# Introduction to Human Anatomy and Physiology

**1. Briefly describe the early development of knowledge about the human body.**

Our earliest ancestors probably became curious about the body during illnesses and injuries. At these times, they visited shamans who relied on superstition and magic. Throughout early time, this curiosity lead to discoveries of the healing powers of certain herbs and potions, especially to treat coughs, headaches, and other common problems. Not until about 2,500 years ago did these superstitious attitudes change and the body was looked at in the new light of modern science. Experiments, accurate observations, and tried techniques rapidly expanded knowledge of the human body. Greek and Latin words were used as a basis to describe body part locations and to explain their functions. This formed the basis for anatomy and physiology.

1. **Distinguish between the activities of anatomists and physiologists.**
   **Anatomists** deal with the structure (morphology) of the body parts. This includes the shapes, forms, and placement of body organs and appendages. **Physiologists** deal with the functions of body parts, what the body parts do, and how this is accomplished.

2. **How does a biological structure's form determine its function? Give an example.**
   The functional role will depend upon the manner in which the part is constructed. The human hand with its long, jointed fingers makes it possible for human beings to grasp things.

3. **List and describe the ten characteristics of life.**
   **Movement** is the ability to self-initiate position changes of either the entire organism or a part of the organism, externally from place to place and/or internally, such as in peristalsis.

   **Responsiveness** refers to the ability of an organism to detect changes either within itself or the environment surrounding it and then react to these changes.

   **Growth** generally refers to an increase in body size without important changes to its general shape.

   **Reproduction** is the process of making a new organism, as in parents producing offspring. It also discusses the process whereby cells can produce others like themselves to take the place of damaged or destroyed cells.

   **Respiration** refers to the process of obtaining oxygen, using the obtained oxygen in release of energy from foods, and removing waste gases that are produced in the process.

   **Digestion** is the chemical change of ingested foods into simpler substances that can be taken in and used by body parts.

   **Absorption** is the passage of digested substances through membranes

4. **Define *metabolism.***
   The totality of chemical changes that occur within body parts.

5. **List and describe five requirements of organisms.**
   **Water,** the most abundant substance in the body, is required for many metabolic processes. It provides the environment for the metabolic processes to take place and then transports substances within the body. It is also important in the process of regulating body temperature.

   **Food** is the substances that provide the body with the necessary chemical to sustain life, in addition to water. These chemicals are used in a variety of ways by the body.

   **Oxygen,** which makes up about one-fifth of air, is used in the process of releasing energy from food substances.

   **Heat,** a form of energy, is a product of metabolic reactions. The rate at which these reactions occur is partly governed by the amount of heat present.

   **Pressure** is a state in which a force is applied to something. Atmospheric pressure is an important role in breathing. Hydrostatic pressure, the pressure of fluid, plays an important role in the circulatory system.

6. **Explain how the idea of homeostasis relates to the five requirements you listed in item 6.**
   **Homeostasis** refers to the stable internal environment of an organism. In human beings, if the requirements listed above become unstable, the body will react in certain ways to regain its stable internal environment. An example would be sweating to help decrease body temperature.

7. **Distinguish between heat and temperature.**
   **Heat** is a form of energy that is a product of metabolic reactions. **Temperature** is the amount of heat that is present at any given time.

8. **What are two types of pressures that may act upon organisms?**
   **Atmospheric pressure** is the pressure of the atmospheric air on the outside of an organism. **Hydrostatic pressure** is the pressure exerted by a liquid on the outside of an organism.

9. **How are body temperature, blood pressure and blood glucose concentration controlled?**
   Homeostasis is maintained in each of these situations by a self-regulating control mechanism that can receive signals about changes away from the normal set points and cause reactions that return conditions to normal.

10. **In what ways do homeostatic mechanisms act by negative feedback?**
    Homeostatic mechanisms detect changes away from the normal state. This stimulates responses in the opposite directions, which are called negative responses. This process is called **negative feedback**.

11. **How does the human body illustrate the levels of anatomical organization?**
    The basic unit of structure and function in the human body is the microscopic **cell**. These cells organize into layers that have common functions. These layers are called **tissues**. These tissues then group together to form **organs**. Groups of organs make up **organ systems**. Groups of organ systems make up the **organism**, which in this case is the human.

12. **Distinguish between the axial and appendicular portions of the body.**
    **Axial portion**—This consists of the head, neck, and trunk.

    **Appendicular portion**—This consists of the arms and the legs.

13. **Distinguish between the dorsal and ventral body cavities, and name the smaller cavities within each.**

The **dorsal cavity** is located at the back of the organism. It can further be subdivided into two parts—the **cranial cavity** within the skull, which houses the brain; and the **spinal cavity**, which contains the spinal cord and is surrounded by sections of the backbone (vertebrae). The **ventral cavity** is the front part of the organism. It is subdivided into two parts—a **thoracic cavity**, which houses the lungs and heart; and a **abdominopelvic cavity**, which houses the stomach, liver, spleen, gallbladder, small and a large intestines, urinary bladder, and the internal reproductive organs.

**14. What are the viscera?**
The **viscera** are the organs found deep within a body cavity.

**15. Where is the mediastinum?**
The **mediastinum** is the region that separates the thoracic cavity into two compartments, which contain the right and left lungs.

**16. Describe the locations of the oral, nasal, orbital, and middle ear cavities.**
**Oral cavity** is the mouth area and contains the teeth and the tongue.

**Nasal cavity** is located within the nose and is divided into right and left portions by a nasal septum. Air-filled sinuses are connected to the nasal cavity, including the sphenoidal and frontal sinuses.

**Orbital cavities** contain the eyes and associated skeletal muscles and nerves.

**Middle ear cavities** are found inside the ear and contain the middle ear bones.

**17. How does a parietal membrane differ from a visceral membrane?**
A **parietal membrane** refers to a membrane that is attached to the wall and forms the lining of a cavity whereas a **visceral membrane** refers to a membrane that is deeper toward the interior and covers the internal organs contained within a cavity.

**18. Name the major organ systems, and describe the general functions of each.**
**Integumentary system**—It protects underlying tissues, helps regulate body temperature, houses a variety of sensory receptors, and synthesizes certain products.

**Skeletal system**—It provides frameworks and protective shields for softer tissues; serves as attachments for muscles when body parts move. It also has a role in blood cell production and storage of inorganic salts.

**Muscular system**—It provides the forces that cause body movements. They also maintain posture and are the main source of body heat.

**Nervous system**—It provides the ability to detect changes that occur inside and outside the body. It interprets the sensory impulses and what to do in response to these impulses. It also plays a role in muscle contraction and gland secretions.

**Endocrine system**—It secretes hormones that alter metabolism of a target tissue.

**Cardiovascular system**—It pumps blood throughout the body. The blood serves as a fluid for transporting gases, nutrients, hormones, and wastes.

**Lymphatic system**—It transports tissue fluid back to the bloodstream and carries certain fatty substances away from the digestive organs. It also plays a role in immunity.

**Digestive system**—It receives various food molecules from the outside and converts them into simpler ones that can be absorbed.

**Respiratory system**—It provides for the intake and output of air and for the exchange of gases between blood and air.

**Urinary system**—It removes various wastes from the blood and assists in maintaining the body's water, electrolyte, and acid-base balances.

**Reproductive system**—It is responsible for the production of whole new organisms like itself.

**19. List the major organs that comprise each organ system.**
**Integumentary system**—It consists of the skin and various accessory organs such as the hair, nails, sweat glands, and sebaceous glands.

**Skeletal system**—It consists of the bones, ligaments, and cartilages.

**Muscular system**—It consists of the muscles.

**Nervous system**—It consists of the brain, spinal cord, nerves, and sense organs.

**Endocrine system**—It consists of glands that secrete hormones.

**Cardiovascular system**—It consists of the heart, arteries, veins, capillaries, and blood.

**Lymphatic system**—It consists of the lymphatic vessels, lymph fluid, lymph nodes, thymus gland, and spleen.

**Digestive system**—It consists of the mouth, tongue, teeth, salivary glands, pharynx, esophagus, stomach, liver, gallbladder, pancreas, small intestine, and large intestine.

**Respiratory system**—It consists of the nasal cavity, pharynx, larynx, trachea, bronchi, and lungs.

**Urinary system**—It consists of the kidneys, ureters, urinary bladder, and urethra.

**Reproductive system**—The male reproductive system consists of the scrotum, testes, epididymides, vasa deferentia, seminal vesicles, prostate gland, bulbourethral glands, penis, and urethra. The female reproductive system consists of the ovaries, uterine tubes, uterus, vagina, clitoris, and vulva.

**20. Name the body cavity housing each of the following organs:**

a. stomach—abdominal
b. heart—thoracic
c. brain—cranial
d. liver—abdominal
e. trachea—thoracic
f. rectum—pelvic
g. spinal cord—vertebral
h. esophagus—thoracic
i. spleen—abdominal
j. urinary bladder—pelvic

**21. Write complete sentences using each of the following terms correctly:**

a. superior—The head is superior to the abdomen.
b. inferior—The legs are inferior to the chest.

c. anterior—The eyes are anterior to the brain.
d. posterior—The brain is posterior to the eyes.
e. medial—The nose is medial to the eyes.
f. lateral—The ears are lateral to the eyes.
g. ipsilateral—The spleen and descending colon are ipsilateral.
h. contralateral—The spleen and gallbladder are contralateral.
i. proximal—The elbow is proximal to the wrist.
j. distal—The fingers are distal to the wrist.
k. superficial—The epidermis is the superficial layer of the skin.
l. peripheral—The nerves that branch from the brain and spinal cord are peripheral nerves
m. deep—The dermis is the deep layer of the skin.

**22. Prepare a sketch of a human body, and use lines to indicate each of the following sections:**
a. sagittal
b. transverse
c. coronal

**23. Prepare a sketch of the abdominal area and indicate the location of each of the following regions:**
a. epigastric
b. umbilical
c. hypogastric
d. hypchondriac
e. lumbar
f. iliac

**24. Prepare a sketch of the abdominal area and indicate the location of each of the following regions:**
a. right upper quadrant
b. right lower quadrant
c. left upper quadrant
d. left lower quadrant

See figure on lecture

**25. Provide the common name for the region described by the following terms:**
a. acromial—point of shoulder
b. antebrachial—the forearm
c. axillary—the armpit
d. buccal—the cheek
e. celiac—the abdomen
f. coxal—the hip
g. crural—the leg
h. femoral—the thigh
i. genital—the reproductive organs
j. gluteal—the buttocks
k. inguinal—the depressed area of the abdominal wall near the thigh (groin).
l. mental—the chin
m. occipital—the lower back region of the head
n. orbital—the eye cavity
o. otic—the ear
p. palmar—the palm of the hand
q. pectoral—the chest
r. pedal—the foot
s. perineal—the region between the anus and external reproductive organs (perineum)
t. plantar—the sole of the foot
u. popliteal—the area behind the knee
v. sacral—the posterior region between the hipbones
w. sternal—the middle of the thorax, anteriorly
x. tarsal—the instep of the foot
y. umbilical—the navel
z. vertebral—spinal column

## Cells

**26. Use specific examples to illustrate how cells vary in size.**
Nerve cells have long, threadlike extensions to transmit impulses. Epithelial cells are smaller and flattened for gas exchange. Muscle cells are slender and rodlike.

