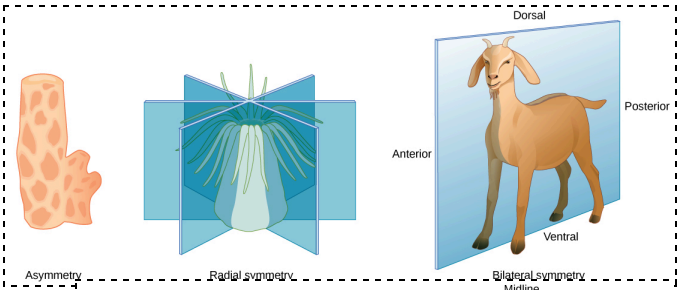
Chapter 1: The Animal Body—Basic Form and Function

fObjectives

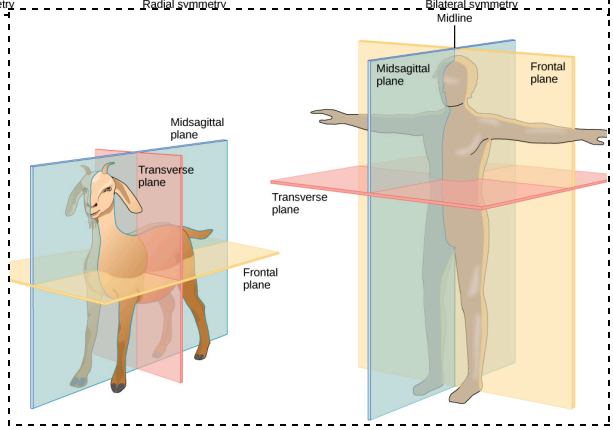
1. Define homeostasis and explain how negative and positive feedback regulate it
2. Name and describe the 2 main types of body fluids
3. Name and describe the 4 main types of tissues
4. Define extracellular matrix, basement membrane
5. Describe the characteristics of epithelial tissue
6. Name and describe the 2 possible surfaces of an epithelial cell
7. Name the 2 main types of epithelial tissue and name and describe the possible subtypes of each one
8. Describe the characteristics of connective tissue
9. Name the 2 main types of connective tissue and name and describe the possible subtypes of each one
10. Describe the characteristics of muscle tissue
11. Name and describe the 3 types of muscle tissue
12. Describe the characteristics of nervous tissue
13. Name and describe the 2 types of cells found in nervous tissue
14. Describe a typical neuron structure and describe the 3 types of neurons
15. Name and describe the 3 regions of the integumentary system and identify which regions make up the skin
16. Describe general functions of the integumentary system
17. Describe the cells of the epidermis and what their functions are
18. Describe the contents of the dermis
19. Compare and contrast ectotherms and endotherms
20. Predict how the body will react if body temperature is too high or low
21. Define hyperthermia, fever, hypothermia, nonshivering heat production, hibernation, estivation

1.1: Animal Form and Function

- 1.1a: Body Plans
  - Body plans follow set patterns related to symmetry
    - Asymmetrical - no pattern or symmetry
    - Radial - up-and-down pattern; any line cut longitudinally produces equal halves
    - Bilateral - pattern of matching left and right sides



- 1.1b: Animal Body Planes
  - Sagittal Plane - divides the body into right and left portions
  - Midsagittal Plane - divides the body exactly in the middle, making two equal right and left halves
  - Frontal/Coronal Plane - divides front from back
  - Transverse/Horizontal Plane - divides the animal into upper and lower portions; also called a cross section
    - Oblique Plane - transverse plane cut at an angle



1.2: Animal Primary Tissues

- 1.2 Introduction
  - Tissue - groups of similar cells group of similar cells carrying out related functions
    - 4 primary types of tissue: epithelial, connective, muscle, and nervous

