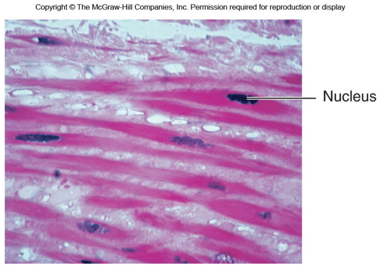
Cardiac Muscle Tissue



Smooth Muscle Tissue

- Found in the walls of digestive, urinary, and reproductive organs, blood vessels, and bronchioles of the lungs
- Not striated

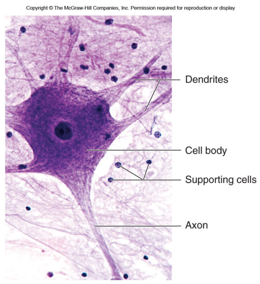
Smooth Muscle Tissue



Nervous Tissue

- Found in the brain, spinal cord, and nerves
- Composed of neurons and glial cells, which support the neurons
- Neurons conduct impulses and have three parts:
  - Dendrites: receive signal
  - Axon: sends signal
  - Cell body: metabolic center

Nervous Tissue



Epithelial Tissue

- Forms the membranes that line /cover body surfaces as well as glands
  - Epithelial membranes are classified by the number of layers:
    - Simple epithelium has one layer and is specialized for transport of substances.
    - Stratified epithelium is composed of multiple layers and provides protection.

Epithelial Tissues

- Epithelial tissues are also classified by the shape of their cells:
  - Squamous: flattened cells
  - Cuboidal: as tall as they are long
  - Columnar: tall cells

(Columnar tissues have goblet cells that secrete mucus and cilia that move in a coordinated fashion.)

Epithelial Tissues

Table 1.3 | Summary of Epithelial Membranes

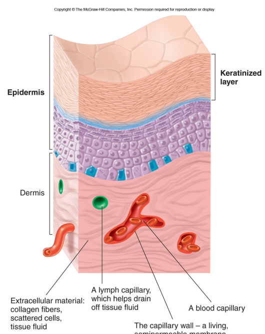
Type	Structure and Function	Location
Simple Epithelia	Single layer of cells; function varies with type	Covering visceral organs; linings of body cavities, tubes, and ducts
Simple squamous epithelium	Single layer of flattened, tightly bound cells; diffusion and filtration	Capillary walls; pulmonary alveoli of lungs; covering visceral organs; linings of body cavities
Simple cuboidal epithelium	Single layer of cube-shaped cells; excretion, secretion, or absorption	Surface of ovaries; linings of kidney tubules, salivary ducts, and pancreatic ducts
Simple columnar epithelium	Single layer of nonciliated, tall, column-shaped cells; protection, secretion, and absorption	Lining of most of digestive tract
Simple ciliated columnar epithelium	Single layer of ciliated, column-shaped cells; transportive role through ciliary motion	Lining of uterine tubes
Pseudostratified ciliated columnar epithelium	Single layer of ciliated, irregularly shaped cells; many goblet cells; protection, secretion, ciliary movement	Lining of respiratory passageways
Stratified Epithelia	Two or more layers of cells; function varies with type	Epidermal layer of skin; linings of body openings, ducts, and urinary bladder
Stratified squamous epithelium (keratinized)	Numerous layers containing keratin, with outer layers flattened and dead; protection	Epidermis of skin
Stratified squamous epithelium (nonkeratinized)	Numerous layers lacking keratin, with outer layers moistened and alive; protection and pliability	Linings of oral and nasal cavities, vagina, and anal canal
Stratified cuboidal epithelium	Usually two layers of cube-shaped cells; strengthening of luminal walls	Large ducts of sweat glands, salivary glands, and pancreas
Transitional epithelium	Numerous layers of rounded, nonkeratinized cells; distension	Walls of ureters, part of urethra, and urinary bladder

Simple Epithelial Tissues

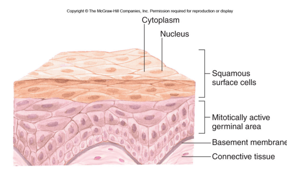
Stratified Epithelial Tissue

- To provide protection, cells of stratified epithelial tissues are held together by structures called junctional complexes.
  - These are too close together to house blood vessels, so are nourished by connective tissues beneath.
  - Epithelial tissues are attached to connective tissues by a basement membrane.

Stratified Epithelial Tissue



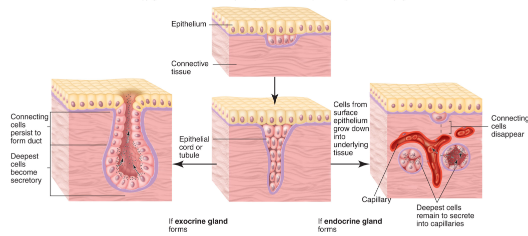
Stratified Epithelial Tissue



Exocrine Glands

- Derived from epithelial tissues
- Secretions are transported by ducts.
  - Examples include lacrimal, sweat, and sebaceous glands; digestive enzyme glands; and the prostate.