**27. Describe how the shapes of nerve, epithelial, and muscle cells are well suited to their functions.**
**Nerve cells** are long with threadlike extensions that can be used to transmit motor or sensory information. **Muscle cells** are slender and rodlike which contract to move parts of the body. **Epithelial cells**, specifically simple squamous, are thin and flattened for gas exchange.

**28. Name the major components of a cell, and describe how they interact.**
The two major components are the **nucleus** and the **cytoplasm**. The nucleus is the innermost part and controls the overall activities of a cell. The cytoplasm is a mass of fluid that surrounds the nucleus and is enclosed by the cell membrane. It holds the organelles.

**29. Discuss the structure and functions of a cell membrane.**
The basic structure of the cell membrane consists of a phospholipid bilayer. It contains embedded protein molecules. It functions to keep the inner portion of the cell intact. It controls the entrance and exit of substances.

**30. How do cilia, flagella, and cell adhesion molecules move cells?**
**Cilia**, small hair like projections that occur in groups, move together in a uniform, wavelike motion. This is used to propel substances along to a certain destination. An example is the uterine tube where the cilia move the egg from the ovary to the uterus.

**Flagella**, which occur singularly, have a whiplike motion to propel the object forward. An example is the sperm cell moving up the vagina toward the cervix.

**Cell adhesion molecules** *(CAMS)* occur on the cell membrane. The resulting interactions can slow the cell and allow it to move in certain ways. **Distinguish between organelles and inclusions.**

An **organelle** is a structure within the cytoplasm that has a specific function. **Inclusions** are masses of lifeless chemicals such as pigments or glycogen.

**31. Define selectively permeable.**
**Selectively permeable** means that the cell membrane allows some substances to pass through easily while excluding other substances.

**32. Describe the chemical structure of a membrane.**
The basic framework consists of a phospholipid bilayer with embedded proteins throughout.

**33. Explain how the structure of a cell membrane determines which types of substances it is permeable to.**
As the cell membrane is comprised chiefly of fatty acid portions of the phospholipid molecule, it allows substances that are soluble in lipids to pass through easily. It is impermeable to water soluble molecules.

**34. Explain the function of membrane proteins.**
The functions of membrane proteins include acting as a receptor to combine with a specific substance such as a hormone, while some form narrow passageways, or channels, through which various molecules and ions can cross the cell membrane. Others function as enzymes in signal transduction.

**35. Describe three kinds of intercellular junctions.**
These include:

**Tight junctions –The membranes of adjacent cells converge** and fuse. The area of fusion surrounds the cell like a belt. This then closes the junction between cells. These are the types of junction found in the lining of the digestive tract.

**Desmosome** –This is where rivets or "spot welds" are placed between adjacent skin cells.

**Gap junctions** –This is where tubular channels interconnect the membranes of certain cells.

**36. Describe the structures and functions of each of the following:**

a. **endoplasmic reticulum –**It is composed of membrane-bound flattened sacs and elongated canals. These are interconnected and communicate with the cell membrane, nuclear envelope, and certain cytoplasmic organelles. Two types of endoplasmic reticulum are found. Smooth endoplasmic reticulum lacks ribosomes embedded into the membrane. These are found in rough endoplasmic reticulum. It functions as a tubular communication system. It also functions in the production of proteins.

b. **ribosome –**These are composed of protein and RNA molecules. These function in the synthesis of proteins.

c. **Golgi apparatus –**Located near the nucleus, it consists of a stack of about six flattened membranous sacs whose membranes are continuous with the endoplasmic reticulum. This functions to refine and "package" the proteins synthesized by the ribosomes associated with the endoplasmic reticulum.

d. **mitochondrion –**These are elongated, fluid-filled sacs. The membrane surrounding a mitochondrion has an inner and outer layer. The inner layer is folded extensively to form partitions called cristae. In the cristae are enzymes that control some of the chemical reactions by which energy is released from glucose and other organic molecules. The cristae function in transforming this energy into a chemical form that is usable by various cell parts.

e. **lysosome –**These appear as tiny, membranous sacs that contain powerful enzymes that are capable of breaking down molecules of nutrient or foreign particles that enter cells. These also function in the destruction of worn cellular parts.

f. **peroxisome –**These are membranous sacs resembling lysosomes in size and shape. They contain enzymes, called peroxidases, which catalyze metabolic reactions that release hydrogen peroxide ($H_2O_2$) as a byproduct. These also contain catalase, which is an enzyme that decomposes hydrogen peroxide, that that is toxic to cells.

g. **cilium –**These contain microtubules arranged in distinct cylindrical patterns. Cilia occur in large numbers on the free surface of some epithelial cells. Each is a tiny hairlike structure about 10 microns long. These are arranged in precise patterns and have coordinated wavelike movement.

h. **flagellum –**There is usually one to a cell. It is longer than a cilium but is structurally put together the same way. This has an undulating, whip like motion. The flagellum is generally used for movement.

i. **centrosome –**Located in the cytoplasm near the Golgi apparatus and nucleus, these are nonmembranous and consist of two hollow cylinders called centrioles. These function in reproduction by aiding in the distribution of chromosomes to the newly forming cells.

j. **vesicle –**These are membranous sacs formed by an action of the cell membrane in which a portion of the membrane folds inward and pinches off. These play a role in phagocytosis and pinocytosis.

k. **microfilament –**Microfilaments are tiny rods of the protein actin arranged in meshworks or bundles. They cause various kinds of cellular movements.

l. **microtubule –**Microtubules are long slender tubes with diameters two or three times greater than a microfilament. These are composed of the globular protein tubulin. These are usually somewhat rigid, forming the cytoskeleton, which helps maintain the shape of the cell.

**37. Describe the structure of the nucleus and the functions of its contents.**
The **nucleus** is a cellular organelle that is usually located near the center of the cell. It is a relatively large, spherical structure enclosed in a double bilayered nuclear envelope, consisting of inner and outer membranes. This allows various substances to move between the nucleus and the cytoplasm. The **nucleolus** is a small, dense body composed largely of RNA and protein. It assists in the production of ribosomes. Chromatin consists of loosely coiled fibers composed of DNA molecules and protein that contain information for synthesizing proteins that promote cellular life processes. These become chromosomes during cell divisions.

**38. Distinguish between diffusion and facilitated diffusion.**
**Diffusion** is the process by which molecules or ions become scattered or are spread spontaneously from regions where they are in higher concentrations toward regions where they are in lower concentrations. Diffusion is a passive process that occurs naturally. **Facilitated diffusion** occurs when a substance that is not normally soluble in lipids combines with a receptor protein carrier molecule. This union forms a compound that is soluble in lipids and diffuses to the other side of the membrane. This receptor then releases the substance allowing for reuse of the carrier molecule.

**39. Name three factors that increase the rate of diffusion.**

These include: a short distance over which the diffusion will occur, a large concentration of the molecules, and an increase in temperature of the diffusing substances.

**40. Explain how diffusion aids in gas exchange within the body.**
Diffusion allows the oxygen molecules that are in high concentrations on one side of the capillary wall to move to areas of lower concentration. At the same time, the carbon dioxide molecules that are in high concentrations are moving to areas of lower concentration.

**41. Define *osmosis*.**
**Osmosis** is a special type of diffusion involving water. This is when water molecules diffuse from a region of higher water concentration to a region of lower water concentration.

**42. Define osmotic pressure.**
The ability of osmosis to generate enough pressure to lift a volume of water is called **osmotic pressure**.

**43. Explain how the number of solute particles in a solution affects its osmotic pressure.**
When the number of solute particles is great, the water concentration will be lowered while the osmotic pressure will be greater. Water will diffuse toward solutions with greater osmotic pressure.

**44. Distinguish among solutions that are hypertonic, hypotonic, and isotonic.**
**Hypertonic** refers to a solution that has a higher osmotic pressure than that of the cell. This causes the cell to shrink as water moves out of the cell. **Hypotonic** refers to a solution that has a lower osmotic pressure than that of the cell. This causes the cell to swell and possibly burst as water moves into it. **Isotonic** refers to a solution that has the same osmotic pressure as body fluids. This allows the cell size to remain unchanged as water or solutes are not being pulled in any specific direction.

**45. Define filtration.**
**Filtration** is the process by which molecules are forced through a membrane by pressure.

**46. Explain how filtration moves substances through capillary walls.**
Blood pressure is the force that allows water and dissolved substances to move through the capillary walls, forming tissue fluid.

**47. Explain why active transport is called a physiological process whereas diffusion is called a physical process.**
A **physiologic process** is defined as a living process. It requires energy. A **physical process** is defined as a passive process. It requires no energy.

**48. Explain the function of carrier molecules in active transport.**
**Carrier molecules** are proteins that have binding sites that combine with the particles being transported. This union triggers the release of cellular energy, and this causes the shape of a carrier molecule to be altered. This allows the "passenger" molecule to move through the membrane.

**49. Distinguish between pinocytosis and phagocytosis.**
**Pinocytosis** is the process by which cells take in tiny droplets of liquid from their surroundings. The cell membrane becomes indented and breaks down, integrating the water into the cytoplasm.
**Phagocytosis** is the process by which solid material is taken inside the cell. The process is the same as pinocytosis, except that solid material is taken inside the cell.

**50. Describe *receptor-mediated endocytosis*. How might it be used to deliver drugs across the blood-brain barrier?**
**Receptor-mediated endocytosis** is where protein molecules extend through the cell membrane and are exposed on its outer surface. The proteins become binding sites for specific substances found in the interstitial fluid. These are then allowed to enter the cell. It would be useful in the blood-brain barrier if there were a specific receptor that could be triggered to allow substances, such as a drug, to cross the membrane.

**51. Explain how *transcytosis* includes endocytosis and exocytosis.**
**Transcytosis** is the selective and rapid transport of a substance or particle from one end of a cell to the other. It also enables substances to cross barriers formed by tightly connected cells.

**52. List the phases in the cell life cycle. Why is interphase *not* a time of cellular rest?**
The phases in the life cycle of a cell include **mitosis**, **cytoplasmic division**, (**cytokinesis**), **interphase**, and **differentiation**. Interphase is the stage in the life cycle of a cell where young cells grow, manufacture compounds, new organelles are made and the chromosomes, and centrioles replicated.

**53. Name the two processes included in cell reproduction.**
The first is the process by which the nuclear portions of the cell divide (**karyokinesis**). The second process is where the cytoplasm divides (**cytokinesis**). These two processes together are called **mitosis**.

**54. Describe the major events of mitosis.**
**Prophase** is the first stage of mitosis where the chromosomes appear scattered throughout the nucleus. The nuclear envelope dissolves and the sister chromatids are attached by the centromere. A spindle-shaped group of microtubules forms between the centrioles as they move apart.