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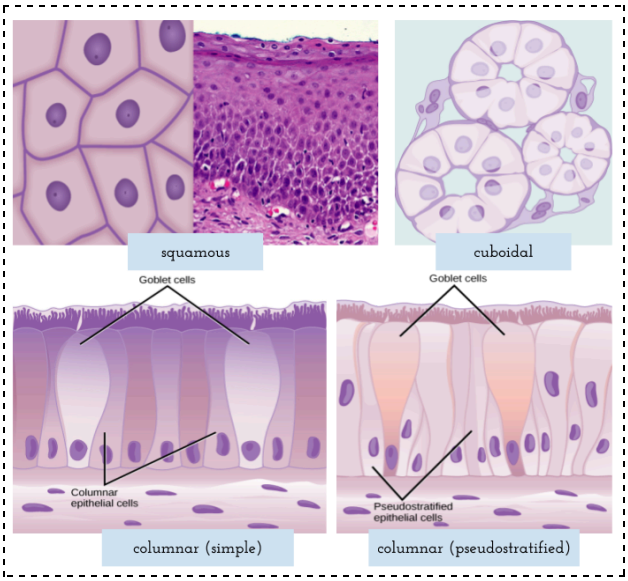
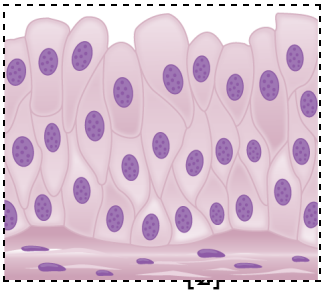
➢ 1.2a: Epithelial Tissues - cover the outside of organs and structures in the body and line the lumens of organs in a single layer or multiple layers of cells—called covering and lining epithelia—can also form glands that secrete substances—called glandular epithelium

Cell Shape	Description	Location
squamous	flat, irregular round shape	*simple*: lung alveoli, capillaries *stratified*: skin, mouth, vagina
cuboidal	cube shaped, central nucleus	glands, renal tubules
columnar	tall, narrow, nucleus toward base tall, narrow, nucleus along cell	*simple*: digestive tract *pseudostratified*: respiratory tract

- Epithelial tissue can be simple—one layer of cells—or stratified—multiple layers of cells
- Different Types of Epithelial Tissues
  - Squamous Epithelia
    - Simple formation facilitates diffusion in tissues
    - Stratified formation protects the body from outside damage
  - Cuboidal Epithelia
    - Simple formation prepares and secretes glandular material
      - Most commonly found in simple formation
  - Columnar Epithelia
    - Simple formation absorbs material from the lumen of the digestive tract and prepare for entry into the body through the circulatory and lymphatic systems
      - Most commonly found in simple formation
    - Pseudostratified (nuclei are arranged at different levels in the layer of cells, making it appear as though there is more than one layer) formation appears to be stratified but is actually simple
      - Nuclei are arranged at different levels
      - Has cilia that enhance movement of mucous material and trapped particles out of the respiratory system
      - Goblet Cells - contain mucous that traps irritants, which in the case of the trachea keep these irritants from getting into the lungs; are interspersed in some tissues



  - Transitional Epithelia
    - Transitional/epithelial cells only appear in urinary system, primarily the bladder and ureter
    - Cells are arranged in stratified layer but are capable of unfolding into thinner and thinner

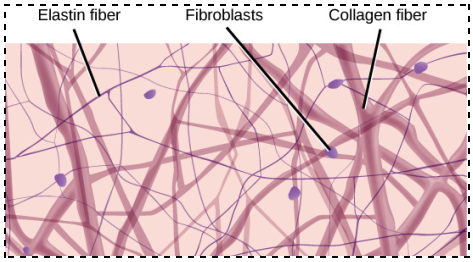


layers as the organ, like an empty bladder, fills up

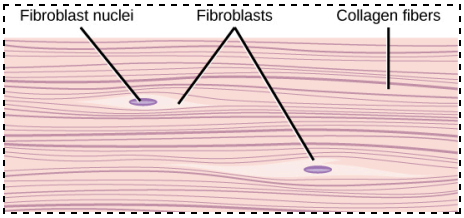
- Glandular Epithelia
  - Can be exocrine or endocrine
    - Exocrine Glands - secrete substances into the outside of the body or into a hollow organ, like the stomach
    - Endocrine Glands - secrete substances into the bloodstream