Exocrine Glands



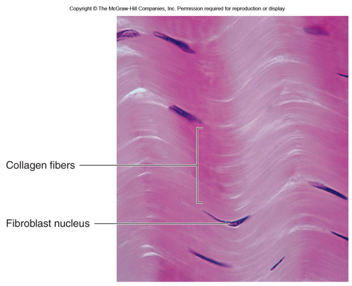
Connective Tissues

- Characterized by a matrix made up of protein fibers and extracellular material
- There are four major categories:
  - Connective tissue proper
  - Cartilage
  - Bone
  - Blood

Connective Tissue Proper

- Composed of protein fibers and a gel-like ground substance
- Subtypes:
  - Loose: collagen fibers scattered loosely with room for blood vessels and nerves
    - Example: upper layer of the dermis of the skin
  - Dense regular: Densely packed collagen fibers with little room for ground substance
    - Examples: tendons and ligaments

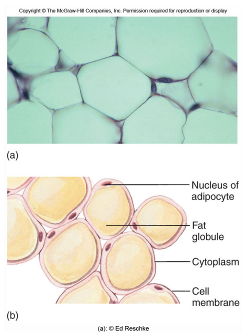
Connective Tissue Proper



Connective Tissue Proper

- Subtypes:
  - Adipose tissue stores fat.
  - Dense irregular connective tissue is composed of densely packed collagen fibers in various arrangements to resist forces.

Connective Tissue Proper



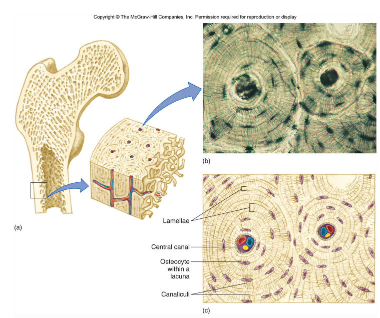
Cartilage Connective Tissue

- Composed of cells called *chondrocytes* surrounded by a semisolid ground substance
  - Serves as a template skeleton during bone development
  - Found in joints to provide a gliding surface for bones

Bone

- Cells called osteoblasts trap mineral salts, forming concentric layers of calcified material around a canal filled with blood vessels and nerves.

Bone

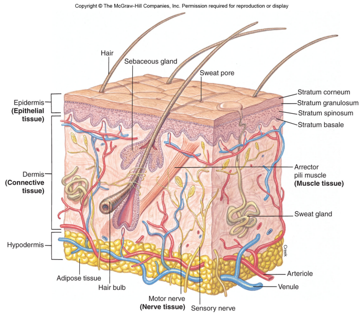


IV. Organs and Systems

Organs

- An organ is composed of two or more tissues that serve different functions in the organ.
- The skin is the largest organ in the body.
  - The skin has all four primary tissues.

Organs



Tissue Development

- Tissues are composed of highly specialized cells that arise from three embryonic germ layers:
  - Endoderm
  - Mesoderm
  - Ectoderm

Stem Cells

- Zygotes are *totipotent*, which means their cells can become any type of cell. These are true stem cells.
  - As cells begin to differentiate, a few adult stem cells are retained to allow for cell replacement.
  - Adult stem cells are still limited to a narrow range of possibilities but can become several related cells and thus are called multipotent.
    - Bone marrow cells can become any type of blood cell.

Systems

- Organs that perform related functions are grouped into systems.

Systems

Table 1.4 | Organ Systems of the Body

System	Major Organs	Primary Functions
Integumentary	Skin, hair, nails	Protection, thermoregulation
Nervous	Brain, spinal cord, nerves	Regulation of other body systems
Endocrine	Hormone-secreting glands, such as the pituitary, thyroid, and adrenals	Secretion of regulatory molecules called hormones
Skeletal	Bones, cartilages	Movement and support
Muscular	Skeletal muscles	Movements of the skeleton
Circulatory	Heart, blood vessels, lymphatic vessels	Movement of blood and lymph
Immune	Bone marrow, lymphoid organs	Defense of the body against invading pathogens
Respiratory	Lungs, airways	Gas exchange
Urinary	Kidneys, ureters, urethra	Regulation of blood volume and composition
Digestive	Mouth, stomach, intestine, liver, gallbladder, pancreas	Breakdown of food into molecules that enter the body
Reproductive	Gonads,external genitalia, associated glands and ducts	Continuation of the human species

Body Fluid Compartments

- Intracellular: area inside the cells
- Extracellular: area outside the cells
  - Examples: blood plasma and interstitial fluid
- Both body fluid compartments are filled primarily with water and are separated by membranes.