**Metaphase** is the second stage of mitosis. The chromosomes move along the spindle fibers and align midway between the centrioles. Spindle fibers become attached to the centromere of the chromosomes.

**Anaphase** is where the centromere of the chromatids separate and the chromatids become individual chromosomes. These are pulled apart toward the opposite sides of the cell.

**Telophase** is the final stage of mitosis where the chromosomes complete their migration toward the centrioles. It is much like prophase but with everything reversed. The nuclear envelope reforms and the chromosomes become invisible.

**55. Explain how the cytoplasm is divided during cellular reproduction.**
The cytoplasm is pinched off beginning in anaphase and completes itself at the end of telophase. There may be more cytoplasm in one of the new daughter cells than in the other.

**56. Explain what happens during *interphase*.**
**Interphase** is the stage in the life cycle of a cell where young cells, grow, manufacture compounds,

new organelles are made, and the chromosomes and the centrioles replicate.

**57. Define differentiation.**
**Differentiation** is the process by which cells develop different characteristics in structure and function.

**58. Explain how differentiation may reflect repression of DNA information.**
Special proteins activate some genes and repress others. The way these are activated do not determine the type of cell that it will become.

**59. How does loss of genetic control cause cancer?**
In a healthy cell, oncogenes are not expressed and the tumor suppressor genes are expressed. As a result, cell reproduction is under control. Cancer begins in a single cell when an oncogene is turned on or a tumor suppressor gene is turned off. If a mutation during chromosome division occurs, cancer could result.

**60. Distinguish between a stem cell and a progenitor cell.**
Stem cells divide mitotically to yield two stem cell daughters, or a stem cell and a progenitor cell, which may show the beginnings of differentiation.

Progenitor cells give rise to progenitors or more differentiated cells of a restricted lineage.

**61. Distinguish between totipotent cell and pluripotent cell.**
Totipotent means the cells can give rise to every cell type.

Bluripotent means that their daughter cells can follow any of several pathways, but not all of them.

**62. Explain how differentiated cells can have the same genetic instructions but look and function very differently.**
As cells specialize, they use some genes and ignore others.

Cellular Metabolism

**63. Define anabolism and catabolism.**
**Anabolism** uses energy to build large molecules from smaller ones. **Catabolism** releases energy by breaking large molecules into smaller ones.

**64. Distinguish between dehydration synthesis and hydrolysis.**
**Dehydration synthesis** is a special form of anabolism where larger molecules are formed by removing an –OH (hydroxyl group) from the end of one molecule and an –H (hydrogen atom) from the end of another. The –OH and –H combine to form $H_2O$ (water), and the ends of the two molecules join by sharing the remaining oxygen atom.

**Hydrolysis** is the opposite of dehydration synthesis. In hydrolysis, a large molecule is split apart at a certain point and a hydrogen atom is attached to one of the new molecules, while a hydroxyl group is attached to the other.

Both of these processes can occur over and over until the original molecule is altered to the cell's needs. In short, dehydration synthesis dehydrates a molecule and hydrolysis rehydrates it.

**65. Define peptide bond?**
A **peptide bond** is found in proteins. It is formed during dehydration synthesis when the carbon atom of one amino acid joins with the nitrogen atom of the other amino acid.

**66. Define *enzyme*.**
An **enzyme** is usually a globular protein that catalyzes the reactions of substances by lowering the activation energy required to cause the desired effect.

**67. How does an enzyme interact with its substrate?**
The surface of an enzyme contains areas called **active sites** that will bind to a specific **substrate** only. When the correct substrates are attached to the active sites (called an enzyme-substrate complex), the enzyme alters the shapes of the substrates in a way that promotes the reaction. All enzymes demonstrate this specificity to its substrates. To illustrate, an enzyme-substrate complex is like a "lock-and-key" model with the enzyme as the lock and the substrate as the key. Although many keys may fit the lock, only one type of key will make it work.

**68. List three factors that increase the rates of enzyme-controlled reactions.**
The three factors are:

a. an increase in the enzyme concentration,
b. an increase in the substrate concentration, and
c. the general efficiency of the particular enzyme.

**69. How are enzymes usually named?**
Enzymes are generally named for the substrate it interacts with, plus the suffix "-ase". For instance, the enzyme that interacts with lipids is called lipase.

**70. Define *cofactor*.**
A **cofactor** is a separate non-protein molecule that binds to an enzyme to aid in the reaction. Usually, a cofactor is a non-organic molecule. A coenzyme is a cofactor that is an organic molecule.

**71. Explain why humans require vitamins in their diets.**
**Vitamins** are organic substances that either cannot be synthesized by the human body, or are synthesized in quantities that are inadequate. For this reason, vitamins must be consumed in the diet.

**72. Explain how an enzyme may be denatured.**
Since enzymes are proteins, they can be **denatured**. This is the process of breaking the hydrogen bonds within the protein thereby rendering it useless. High heat, excessive radiation or electricity, and certain chemicals and fluids with extreme pH values cause denaturation. A good example is the egg white during frying. It starts a clear color and turns white upon application of the heat. This is the protein being denatured. This is a permanent process and cannot be reversed.

**73. Define *energy*.**
**Energy**, by definition, is the ability to do work.

**74. Explain how the oxidation of molecules inside cells differs from the burning of substances outside cells.**
The burning of a substance outside the cell usually requires large amounts of energy to start the reaction. This burning indiscriminately breaks all chemical bonds in the substance and releases the energy as light and heat. Oxidation inside the cell utilizes enzymes that require less activation energy, controls the by-products released, and uses certain energy capturing molecules to trap about one-half of the released energy for use elsewhere. The rest is lost as heat.

**75. Define *cellular respiration*.**
The controlled, sequential process of oxidation and energy recapture is referred to as **cellular respiration**.

**76. Distinguish between anaerobic and aerobic respiration.**
During cellular respiration, the oxidative processes that occur in the absence of oxygen are called **anaerobic respiration**. The oxidative processes that require the presence of oxygen for their reactions are called **aerobic respiration**.

**77. Explain the importance of ATP to cellular processes.**
**ATP** is the primary energy-carrying molecule in the cell. It acts as a rechargeable battery for cellular processes by carrying energy in the terminal bond of the phosphate molecule and returning to recapture energy when it is used. Without ATP, the cell would die.

**78. Describe the relationship between ATP and ADP molecules.**
**ATP** releases its energy by breaking off the third, or terminal, phosphate molecule. When this occurs, it becomes **ADP** (with only two phosphate molecules). The ADP returns to "recharge" by picking up a third phosphate molecule with energy, and the cycle repeats.

**79. Define *metabolic pathway?***
A **metabolic pathway** is a sequence of enzyme-controlled reactions required to convert substances into useable forms. These pathways are interconnected so that substances can be catabolized or anabolized per the needs of the cells at that particular time.

**80. Describe the starting material and products of *glycolysis*.**
Glucose is the starting material for **glycolysis**. In order for glucose to be used for energy production, it must be broken down by enzymes. To begin, ATP donates one phosphate molecule to the end of the glucose, and the glucose is rearranged into fructose. Then another ATP donates a phosphate molecule to the other end. These first steps are called phosphorylation because phosphates are being used in the alteration of the molecule. At this point, the fructose is split into two three-carbon sugars. A second phosphate is again added to each molecule and two hydrogen atoms are separated from each for use in the electron transport system. The molecules each lose one phosphate molecule to an ADP molecule (making two ATP). At this point, the molecules are rearranged twice to produce a pyruvic acid configuration with an attached phosphate. In the final step, the phosphate is lost to an ADP (converting to ATP) and the result is pyruvic acid.

In the presence of oxygen, a pyruvic acid molecule is oxidized into an acetyl group that combines with a molecule of coenzyme A. This step also releases two hydrogen atoms for each converted acetyl group. In the absence of oxygen, the pyruvic acid is converted into lactic acid. When oxygen is again available, the lactic acid is converted back into pyruvic acid for use in energy production.

**81. State the products of the citric acid cycle.**
The final products of the **citric acid cycle** (*Kreb's cycle*) are 38 ATP molecules. 36 ATP molecules can be used. The other two ATP molecules must be reused to start the process over again.

**82. How are carbohydrates stored?**
In the presence of excess glucose, such as after a meal, cells send the sugar into anabolic pathways for conversion into glycogen for storage. The liver and the muscle cells do the majority of the storage because they need constant reserves for activity. If the glycogen reserves have been filled, the excess glucose is converted into fat and stored in fat tissues. Because the body can perform this conversion without limits, overeating can cause obesity.

**83. Explain how one enzyme can regulate a metabolic pathway.**
Typically, the first enzyme in a pathway regulates the rate at which the pathway can work. This enzyme is called a rate-limiting enzyme because it is present in a limited quantity, and once saturated with substrates, the rate of reaction will not increase.

**84. Describe how a negative feedback mechanism can help control a metabolic pathway.**
The final product of the pathway can inhibit the rate-limiting enzyme. As the final product accumulates, it inhibits the rate of the first enzyme, regardless of the concentration of substrates. This negative feedback mechanism helps prevent excess product from being produced.

**85. Explain the chemical basis of genetic information.**
Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic information. It is composed of the 5-carbon sugar deoxyribose, a phosphate group, and one of several organic, nitrogenous bases. The four bases associated with DNA are adenine, thymine, cytosine, and guanine. These bases pair systematically, which bind the two long polynucleotide chains together. The entire molecule is then twisted into a double helix.

**86. Describe the chemical makeup of a gene.**
A **gene** is a specific "blueprint" for a protein or enzyme. Depending on how the base pairs are arranged, they will code for different proteins. Each gene is a variation of the possible proteins that code for a specific trait.

**87. Describe the general structure and components of a DNA molecule.**
A DNA molecule looks like a ladder in form. It is composed of two polynucleotide chains, with a backbone of sugars and phosphates, and nitrogenous bases projecting outward on one side. The sugar phosphate backbones make the uprights of the ladder, while the nitrogenous bases, linked together by hydrogen bonds, make the rungs.

The bases are paired in only one pattern across the DNA molecule. Adenine (A) binds only with thymine (T), and cytosine (C) binds only with guanine (G). These combinations are called complimentary base pairs. Because the DNA molecule is so large, it is twisted into a double-helix to conserve space

**88. Distinguish between the functions of messenger RNA and transfer RNA.**
A **messenger RNA** (*mRNA*) molecule is a special type of RNA that is made of the complementary base sequences, necessary for the production of a protein, from the DNA molecule. **Transfer RNA** (*tRNA*) is a group of RNA molecules that bind to activated amino acids in the cytoplasm and bring them to the mRNA molecule for assembly into a protein. A tRNA molecule can bind with only one kind of amino acid. Therefore, since there are twenty different amino acids, there must be at least twenty different kinds of tRNA molecules.

**89. Distinguish between transcription and translation.**
The process by which a mRNA molecule is formed from DNA is called **transcription**. The synthesis of protein molecules from the mRNA is called **translation**.