➢ 1.2b: Connective Tissues - are made up of living cells and a non-living matrix

- The non-living matrix is made of fibers and "ground substances", like water and calcium salts
  - Fibers can be collagen, elastic, or reticular
    - Collagen Fibers - provide strength to the tissue, preventing it from being torn or separated from the surrounding tissues
      - Relatively wide and stain pink
    - Elastic Fibers - provide flexibility to the tissues
      - Made of the protein elastin
      - Can stretch to one and one half of its length and return to its original size and shape
      - Thin and stain dark blue to black
    - Reticular Fibers - provides support to the tissue and other organs
      - Made of thin collagen strands that form a network
- Fibroblast - cells that build fibers and then secrete them from the cell to become part of the extracellular matrix
- Various types of connective tissue include loose/areolar, dense and fibrous, cartilage, bone, adipose/fat, and blood

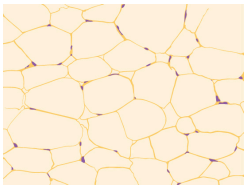


  - Loose/Areolar Connective Tissue - made of some fibroblasts, macrophages, collagen fibers, and elastic fibers
    - Space between elements is filled with ground substances
    - Material in connective tissue gives it a loose consistency
    - Found around every blood vessel to help keep it in place and around/between body organs
  - Dense Fibrous Connective Tissue - made of large amounts of nonliving matrix—mostly collagen—and a few cells
    - Fibers can be arranged regularly or irregularly
      - Irregular arrangement found in areas of the body where stress occurs from all directions
      - Regular arrangement found in tendons (which connect muscles to bones) and ligaments (which connect bones to bones)



  - Cartilage Connective Tissue - made of mostly ground substance and variable amounts of fibers

        - Chondroblasts - cells that make the fibers
        - Chondrocytes - chondroblasts that are done making fibers
            - Found in spaces within a tissue called lacunae
    - Hyaline Cartilage - cartilage with few collagen and elastic fibers
        - Found in moveable joints
        - Lacunae are randomly scattered
        - Matrix looks milky/scrubbed with histological stains
        - Found at the end of long bones
    - Elastic Cartilage - cartilage with large amounts of elastic fibers, giving it tremendous flexibility
        - Found in most vertebrate ears and the larynx/voice box
    - Fibrocartilage - cartilage with large amounts of collagen fibers, giving the tissue tremendous strength
        - Found in intervertebral discs in vertebrates
        - Replaces hyaline cartilage after it is damaged, making the injured joint stiff
- Bone/Osseous Tissue - made of large amounts of two different types of matrix material: organic and inorganic
    - Organic Matrix - gives strength and flexibility to the tissue
        - Similar to the matrix material found in other connective tissues, including some amount of collagen and elastic fibers
        - Without adequate organic material in the matrix, the tissue is brittle and is at higher risk of breaking
    - Inorganic Matrix - gives the tissue hardness
        - Made of mineral salts
        - Without adequate inorganic material in the matrix, the tissue may bend

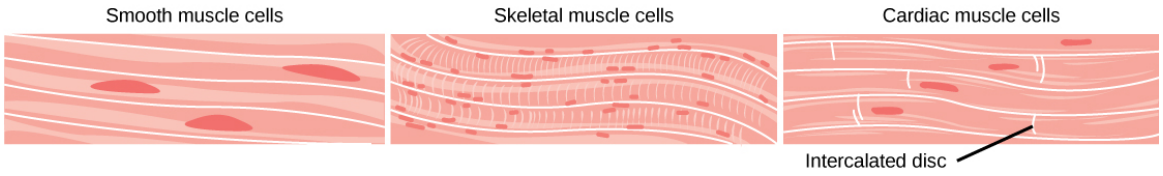


- Adipose/Fat Tissue - made of adipocytes
    - Adipocyte - collect and store fat in the form of triglycerides, for energy metabolism
        - Considered a connective tissue even though it does not have fibroblasts or a real matrix and only has a few fibers
    - Serves as insulation and protective cushioning
- Blood - made of plasma; no fibers
    - Plasma - the fluid portion of whole blood, its matrix, which is made of red blood cells (RBC)/erythrocytes and white blood cells (WBC)/leukocytes
        - RBCs, predominant cell type, transport O_2 and CO_2
        - WBCs are involved in immune response