**90. Explain two functions of ribosomes in protein synthesis.**
In protein synthesis, a ribosome moves along with the mRNA and knits together a chain of amino acids by attaching itself to a portion of the mRNA and bonding with the complementary amino acid on a tRNA molecule. As it moves along the mRNA, it attaches each amino acid in sequence and releases the empty tRNA back into the cytoplasm.

**91. Distinguish between a codon and an anticodon.**
The sequences of nucleotides on a mRNA molecule are called **codons**. These are complimentary sets of bases from the DNA molecule. An **anticodon** is the compliment of the complimentary sequence on the mRNA molecule. Each is a set of three nucleotides that describe an amino acid.

**92. Explain how a DNA molecule is replicated.**
During a phase before cell reproduction an enzyme called DNA polymerase breaks the hydrogen bonds between the complimentary base pairs of the DNA molecule. As the DNA molecule splits and unwinds, new nucleotides bond with the exposed nucleotides of the parental strand and a new sugar-phosphate backbone is built. The result is two complete DNA molecules, each containing one parental strand and one daughter strand. These DNA molecules are then separated so that each new cell receives one complete DNA molecule.

**93. Define *mutation*, and explain how mutations may originate.**
A **mutation** is defined as a mistake in, or damage to, the DNA strand that is not corrected and is passed on to the new cells. Mutations can occur during replication when an incorrect nucleotide or extra nucleotides bind to the parental DNA strand. Mutations can also occur if sections of the DNA strands are deleted, misplaced, or attached to the wrong chromosome.

**94. Define *repair enzyme.***
If the mutation to a DNA molecule occurs only on one strand, the cell uses special enzymes called **repair enzymes** to clip out the defective portion and rebuild it correctly.

**95. Explain how a mutation may affect an organism's cells or not affect them?**
Because of the importance of the DNA molecule, there are many safeguards against mutation. For instance, there are sixty-one codons that specify the twenty amino acids. If the mutation occurs in the third nucleotide of a codon, it is likely that this mutation will still yield the correct amino acid. If the mutation is in the second codon, the new sequence will generally yield a structure similar enough to the original amino acid that the effect would not be significant. There are two copies of each chromosome in an adult cell. If one chromosome is mutated, the genes of the second chromosome will usually provide enough normal "blueprints" to maintain the health of the cell.

If a mutation occurs in a cell of an adult, it will probably go unnoticed because of the many normal cells around it. If the mutation occurs in the cell of an embryo or child, the results can be catastrophic because that cell may be the first, or be the parent, to many other cells as the infant grows.

## Tissues

**96. Define *tissue*.**
A **tissue** is a group of cells performing a specialized structural or functional role.

**97. Name the four major types of tissue found in the human body.**
The four major tissue types are epithelial, connective, muscle, and nervous.

**98. Describe the general characteristics of epithelial tissues.**
Epithelial tissues cover the body surfaces, cover and line internal organs, and compose glands. Because they cover the surfaces of all cavities and hollow organs, they always have a free surface (one exposed to the outside or having an open space). Epithelial tissues always anchor to connective tissue by a noncellular layer called the basement membrane. Generally epithelial tissues lack blood vessels. Epithelium reproduces readily and heals quickly. They are tightly packed with little intercellular material. Because of this, they serve as excellent barriers. Other functions include secretion, absorption, excretion, and sensory reception.

**99. Distinguish between simple epithelium and stratified epithelium.**
**Simple epithelium** occurs as a single cell or a single sheet of cells. **Stratified epithelium** consists of layers of cells.

**100. Explain how the structure of simple squamous epithelium provides its function.**
**Simple squamous epithelium** consists of a single layer of think, flattened cells. These fit together like floor tiles and the nuclei are broad and thin. Substances diffuse easily through this tissue. Because of this, simple squamous epithelium lines the alveoli of the lungs, forms the walls of capillaries, lines the insides of blood vessels, and covers the membranes that line body cavities. Because it is so thin, simple squamous epithelium is damaged easily.

**101. Name an organ that includes each of the following tissues, and give the function of the tissue.**

a. **Simple squamous epithelium**—Found in the walls of capillaries; it functions to allow the exchange of oxygen and waste products between the blood and the cells.
b. **Simple cuboidal epithelium**—Found in kidney tubules; it functions in secretion and absorption.
c. **Simple columnar epithelium**—Found in the intestinal tract; it functions in secretion of digestive fluids and absorption of nutrient molecules.
d. **Psuedostratified columnar epithelium**—Found in the passages of the respiratory system; the ciliated free surface moves the mucous produced by goblet cells up the respiratory tract and out of the airways.
e. **Stratified squamous epithelium**—Forming the outer layer of the skin (epidermis); it becomes hardened with keratin and makes a tough, dry, protective covering.

f. **Stratified cuboidal epithelium**—Found in the larger ducts of salivary glands; it provides extra protection.

g. **Stratified columnar epithelium**—Found in the male urethra; the goblet cells provide mucous for lubrication.

h. **Transitional epithelium**—Forming the inner lining of the urinary bladder; because of its stretchable nature, it forms a barrier that prevents the contents of the urinary tract from diffusing back into the body fluids.

**102. Define *gland*.**
A **gland** is composed of cells specialized to produce and secrete substances. Most commonly these cells are columnar or cuboidal epithelium. One or more of these cells constitutes a gland.

**103. Distinguish between an exocrine gland and an endocrine gland.**
**Exocrine glands** secrete their products into ducts that open onto an internal or external surface. **Endocrine glands** secrete directly into tissue fluid or blood.

**104. Explain how glands are classified according to the structure of their ducts and the organization of their cells.**
A single cell can make up an exocrine gland. This is called a **unicellular gland**. If it is made up of two or more cells, it is called a **multicellular gland**. Multicellular glands can be further subdivided into two groups based upon their duct structure. A **simple gland** has an *unbranched* duct. A **compound gland** has a *branched* duct. These can be further classified into **tubular glands** (*epithelial lined tubes*), or **acinar glands** (*saclike dilatations*).

**105. Explain how glands are classified according to the function and the nature of their secretions.**
**Merocrine glands** are glands that release fluid products through cell membranes without the loss of cytoplasm. **Apocrine glands** lose small portions of their glandular cell bodies during secretion. **Holocrine glands** are glands that release entire cells filled with secretory products. They are also classed as secreting serous fluid or mucus.

**106. Distinguish between a serous cell and a mucous cell.**
**Serous cells** produce a watery fluid that has a high enzyme concentration. **Mucous cells** produce a thick mucus that is rich in the glycoprotein mucin.

**107. Describe the general characteristics of connective tissue.**
Connective tissue is found throughout the body and is the most abundant type by weight. It binds structures, provides support, serves as frameworks, fills spaces, stores fat, produces blood cells, protects against infection, and helps repair damage. These cells are not adjacent to each other like epithelial cells and have abundant intercellular material called matrix. This material consists of fibers and a ground substance whose consistency varies from fluid to solid. Connective tissue has a good blood supply and is well nourished. Bone and cartilage are quire rigid; however, loose connective tissue, adipose, and fibrous connective tissue are more flexible.

**108. Define *matrix* and *ground substance*.**
Matrix is intracellular material between the connective tissue cells. This matrix consists of a ground substance whose consistency varies from fluid to semisolid to solid. The ground substance binds, supports, and provides a medium through which substances may be transferred between the blood and cells within the tissue.

**109. Describe the three major types of connective tissue cells.**
**Fibroblast**-a fixed cell in connective tissues. It produces fibers by secreting protein into the matrix of connective tissues. **Mast cells**-another fixed cell releases histamine and heparin.
**Macrophages**-wandering cells that can detach and move about. These are specialized to carry on phagocytosis.

**110. Distinguish between collagen and elastin.**
**Collagen** fibers are thick, threadlike, and made of the protein collagen. They are formed in long, parallel bundles and are flexible, but not elastic. That is, they can bend, but they cannot stretch. They have great tensile strength and are important to structures such as tendons. **Elastin** is the protein that elastic fibers originate from. These fibers are branched and form complex networks. They have low tensile strength, but are very elastic. That is, they can be easily stretched and resume their original length and shape. They are the primary component of the vocal cords.

**111. Explain the difference between loose connective tissue and dense connective tissue.**
**Dense connective tissue** has abundant collagenous fibers that appear white. This is sometimes known as white fibrous connective tissue. **Loose connective tissue** or areolar tissue has sparse collagenous fibers.

**112. Explain how the quantity of adipose tissue in the body reflects diet.**
Individuals are born with a certain number of fat cells. Excess food calories are likely to be converted into fat and stored. This illustrates that the amount of adipose tissue in a human is reflective of the individual diet.

**113. Distinguish between regular and irregular dense connective tissue.**
**Regular dense connective tissue** has organized patterns of the fibers. It is very strong, enabling the tissue to withstand pulling forces. It often binds body parts together. **Irregular dense connective tissue** has thicker, interwoven, and more randomly organized patterns of fibers. This allows for the tissue to sustain tensions exerted from many different directions. It is found in the dermis of the skin.

**114. Distinguish between elastic and reticular connective tissues.**
**Elastic connective tissue** is made up of yellow elastic fibers in parallel strands or in branching networks. In the fibers of this tissue are collagen fibers and fibroblasts. This tissue is found in the walls of certain hollow internal organs. **Reticular connective tissue** is composed of thin, collagenous fibers arranged in a three-dimensional network. It supports walls of certain internal organs such as the liver, spleen, and lymphatic organs.

**115. Explain why injured loose connective tissue and cartilage are usually slow to heal.**
Because fibrous connective tissue and cartilage are so dense and so closely packed, they lack a direct blood supply. For this reason, nutrients diffusing from outside tissues take a long time to reach the cells. This makes injury repair a very slow process.

**116. Name the major types of cartilage, and describe their differences and similarities.**

a. **Hyaline**—the most common type of cartilage. It looks somewhat like white plastic. It is found at the ends of bones in many joints, in the soft part of the nose, and in the supporting rings of the respiratory passage. It is also important in the development of bones.

b. **Elastic**—is very flexible and its matrix contains many elastic fibers. It is found in the external ears and in parts of the larynx.

c. **Fibrocartilage**—a very tough tissue, it contains many collagenous fibers. It is designed to function as a shock absorber. It forms the intervertebral disks and the protective cushions between bones in the knee and the pelvic girdle.

**117. Describe how bone cells are organized in bone tissue.**

The matrix for bone is laid down in thin layers called lamellae. The lamellae are arranged in concentric patterns around tubes called osteonic canals. Between the layers of lamellae the osteocytes are placed in depressions called lacunae. This pattern of concentric circles forms a cylinder-shaped unit called the osteon.

**118. Explain how bone cells receive nutrients.**

An osteon is a cylinder-shaped unit that the concentric circular pattern of bones cells form. Each osteonic canal contains blood vessels so that every cell is close to a nutrient supply. Bone cells also have cytoplasmic processes called canaliculi that extend outward and attach to the membranes of other cells. As a result, nutrients move rapidly between the bone cells.

**119. Describe the composition of blood.**

**Red blood cells** are the cells that carry oxygen to, and carbon dioxide from, cells. **White blood cells** function in immunity and infection control. **Platelets** are cellular fragments that function in blood clotting.

**120. Describe the general characteristics of muscle tissues.**

Muscle tissues are contractile. Muscle fibers within the tissue change shape to become shorter and thicker. This causes muscle fibers to pull at the attached ends and move body parts.

**121. Distinguish among skeletal, smooth, and cardiac muscle tissues.**

**Skeletal muscle tissue** is found in the muscles attached to bones and can be controlled by conscious effort. Because of this, it is also called voluntary muscle tissue. The cells or muscle fibers are long and threadlike with alternating bands of dark and light cross-markings called striations. Each fiber has many nuclei located near the cell membrane. When the muscle is stimulated by nerve fibers, it contracts and relaxes.

**Smooth muscle tissue** is named for its lack of striations. It is found in the intestinal tract, urinary bladder, blood vessels, and other hollow organs. It is not consciously controlled, and is therefore called involuntary muscle. Smooth muscle cells are shorter than those of skeletal muscle, and has a single, centrally located nucleus.

**Cardiac muscle** is found only in the heart. Its cells, which are striated, are joined end to end by a specialized connection called an intercalated disk. The cardiac muscle fibers are branched and interconnected in a complex network. Although it is striated, it cannot be controlled voluntarily.

**122. Describe the general characteristics of nervous tissue.**

Nervous tissue is found in the brain, spinal cord, and peripheral nerves. It is composed of neurons (nerve cells) and supporting neuroglial cells.

**123. Distinguish between neurons and neuroglial cells.**

Nervous tissue is composed of two types of cells. **Neurons**, or nerve cells, are sensitive to changes in their surroundings and respond to stimulation of impulses along nerve fibers. In addition to neurons, neuroglial cells serve to support the neurons and bind the nervous tissue together. **Neuroglial cells** carry on phagocytosis and bring nutrients to the neurons as well as remove waste from cells. They also serve to bind nervous tissue together. In many ways, these cells act as connective tissue found only in nervous tissue.

**124. Explain why a membrane is an organ.**

Two or more kinds of tissues grouped together and performing specialized functions constitute an organ. For example, epithelial membranes are usually composed of epithelial and underlying connection tissues.

**125. Identify locations in the body of the four types of membranes.**

Epithelial membranes cover body surfaces and line body cavities and organs.

Synovial membranes line joints.

Serous membranes line body cavities.

Mucous membranes line the cavities and tubes that open to the outside of the body.

## Skin and the Integumentary System

**126. Define integumentary system.**

The **integumentary organ system** is defined by the inclusion of the cutaneous membrane and the accessory organs within it. It is more commonly known as the skin.

**127. List the six functions of skin.**

a. A protective covering
b. Aids in body temperature regulation
c. Retards water loss
d. Houses sensory receptors
e. Synthesizes various chemicals
f. Secretes small quantities of waste substances

**128. Distinguish between the epidermis and the dermis.**

The **epidermis** is the outermost layer of the skin and is composed of keratinized stratified squamous epithelium. The **dermis** is the inner, thicker layer, and includes various tissues, such as connective tissue, epithelial tissue, smooth muscle tissue, nervous tissue, and blood. The epidermis and dermis are separated by a basement membrane that is anchored to the dermis by short fibrils.

**129. Describe the subcutaneous layer.**

The **subcutaneous layer** (*hypodermis*) lies beneath the dermis and consists largely of connective and adipose tissues. The collagenous and elastic fibers run mostly parallel to the surface of the skin, but also travel in all directions. As a result, there is no clear boundary between the dermis and the subcutaneous layer.

**130. Explain what happens to epidermal cells as they undergo keratinization.**

As new cells in the epidermis are produced, they are pushed upwards from the basement membrane towards the outside of the skin. As they get further from their nutrient source they die. As the process occurs, the maturing cells undergo a hardening process (**keratinization**) during which the cytoplasm develops strands of tough, fibrous, waterproof proteins called keratin. These dead cells form many tough, waterproof layers. These dead cells are rubbed away as newer cells replace them.

**131. List the layers of the epidermis.**
The layers in the epidermis are:

**Stratum basale**—the deepest layer
**Stratum spinosum**—a relatively thick layer
**Stratum granulosum**—a granular layer
**Stratum corneum**—a fully keratinized layer
**Stratum lucidum**—this layer appears between the stratum granulosum and stratum corneum in the thickened skin of the palms and soles.

**132. Describe the function of melanocytes.**
An important function of the skin is to protect the deeper tissues from the harmful effects of sunlight. One method of accomplishing this is the production of melanin, the dark pigment produced by **melanocytes** in the deeper layers of the epidermis and in the upper layers of the dermis. Melanin absorbs light energy and protects deeper tissues. Although melanocytes are found deep in the epidermis, the pigment can be found in any of the nearby cells due to the melanocytes' long, pigment-containing extensions that pass upward between neighboring epidermal cells. These extensions can then transfer the granular melanin to these other cells by a process called cytocrine secretion. As a result, the neighboring cells often contain more melanin than the melanocytes themselves.

**133. Describe the structure of the dermis.**
The **dermis** is composed largely of irregular dense connective tissue that includes tough collagenous fibers and elastic fibers in a gel-like substance. It has fingerlike projections called papillae that help form the fingerprints. The dermis also includes muscle tissue. It is usually smooth muscle, but striated muscle is also present in certain portions such as the face to help with voluntary facial movements. The dermis contains both sensory and motor nerves. It also contains blood vessels, hair follicles, sebaceous glands, and sweat glands.

**134. Review the functions of the dermal nervous tissue.**
The dermal nervous tissue has both sensory and motor fibers. Sensory fibers include Pacinian corpuscles, which are stimulated by heavy pressure and Meissner's corpuscles, which are sensitive to light touch. The motor fibers stimulate dermal muscles and glands.

**135. Explain the functions of the subcutaneous layer.**
The **subcutaneous layer** contains adipose tissue that acts as an insulator, conserving internal body heat and preventing the entrance of heat from the outside. This layer also contains the major blood vessels that supply nutrients and oxygen to the skin.

**136. Distinguish between a hair and a hair follicle.**
**Hair** is present on all skin surfaces except the palms, soles, lips, nipples, and various parts of the external reproductive organs. A **hair follicle** is a group of epidermal cells at the base of a tubelike depression. The root of the hair occupies this follicle. As these cells divide and grow, they are pushed toward the surface and undergo keratinization and subsequent cell death. The cells' remains form the structure of a developing hair whose shaft extends away from the skin surface. This shaft is called the hair.

**137. Review how hair color is determined.**
Genes that direct the type and amount of pigment produced by epidermal melanocytes determine hair color. Bright red hair contains an iron pigment (*trichosiderin*) that does not occur in hair of any other color. Gray hair is the result of a mixture of pigmented and unpigmented hair.

**138. Describe how nails are formed.**
Stratified squamous epithelial cells in the region known as the nail root form **nails**. The whitish half-moon-shaped area called the lunula marks the nail root. As these cells are pushed outward, they are keratinized into a hard tissue that slides forward over the nail bed to which it remains attached.

**139. Explain the function of sebaceous glands.**
**Sebaceous glands** contain groups of specialized epithelial cells and are usually associated with hair follicles. They are holocrine glands that secrete an oily substance called sebum (a mixture of fatty materials and cellular debris) that serve to keep the hair and skin soft, pliable, and relatively waterproof.

**140. Distinguish between eccrine and apocrine sweat glands.**
Certain sweat glands, known as **apocrine glands**, respond to emotional stress and become active when a person is emotionally upset, frightened, or experiencing pain. They are most numerous in the armpits and groin. These are usually connected to hair follicles. The development of these glands is stimulated by sex hormones so they become mature at puberty. **Eccrine glands** are not associated with hair follicles, and function throughout life in response to elevated body temperature associated with environmental heat and physical exercise. These sweat glands are found primarily on the forehead, neck, and back where they produce profuse sweating.

**141. Explain the importance of body temperature regulation.**
Body temperature regulation is vitally important because even slight shifts in body temperature can disrupt the rates of metabolic reactions.

**142. Describe the role of the skin in promoting the loss of excess body heat.**
In intense heat, the nerve impulses stimulate the skin and other organs to release heat. The muscles when active, release heat. The peripheral blood vessels dilate (vasodilation) which allows more of the warmed blood to be close to the outside for dispersal by radiation. The deeper blood vessels constrict (vasoconstriction) forcing more blood to the surface. The heart rate increases to circulate the blood faster. The sweat glands are also stimulated to add perspiration to the skin for evaporation.

**143. Explain how body heat is lost by radiation.**
**Radiation** is the primary means of body heat loss. This is accomplished when infrared heat rays escape from warmer surfaces to cooler surroundings.

**144. Distinguish between conduction and convection.**
**Conduction** is the process by which heat moves directly into the molecules of cooler objects in contact with its surface. **Convection** is the process

by which heat is carried away from the body by air molecules that circulate over the body.

**145. Describe the body's responses to decreasing body temperature.**
As excessive body heat is lost, the brain triggers responses in skin structure. For example, the muscles in the walls of the dermal blood vessels contract, decreasing the blood flow. The sweat gland become inactive and skeletal muscles throughout the body contract slightly (shivering).

**146. Review how air saturated with water vapor may interfere with body temperature regulation.**
The air can only hold so much of the water molecules. If it is already saturated, the person who is sweating will not have evaporation occur and they will be wet and uncomfortable.

**147. Explain how environmental factors affect skin color.**
Factors such as sunlight, ultraviolet light, and X-rays stimulate increased melanin production.

**148. Describe three physiological factors that affect skin color.**
The dermal blood supply affects skin color. For example, when the blood is well oxygenated, the hemoglobin makes the skin appear pinkish. When the blood is not well oxygenated, the hemoglobin is darker and the skin appears bluish (cyanosis). If the blood vessels are dilated or constricted, the skin will carotene, which is especially common in yellow vegetables, may give the skin a yellowish cast. Illnesses may affect skin color.

**149. Distinguish between the healing of shallow and deeper breaks in the skin.**
If the break in the skin is very shallow, the epithelial cells along the margin are stimulated to reproduce more rapidly. These newly produced cells simply fill in the gap. A deeper break involves the blood vessels. The clot will form and tissue areas will seep into the area and dry. This will then form a scab for underlying protection. Fibroblasts then produce fibers that bind the edges of the wound together. Growth factors are released to stimulate damaged tissue replacement. Healing continues beneath the scab, which sloughs off, when healing is complete.

**150. Distinguish among first-, second-, and third-degree burns.**
A first-degree burn is a superficial partial-thickness burn. An example would be a sunburn. A second-degree burn is a deep partial-thickness burn. Any burn that blisters is a second-degree burn. A third-degree burn is a full-thickness burn. It can burn away all the skin and muscles leaving bone exposed.

**151. Describe possible treatments for a third-degree burn.**
Skin grafts are one possible treatment. An **autograft** is a piece of skin from the victim. A **homograft** is one from a cadaver. Skin grafts leave scaring.