Tissue	Cells	Fibers	Location
loose/areolar	fibroblasts, macrophages, some lymphocytes, some neutrophils	few (collagen, elastic, reticular)	around blood vessels; anchors epithelia
dense fibrous connective tissue	fibroblasts, macrophages,	many (mostly collagen)	irregular: skin regular: tendons, ligaments

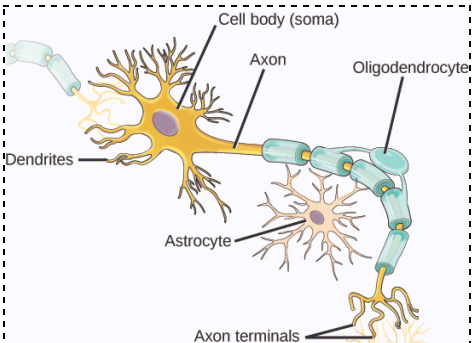
cartilage	chondrocytes, chondroblasts	hyaline: few collagen fibrocartilage: large amount of collagen	shark skeleton, fetal bones, human ears, intervertebral discs
bone	osteoblasts, osteocytes, osteoclasts	some (collagen and elastic)	vertebrate skeletons
adipose	adipocytes	few	adipose/fat
blood	RBCs, WBCs	none	blood

➢ 1.2c: Muscle Tissue
- Types of muscle: smooth/non-striated, skeletal, cardiac



- Smooth/Non-Striated Muscle
  - No striations in cells
  - Single, centrally located nucleus
  - Constriction of smooth muscle occurs under involuntary, autonomic nervous control and in response to local conditions in the tissues
  - Walls of blood vessels, the tubes of the digestive system, and the tubes of the reproductive systems are composed of mostly smooth muscle
- Skeletal Muscle
  - Has striations across its cells
    - Caused by arrangement of contractile proteins, actin and myosin
  - Have multiple nuclei along edge of cells which are relatively long
  - Under voluntary, somatic nervous system control and is found in the muscles that move bones
- Cardiac Muscle
  - Has striations in cells
  - Single, central nucleus
  - Only found in the heart
  - Not under voluntary control but can be influenced by the autonomic nervous system to speed up or slow down
  - Intercalated Disc - a line than extends along the end of the cell as it abuts the next cardiac cell in the row; assists in passing electrical impulse efficiently from one cell to the next and maintains the strong connection between neighboring cardiac cells

➢ 1.2d: Nervous Tissue
- Made of cells specialized to receive and transmit electrical impulses from specific areas of the body and to send them to specific locations in the body
- Neuron - main cell of the nervous system
  - Cell Body/Soma - a large structure with a central nucleus



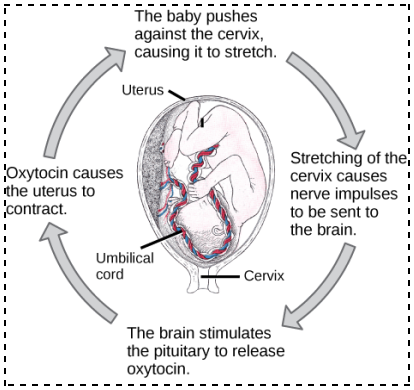
- Projections - branches coming from the cell body/soma; from the cell body are either dendrites or a single axon
  - Dendrite - specialized in receiving input
  - Axon - specialized in transmitting impulses
- Glial Cells/Neuroglia - other cells in nervous tissue that are generally are involved in supporting neurons in various ways
  - Astrocyte - regulates the chemical environment of the nerve cell
  - Oligodendrocyte - insulates the axon so the electrical nerve impulse is transferred more efficiently
  - Other glial cells support nutritional and waste requirements
    - Phagocytic Glial Cells - remove debris or damaged cells from the tissue

- Nerves are made of neurons and glial cells
- Types of Neurons: sensory, motor, and interneurons
  - Sensory - activated by sensory input from the environment
  - Motor - part of the central nervous system (CNS) and connect to muscles, glands and organs throughout the body; transmit impulses from the spinal cord to skeletal and smooth muscles (such as those in your stomach), and so directly control all of our muscle movements
  - Interneurons - connect spinal motor and sensory neurons