**152. List three effects of aging on the skin.**
Aging skin affects appearance as "age spots" or "liver spots" appear and grow, along with wrinkling and sagging.

Due to changes in the number of sweat glands and shrinking capillary beds in the skin, elderly people are less able to tolerate the cold and cannot regulate heat.

Older skin has a diminished ability to activate vitamin D necessary for skeletal health.

## Skeletal System

**153. List four groups of bones based upon their shapes, and name an example from each group.**

a. **Long bones**—femur and humerus
b. **Short bones**—tarsals and carpals
c. **Flat bones**—ribs, scapulae, and bones of the skull
d. **Irregular bones**—vertebrae and many facial bones

**154. Sketch a typical long bone, and label its epiphyses, diaphysis, medullary cavity, periosteum, and articular cartilages.**
See figure 7.2, page 183.

**155. Distinguish between spongy and compact bone.**
**Compact bone** is comprised of tightly packed tissue that is strong, solid, and resistant to bending. **Spongy bone** consists of numerous branching bony plates. Irregular interconnected spaces occur between these plates, thus reducing the weight of the bone.

**156. Explain how central canals and perforating canals are related.**
**Central canals** (*Haversian canals*) contain one or two small blood vessels and a nerve, surrounded by loose connective tissue. These vessels provide nourishment for the bone cells associated with the osteonic canals. The osteonic canals run longitudinally. **Perforating canals** (*Volkmann's canals*) run transversely and contain larger blood vessels and nerves by which the vessels and nerves in osteonic canals communicate with the surface of the bone and the medullary cavity.

**157. Explain how the development of intramembranous bone differs from that of endochondral bone.**
**Intramembranous bones** develop from sheetlike masses of connective tissue. Some of the primitive connective tissue cells enlarge and differentiate into osteoblasts. Spongy bone tissue is produced in all directions by these osteoblasts in the membrane. Eventually, the periosteum is developed by outside cells of the membrane of the developing bone. **Endochondral bones** develop of masses of hyaline cartilage with shapes similar to the future bone structures. These models grow rapidly for a while, and then begin to undergo extensive changes. The center of the diaphysis in long bones breaks down and disappears. At the same time, a periosteum forms from connective tissues that encircle the developing diaphysis. The primary ossification center is formed. Later on, the secondary ossification centers form and spongy bone forms from this.

**158. Distinguish between osteoblasts and osteocytes.**
**Osteoblasts** are bone-forming cells. **Osteocytes** are mature bone cells surrounded by matrix.

**159. Explain the function of an epiphyseal plate.**
The **epiphyseal plate** is a band of cartilage that is left between the primary and secondary ossification centers. This plate includes rows of young cells that are undergoing mitosis and producing new cells. As the epiphyseal plate thickens due to the new cells, bone length is increased.

**160. Explain how a bone grown in thickness.**
A developing bone grows in thickness as compact bone tissue is deposited on the outside, just

beneath the periosteum. Bone tissue is being eroded away on the inside by osteoclasts.

**161. Define *osteoclast.***
**Osteoclasts** are large multinucleated cells that break down the calcified matrix.

**162. Explain how osteoclasts and osteoblasts regulate bone mass.**
**Osteoclasts** secrete an acid that dissolves the inorganic component of the calcified matrix, and their lysosomal enzymes digest the organic components. After the osteoclasts remove the matrix, bone building **osteoblasts** invade the regions and deposit bone tissue.

**163. Describe the effects of vitamin deficiencies on bone development.**
**Vitamin D** is necessary for proper absorption of calcium in the small intestine. If this is lacking, *rickets* can develop or *osteomalacia* in adults. **Vitamin A** is necessary for bone resorption during normal development. **Vitamin C** is needed for collagen synthesis. Lacking either Vitamin A or C can hinder normal bone growth.

**164. Explain the causes of pituitary dwarfism and gigantism.**
**Pituitary dwarfism** results from the failure of the pituitary gland to secrete adequate amounts of growth hormone. **Pituitary giantism** results from the pituitary gland secreting an excessive amount of growth hormone prior to epiphyseal disk ossification.

**165. Describe the effects of thyroid and sex hormones on bone development.**
**Thyroid hormone** stimulates the replacement of cartilage in the epiphyseal disks of long bones with bone tissue. Thyroid hormone can halt bone growth by causing premature ossification of the epiphyseal disks. A deficiency in thyroid hormone may stunt growth as the pituitary gland depends upon thyroid hormone to stimulate the secretion of growth hormone. **Sex hormones** promote the formation of bone tissue. Female sex hormones have a slightly stronger effect than male sex hormones, allowing females to reach their maximum heights at an earlier age than males.

**166. Explain the effects of exercise on bone structure.**
**Physical exercise** causes the skeletal muscle to contract and the resulting stress stimulates the bone tissue to thicken and strengthen. On the other hand, lack of physical exercise causes bone to thin and weaken.

**167. Provide several examples to illustrate how bones support and protect body parts.**
Bones of the feet, legs, pelvis, and backbone support the weight of the body. The bones of the skull protect the brain. The rib cage and shoulder girdle protect the heart and lungs.

**168. Describe a lever, and explain how its parts may be arranged to form first-, second-, and third-class levers.**
A **lever** has four basic components: (a) a rigid bar or rod; (b) a pivot, or fulcrum, on which the bar turns; (c) an object or resistance (weight) that is moved; and a force that supplies the energy for the movement of that part.

A **first-class lever** has the sequence of resistance-pivot-force. Example of first-class levers would include scissors, seesaw, or hemostats. A **second-class lever** has the sequence of pivot-resistance-force. An example of a second-class lever would be a wheelbarrow. A **third-class lever** would have the sequence of resistance-force-pivot. Examples of third-class levers would include eyebrow tweezers or forceps.

**169. Explain how upper limb movements function as levers.**
The upper limb is a first-class lever as the forearm bones serve as the rigid bar while the hand is the resistance and the elbow joint is the pivot. The triceps brachii supply the force. This movement is when the forearm is straightened.

**170. Describe the functions of red and yellow bone marrow.**
**Red marrow** functions in the formation of red blood cells, white blood cells, and blood platelets. Its red color is derived from the oxygen-carrying pigment hemoglobin. **Yellow marrow** functions in fat storage and is inactive in blood cell production.

**171. Explain the mechanism that regulates the concentration of blood calcium ions.**
When the blood is low in calcium, parathyroid hormone stimulates the osteoclasts to break down bone tissue, releasing calcium salts from the intercellular matrix into the blood. Conversely very high blood calcium inhibits the osteoclast activity, and calcitonin from the thyroid gland stimulates the osteoblasts to form bone tissue, storing the excess calcium in the matrix.

**172. List three substances that may be abnormally stored in bone.**
Bone tissue may accumulate **lead**, **radium**, or **strontium**.

**173. Distinguish between the axial and appendicular skeletons.**
The **axial skeleton** consists of the bones that make up the skull, the hyoid bone, the vertebral column, and the thoracic cage. The **appendicular skeleton** consists of the pectoral girdle, the bones that comprise the upper and lower limbs, and the pelvic girdle.

**174. Name the bones of the cranium and facial skeleton.**
The bones of the cranium include one **frontal** bone, two **parietal** bones, one **occipital** bone, two **temporal** bones, one **sphenoid** bone, and one **ethmoid** bone. The bones of the facial skeleton include two **maxilla** bones, two **palatine** bones, two **zygomatic** bones, two **lacrimal** bones, two **nasal** bones, one **vomer** bone, two **inferior nasal conchae** bones, and one **mandible** bone.

**175. Explain the importance of fontanels.**
**Fontanels** permit some movement between the bones so that the developing skull is partially compressible and can change shape slightly. This allows the infant's skull to pass more easily through the birth canal.

**176. Describe a typical vertebra.**
A **typical vertebra** contains the following that are generic to all types:

a. **Body**—The body is drum-shaped and forms the thick anterior portion of the bone.
b. **Pedicles**—These consist of two short stalks and project posteriorly.
c. **Laminae**—These are two plates that arise from the pedicles and fuse in the back.
d. **Spinous process**—These results from the laminae fusing.

e. **Vertebral arch**—A bony arch comprised of the pedicles, laminae, and spinous process.

f. **Vertebral foramen**—The opening through which the spinal cord passes.

g. **Transverse process**—Projections from each side between the pedicles and laminae.

h. **Superior and inferior articulating processes**—Cartilage covered facets that project either upward or downward where the vertebrae are joined to the one above and below it.

i. **Intervertebral foramina**—Notches on the lower surfaces of the vertebral pedicles that form openings, which provide passageways for the spinal nerves that, communicate with the spinal cord.

**177. Explain the differences among cervical, thoracic, and lumbar vertebrae.**
The **cervical vertebrae** are distinctive due to the bifid spinous processes and transverse foramina in the transverse process. The **thoracic vertebrae** are larger than the cervical vertebrae and have long, pointed spinous processes that slope downward, and facets on the side of their bodies that articulate with a rib. Starting with the third thoracic vertebrae, the bodies of these vertebrae increase in size. The **lumbar vertebrae** have the largest bodies and short, stubby spinous processes.

**178. Describe the locations of the sacroiliac joint, the sacral promontory, and the sacral hiatus.**
The **sacroiliac joint** occurs where the sacrum is wedged between the coxal bones of the pelvis and is united to them at its auricular surfaces by fibrocartilage. The **sacral promontory** is the upper anterior margin of the sacrum. Physicians use this to determine pelvis size for childbirth. The **sacral hiatus** is the opening at the tip of the sacrum dorsally.

**179. Names the bones that comprise the thoracic cage.**
The **thoracic cage** includes the **ribs**, **thoracic vertebrae**, **sternum**, and **costal cartilages** that attach the ribs to the sternum.

**180. List the bones that form the pectoral and pelvic girdles.**
The **pectoral girdle** consists of two **clavicles** and two **scapulae**. The **pelvic girdle** consists of two **coxal bones** that articulate with each other anteriorly and with the sacrum posteriorly.

**181. Name the bones of the upper limb.**
The bones of the upper limb include a **humerus**, a **radius**, an **ulna**, and several **carpals**, **metacarpals**, and **phalanges**.

**182. Name the bones that comprise a coxa.**
A **coxal bone** develops from three parts—an **ilium**, an **ischium**, and a **pubis** that fuse together.

**183. List the major differences that may occur between the male and female pelves.**
The female iliac bones are more flared than the males. The angle of the female pubic arch may be greater. There may be more distance between the ischial spines and the ischial tuberosities. The sacral curvature may be shorter and flatter. The bones of the female pelvis are usually lighter, more delicate, and show less evidence of muscle attachments.

**184. List the bones of the lower limb.**
The bones of the lower limb include a **femur**, a **tibia**, a **fibula**, and several **tarsals**, **metatarsals**, and **phalanges**.

**185. Describe changes in trabecular bone and compact bone with aging.**
Trabecular bone, due to its spongy, less compact nature, shows the changes of aging first, as they thin, increasing in porosity and weakening the overall structure. The vertebrae consist mostly of trabecular bone. It is also found in the upper part of the femur, whereas the shaft is more compact bone. The fact that trabecular bone weakens sooner than compact bone destabilizes the femur, which is why it is a commonly broken bone among the elderly.

Compact bone loss begins at around age forty and continues at about half the rate of loss of trabecular bone. As remodeling continues throughout life, older osteons disappear as new ones are built next to them. With age, the osteons may coalesce, further weakening the overall structures as gaps form.

**186. List factors that may preserve skeletal health.**
Preserving skeletal health may involve avoiding falls, taking calcium supplements, getting enough vitamin D, avoiding carbonated beverages (phosphates deplete bone), and getting regular exercise.

**Match the parts listed in column I with the bones listed in column II.**

| I | | II |
|---|---|---|
| 1. | Coronoid process | C. Mandible |
| 2. | Cribriform plate | A. Ethmoid bone |
| 3. | Foramen magnum | E. Occipital bone |
| 4. | Mastoid process | F. Temporal bone |
| 5. | Palatine process | D. Maxillary bone |
| 6. | Sella turcica | G. Sphenoid bone |
| 7. | Supraorbital notch | B. Frontal bone |
| 8. | Temporal process | H. Zygomatic bone |
| 9. | Acromion process | M. Scapula |
| 10. | Deltoid tuberosity | K. Humerus |
| 11. | Greater trochanter | I. Femur |
| 12. | Lateral malleolus | J. Fibula |
| 13. | Medial malleolus | O. Tibia |
| 14. | Olecranon process | P. Ulna |
| 15. | Radial tuberosity | L. Radius |
| 16. | Xiphoid process | N. Sternum |

## Joints of the Skeletal System

**187. Define *joint*.**
A **joint** is a functional junction between bones.

**188. Explain how joints are classified.**
The type of tissue that binds the bones together at each junction can classify joints. They can also be

classified according to the degree of movement possible at the bony junctions.

**189. Compare the structure of a fibrous joint with that of a cartilaginous joint.**
A **fibrous joint** uses fibrous connective tissue to hold bones together that were in close contact with one another. A **cartilaginous joint** uses hyaline or fibrocartilage to hold the articulation together. Neither type allows much movement.

**190. Distinguish between a syndesmosis and a suture.**
A **syndesmosis** is characterized by bone being bound together by long fibers of connective tissue that form an interosseous ligament. This type of joint has slight movement. A **suture** has a thin layer of fibrous connective tissue that forms the sutural ligament. This type of joint has no movement.

**191. Describe a gomphosis, and name an example.**
A **gomphosis** is a joint formed by the union of a cone-shaped bony process in a bony socket. The peglike root of a tooth fastened to a jawbone by a periodontal ligament is such a joint.

**192. Compare the structures of a synchondrosis and a symphysis.**
A **synchondrosis** uses bands of hyaline cartilage to unite to bones. Many of these joints are temporary structures that disappear during growth. This particular type of joint allows no movement. A **symphysis** has the articular surfaces of bones covered with hyaline cartilage that is attached to a pad of fibrocartilage. This particular type of joint allows a limited type of movement.

**193. Explain how the joints between adjacent vertebrae permit movement.**
Each of these are **symphysis joints**. Between each vertebra, there is an **intervertebral disk** that is composed of a band of fibrocartilage that surrounds a gelatinous core. The disk absorbs shocks and helps equalize pressure between the vertebrae during body movement. As each disk is slightly flexible, the combined movements of many of the joints in the vertebral column allow the back to bend forward, to the side, or to twist.

**194. Describe the general structure of a synovial joint.**
A **synovial joint** will include the following components:

a. **Articular cartilage**—Thin layer of hyaline cartilage on the ends of the articulating bones.
b. **Joint capsule**—Tubular structure that has two distinct layers. The outer layer is made up of dense fibrous connective tissue. The inner layer is a shiny vascular membrane called the synovial membrane.
c. **Synovial fluid**—A clear viscous fluid secreted by the synovial membrane for lubrication of the joint.
d. **Ligaments**—Bundles of tough collagenous fibers that serve to reinforce the joint capsule.
e. **Menisci**—Disks of fibrocartilage found in some synovial joints that serve as shock absorbers.
f. **Bursae**—Fluid-filled sacs that cushion and aid the movement of tendons within a synovial joint.

**195. Describe how a joint capsule may be reinforced.**
**Ligaments** are used to bind the articular ends of bones together reinforcing the joint capsule. These can be thickenings in the fibrous layer of the joint capsule or accessory structures that are located outside of the joint capsule.

**196. Explain the function of the synovial membrane.**
The **synovial membrane** covers all surfaces within the joint capsule, except the areas the articular cartilage covers. It fills spaces and irregularities within the cavity. It secretes synovial fluid. It may store adipose tissue. It also reabsorbs the synovial fluid.

**197. Explain the function of synovial fluid**
**Synovial fluid** helps to cushion, moisten, and lubricate the smooth cartilaginous surfaces within the joint. It also supplies the articular cartilage with nutrients.

**198. Define *meniscus*.**
A **meniscus** is a disk of fibrocartilage that occurs in some synovial joints dividing them into two compartments. It serves as a shock absorber and allows bony prominences to fit together easier.

**199. Define *bursa*.**
A **bursa** is a fluid-filled sac associated with freely moveable joints.

**200. List six types of synovial joints, and name an example of each type.**

| Type | Example |
|---|---|
| **Ball-and-Socket** | Hip joint, shoulder joint |
| **Condyloid** | Joints between the metacarpals and phalanges |
| **Gliding** | Joints between the various bones of the wrist and ankle |
| **Hinge** | Elbow joint, knee joint |
| **Pivot** | Joint between the proximal end of the radius and ulna |
| **Saddle** | Joint between the carpal and metacarpal of the thumb |

**201. Describe the movements permitted by each type of synovial joint.**

| Type | Type of Movement |
|---|---|
| **Ball-and-Socket** | Movement in all planes, as well as rotational movement around a central axis. |
| **Condyloid** | Variety of movement in different planes, but rotational movement is possible. |
| **Gliding** | Sliding back and forth motion only. |
| **Hinge** | Flexion and extension in one plane only. |
| **Pivot** | Rotation around a central axis only. |
| **Saddle** | Variety of movements. |

**202. Name the parts that comprise the shoulder joint.**
The **shoulder joint** consists of the head of the humerus and the glenoid cavity of the scapula.

**203. Name the major ligaments associated with the shoulder joint.**
**Coracohumeral ligament**—Connects the coracoid process of the scapula to the greater tubercle of the humerus.

**Glenohumeral ligament**—Three binds of fibers that appear as thickenings in the ventral wall of the joint capsule and extend from the edge of the glenoid fossa to the lesser tubercle and the anatomical neck of the humerus.

**Transverse humeral ligament**—Runs between the greater and lesser tubercles of the humerus.

**Glenoidal labrum**—Attached along the margin of the glenoid fossa and forms a rim with a thick free edge that deepens the fossa.

**204. Explain why the shoulder joint permits a wide range of movements.**
The **shoulder joint** permits a wide range of movements due to the looseness of it attachments and the relatively large articular surface of the humerus compared to the shallow depth of the glenoid fossa. The movements include flexion, extension, abduction, adduction, rotation, and circumduction.

**205. Name the parts that comprise the elbow joint.**
The **elbow joint** includes the trochlea of the humerus, the trochlear notch of the ulna, the capitulum of the humerus, and a fovea on the head of the radius.

**206. Describe the major ligaments associated with the elbow joint.**
**Radial collateral ligament**—Connects the lateral epicondyle of the humerus to the annular ligament of the radius.

**Annular ligament**—Connects the margin of the trochlear notch of the ulna and encircles the head of the radius.

**Ulnar collateral ligament**—Connects the medial epicondyle of the humerus to the medial margin of the coronoid process. It also connects posteriorly to the medial epicondyle of the humerus and to the olecranon process of the ulna.

**207. Name the movements permitted by the elbow joint.**
The only movement permitted between the humerus and ulna are flexion and extension. The head of the radius, however, is free to rotate in the annular ligament, which allows pronation and supination of the hand.

**208. Name the parts that comprise the hip joint.**
The **hip joint** consists of the head of the femur and the cup-shaped acetabulum of the coxal bone.

**209. Describe how the articular surfaces of the hip joint are held together.**
**Acetabular labrum**—Horseshoe-shaped ring of fibrocartilage at the rim of the acetabulum and deepens the acetabular cavity encloses the head of the femur.

**Iliofemoral ligament**—Connects the anterior inferior iliac spine of the coxal bone to the intertrochanteric line between the greater and lesser trochanters of the femur.

**Pubofemoral ligament**—Extends between the superior portion of the pubis and the iliofemoral ligament.

**Ischiofemoral ligament**—Originates on the ischium just posterior to the acetabulum and blends with the fibers of the joint capsule.

**210. Explain why there is less freedom of movement in the hip joint than in the shoulder joint.**
Muscles surround the joint capsule of the hip. The articulating parts of the hip are held more closely together than those of the shoulder, allowing considerably less freedom of movement.

**211. Name the parts that comprise the knee joint.**
The **knee joint** consists of the medial and lateral condyles at the distal end of the femur, and the medial and lateral condyles at the proximal end of the tibia. The femur also articulates anteriorly with the patella.

**212. Describe the major ligaments associated with the knee joint.**
**Patellar ligament**—Continuation of a tendon from the quadriceps muscle group that extends from the margin of the patella to the tibial tuberosity.

**Oblique popliteal ligament**—Connects the lateral condyle of the femur to the margin of the head of the tibia.

**Arcuate popliteal ligament**—Extends from the lateral condyle of the femur to the head of the fibula.

**Tibial collateral ligament** (*medial collateral ligament*)—Connects the medial condyle of the femur to the medial condyle of the tibia.

**Fibular collateral ligament** (*lateral collateral ligament*)—Connects the lateral condyle of the femur and the head of the fibula.

**Anterior cruciate ligament** (*ACL*)—Originates from the anterior intercondylar area of the tibia and extends to the lateral condyle of the femur.

**Posterior cruciate ligament** (*PCL*)—Connects the posterior intercondylar area of the tibia to the medial condyle of the femur.

**213. Explain the function of the menisci of the knee.**
The **menisci** serve as shock absorbers. They also function to compensate for the differences in shapes between the surfaces of the femur and tibia.

**214. Describe the locations of the bursae associated with the knee.**
**Suprapatellar bursa**—Located between the anterior surface of the distal end of the femur and the quadriceps muscle group above it.

**Prepatellar bursa**—Located between the patella and the skin.

**Infrapatellar bursa**—Located between the proximal end of the tibia and the patellar ligament.

**215. Describe the process of aging as it contributes to the stiffening of fibrous, cartilaginous, and synovial joints.**
Joint stiffness is often the earliest sign of aging.

a. Collagen changes cause the feeling of stiffness.

b. Regular exercise can lessen the effects.