1.3: Homeostasis

➢ 1.3a: Homeostatic Process
- Homeostasis - process of maintaining dynamic equilibrium around a set point
- Stimulus - change in the internal or external environment, detected by a receptor
- Response to stimuli is to adjust the deviation parameter toward the set point
- The Process
  - Receptor senses change and alerts the control center
  - Control center generates a response that is signaled to an effector
    - Effector - a muscle (that contracts or relaxes) or a gland that secretes a biochemical impulse, an electrical signal of sorts, which travels via nerve fibers away from the central nervous system

➢ 1.3b: Control of Homeostasis
- Maintained by negative feedback loops and disrupted by positive feedback loops
  - Negative Feedback Loop - feedback to a control mechanism that increases or decreases a stimulus instead of maintaining it
    - Ex.: hungry → eat
  - Positive Feedback Loop - feedback to a control mechanism that continues the direction of a stimulus
    - Ex.: childbirth

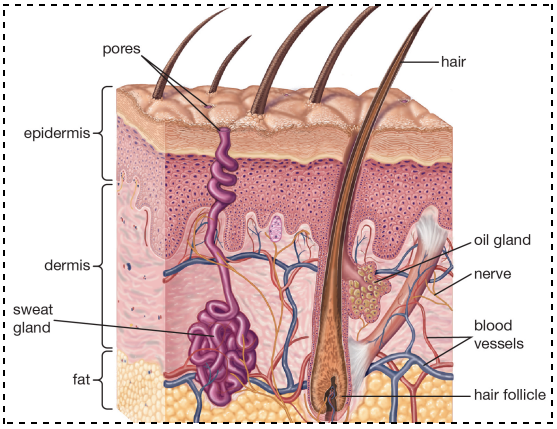


➢ 1.3c: Integumentary System - organ system consisting of skin and related tissues; the primary body systems involved in regulating homeostasis
- Involves the skin and its major structures (epidermis and dermis)
  - Epidermis - upper region of the skin, made of stratified squamous epithelium

- Provide a strong barrier, blocking access to the inside of the skin
- Very hard and waterproof due to stratified squamous epithelial cells and large amounts of keratin inside the cells
    - Keratin - protein that makes skin cells hard and water-resistant

■ Dermis - lower region of the skin, made of connective tissue and various structures

- Connective tissue holds the dermis together and anchors the epidermis to it
- Hair Follicles - made of specialized epithelial cells that produce even more keratin than the stratified squamous cells in the epidermis
    - As the cells divide, older cells are pushed out, forming hair
    - Attached to hair follicles are sebaceous glands, which secrete sebum, a mixture of lipids which helps to lubricate skin and hair, and also serves a protective function against many microbes



- Sweat Glands - secrete sweat (water and salts) directly to the surface of the skin; not attached to hair follicles
    - Helps regulate homeostasis because the production and evaporation of sweat cools the body down when it is too hot
    - Blood vessels bring oxygen to the various cells in the dermis, and also help to cool the body when it's too hot
        - The blood vessels expand, releasing more heat to the surface of the body
- Nerves - send signals from the brain to regulate the glands and blood vessels; serve a sensory purpose byu detecting stimuli

➢ 1.3d: Animal Bioenergetics

- Animals convert energy from ingested food into adenosine triphosphate (ATP) for short-term storage and use by all cells
    - Longer term: glucogen
    - Long term: triglycerides, stored in the adipose tissue
- Endothermic - warm-blooded animal that can conserve that heat and maintain a relatively constant body temperature
- Ectothermic - cold-blooded animal that lacks insulation; dependent on the environment for body heat
- Energy Requirements Related to Environment
    - Torpor - a process that leads to a decrease in activity and metabolism and allows animals to survive adverse conditions; includes hibernation

- Estivation - when torpor occurs during the summer months with high temperatures and little water; state where some animals go through dormancy or lack of activity during the warm, arid season
- Hibernation - when torpor occurs during the winter months with low temperatures and little food; state of inactivity and metabolic depression in endotherms

■ Torpor can occur on a daily basis

- Hyperthermia - body is exposed to excessive heat
- Hypothermia - body is losing heat faster than it can be produced
- Fever - having a temperature above the normal range due to an increase in the body's temperature set point
- Nonshivering Heat Production - an increase in metabolic heat production (above the basal metabolism) that is not associated with muscle activity