Fibrous joints are the first to begin to change and strengthen over a lifetime.

Synchondroses of the long bones disappear with growth and development.

Changes in symphysis joints of the vetebral column diminish flexiblility and decrease height.

Over time, synovial joints lose elasticity.

**Part B**

**Match the movements in column I with the descriptions in column II.**

| | **I** | **II** |
|---|---|---|
| 1. | Rotation<br>Moving part around an axis | D. |
| 2. | Supination<br>Turning palm upward | A. |
| 3. | Extension<br>Increasing angle between parts | F. |
| 4. | Eversion<br>Turning sole of foot outward | E. |

5. Protraction — C.
   Moving part forward
6. Flexion — B.
   Decreasing angle between parts
7. Pronation — H.
   Turning palm downward
8. Abduction — I.
   Moving part away from midline
9. Depression — G.
   Lowering a part

## Muscular System

**216. List the three types of muscle tissue.**
The three types of muscle tissue are: **skeletal**, **smooth**, and **cardiac**.

**217. Distinguish between a tendon and an aponeurosis.**
A **tendon** is a projection of connective tissue beyond the ends of the muscle that attaches to bone. An **aponeurosis** is a broad fibrous sheet of connective tissue that connects muscles to adjacent muscles.

**218. Describe the connective tissue coverings of a skeletal muscle.**
Muscle fibers are grouped together in fascicles that are surrounded by a layer of connective tissue called the **endomysium**. The fascicles are bundled together and surrounded by another layer of connective tissue called the **perimysium**, which also fills the spaces between the fascicles. Several layers of fibrous connective tissue called the epimysium, which surrounds the entire muscle, then cover the perimysium.

**219. Distinguish between deep fascia, subcutaneous fascia, and subserous fascia.**
**Deep fascia** is the portion of the network of the fasciae that surrounds and penetrates the muscles. **Subcutaneous fascia** is the portion that lies just beneath the skin forming the subcutaneous layer. **Subserous fascia** is the portion that forms the connective tissue layer of the serous membranes covering organs in various body cavities and lining those cavities.

**220. List the major parts of a skeletal muscle fiber, and describe the function of each part.**
A muscle fiber is a single, multinucleated cell, which contracts when stimulated. It is a thick, elongated cylinder with rounded ends that may extend the entire length of the muscle. Its component parts are:

**Sarcolemma**—The specific name for a muscle fiber's cell membrane.

**Sarcoplasm**—The specific name for a muscle fiber's cytoplasm. It contains the many small, oval nuclei and mitochondria.

**Myofibrils**—The numerous, threadlike proteins that lie parallel to one another and are contained in the sarcoplasm. The arrangement of the two proteins below produces the striations seen in the skeletal muscle.

1. Myosin—The primary protein of the myofibril. It is a thick protein filament running longitudinally within the muscle fiber.
2. Actin—The thin protein filaments arranged intertwined within the myosin filaments

The alternating light and dark striations are named for their positions within the fiber.

1. A bands—The primary location of the myosin filaments that produces the dark striations.
2. I bands—The primary location of the actin filaments that produces the light striations.
3. Z lines—The attachment point of the actin filaments at the ends of I bands. They are arranged so that those of adjacent myofibrils side by side.

**Sarcomere**—The segment of the myofibril between two successive Z lines. This regular arrangement causes the muscle fiber to appear striated.

**Sarcoplasmic reticulum** (**S.R.**)—The specific name for the endoplasmic reticulum. The network of membranous channels that surround each myofibril running parallel to them.

**Transverse tubules** (**T-tubules**)—The invaginations of the fiber's sarcoplasm that extend inward and pass completely through the fiber. It is open to the outside of the sarcoplasm at both ends and contains extracellular fluid. Each T-tubule likes between two enlarged portions of the S.R., called cisternae, near the regions where the actin and myosin filaments overlap. With the S.R., the T-tubules activate the muscle contraction mechanism.

**221. Describe a neuromuscular junction.**
Each skeletal muscle fiber is connected to a fiber from a nerve cell called a motor neuron. The muscle fiber contracts only when stimulated by this specific fiber. At the connection point between the never fiber and the muscle fiber, the muscle fiber's sarcolemma is tightly coiled and heavily concentrated with mitochondria. This region is known as the motor end plate. The branches of the motor nerve fiber project into recesses (synaptic clefts) of the motor end plates and the distal ends are filled with mitochondria and synaptic vesicles that store chemicals called neurotransmitters. This entire region is known as a **neuromuscular junction**.

**222. Define *motor unit*, and explain how the numbers of fibers within a unit affects muscular contractions.**
The nerve fibers of a motor neuron are highly branched. Each of these branches is connected to the motor end plate of a single muscle fiber. When the motor neuron is stimulated, the impulse is carried to all of the muscle fibers attached to its branches. In this way a single motor neuron controls the contractions of many muscle fibers. All the muscle fibers attached to this motor neuron and the motor neuron itself constitute a **motor unit**. The fewer muscle fibers in the motor unit, the finer the movements that can be produced.

**223. Explain the function of a neurotransmitter substance.**
A **neurotransmitter** is a chemical stored in the synaptic vesicles, which, when stimulated by a nerve impulse, is released into the gap at the motor end plate and stimulates the fiber to contract.

**224. Describe the major events that occur when a muscle fiber contracts.**
Muscle fiber contraction is a complex process involving a number of cell parts and chemical substances that result in the sliding movement of the actin and myosin filaments and causes a contraction. A myosin filament is composed of protein strands with globular ends called cross-bridges that extend outward along the length of the filament. The actin filaments have ADP molecules attached to its surface that serve as active sites for linking the cross-bridges of the myosin filaments.

Although the process is not completely understood, the sliding filament theory suggests that the myosin cross-bridge attaches to an actin active site and bends slightly, pulling the actin with it. It releases its attachment, straightens, and combines with another active site further down the actin filament, causing the sarcomere to shorten.

When the nerve impulse reaches the distal end of its branch, acetylcholine is released into the gap. The acetylcholine diffuses rapidly across the motor end plate and combines with protein receptors in the sarcolemma. This causes a muscle impulse to be generated and pass in all directions over the entire sarcolemma, and through the T-tubules deep into the fiber. The S.R., which contains a high concentration of calcium ions, becomes more permeable and allows the ions to diffuse into the sarcoplasm. When a high enough concentration is present in the sarcoplasm, the linkages between the actin and myosin filaments occur and contraction takes place. The calcium ions are moved quickly back into the S.R. by an active transport system (calcium pump). When enough calcium ions have been removed from the sarcoplasm, the muscle relaxes. At the same time, the acetylcholine is rapidly decomposed by the enzyme cholinesterase. This prevents a single nerve impulse from causing a sustained contraction.

**225. Explain how ATP and creatine phosphate function in muscle contraction.**
The basic energy source for muscle contraction comes from **ATP** molecules supplied by the mitochondria. The cross-bridges of myosin contain the enzyme ATPase that causes ATP to decompose into ADP and phosphate, thereby releasing energy. The primary source of regeneration of ATP from ADP is **creatine phosphate**. Creatine phosphate contains high-energy phosphate bonds and is four to six times more abundant in the muscle fibers than ATP. Creatine phosphate cannot directly supply energy to the muscle fiber. Instead, it acts as a storehouse of energy for the ADP. In the mitochondria, the enzyme creatine phosphokinase creates creatine phosphate to be used for ATP synthesis. The creatine phosphate, in turn, converts ADP into ATP by resupplying the phosphate molecule.

**226. Describe how oxygen is supplied to skeletal muscles.**
Oxygen is carried from the lungs by **hemoglobin** in the blood. When the hemoglobin reaches the muscle, the oxygen is transferred to the **myoglobin** in the muscle fiber. Myoglobin is similar to hemoglobin in its oxygen capacity, and reduces the muscle's need for continuous blood supply during contraction.

**227. Describe how an oxygen debt may develop.**
When skeletal muscles have been used where they have exceeded their oxygen reserves, anaerobic respiration must take over. Anaerobic respiration changes glucose into pyruvic acid, and due to the lack of oxygen, the pyruvic acid is converted into lactic acid. The lactic acid diffuses out of the muscles and is taken to the liver by the blood. The liver can change lactic acid back into glucose: however, this conversion also requires the use of ATP. During strenuous exercise, primarily the muscles and not the liver use the oxygen, so the lactic acid accumulates. **Oxygen debt** then, is defined as the amount of oxygen needed by the liver to convert the lactic acid back into glucose, plus the amount needed by the muscles to resynthesize ATP and creatine phosphate and return them to their original concentrations. Because the conversion of lactic acid into glucose is a slow process, it may take several hours to repay the oxygen debt.

**228. Explain how muscles may become fatigued and how a person's physical condition may affect tolerance to fatigue.**
If a muscle is exercised strenuously for a long period, it may lose its ability to contract. This is called **muscle fatigue**. This condition may result from an interruption in a muscle's blood supply or from the depletion of acetylcholine in the motor nerve fibers. The most common cause of muscle fatigue is due to the accumulation of lactic acid from anaerobic respiration. The lactic acid causes factors, such as pH, to change so that the muscle fibers no longer respond. Occasionally, a muscle becomes fatigued and develops a cramp simultaneously. A cramp is a painful condition in which the muscle contracts spasmodically, but does not completely relax. This may be caused by a lack of ATP. A person who exercises can stimulate new capillaries to grow within the muscles, supplying more oxygen and nutrients to the muscle fibers. This will allow more aerobic respiration to take place, thereby decreasing dependence on anaerobic respiration, which results in less lactic acid buildup.

**229. Explain how actions of skeletal muscles affect maintenance of body temperature.**
Two-thirds of the energy released in cellular respiration is lost as heat. Muscle accounts for most of the total body mass so when muscles are active, large amounts of heat are produced. This is circulated throughout the body by the blood thereby supporting the maintenance of **body temperature**.

**230. Define *threshold stimulus.***
A muscle fiber remains unresponsive until a certain amount of stimulus is applied. This minimal strength required is called the **threshold stimulus**.

**231. Explain *all-or-none response.***
When a muscle fiber contracts, it always contracts to the fullest extent possible. Because a muscle fiber cannot contract partially, this phenomenon is called the **all-or-none response**.

**232. Describe the staircase effect.**
A muscle fiber that has been inactive can be subjected to a series of stimuli, such that it undergoes a series of twitches with complete relaxation in between. However, the strength of each successive contraction increases, reaching a maximum. This phenomenon is called the **staircase effect**.

**233. Explain *recruitment*.**
Because all of the muscle fibers in a motor unit are controlled by a single motor neuron, all of the fibers will contract in response to the motor neuron stimulus. When the nerve impulse is so great that one motor neuron cannot handle it; the excess impulse is shunted to other motor neurons. This ability to cause more than one motor unit to respond to a stimulus is called **motor unit recruitment**.

**234. Explain how a skeletal muscle can be stimulated to produce a sustained contraction.**
If a muscle is exposed to a series of stimuli increasing in frequency, a point is reached where the muscle is unable to complete its relaxation period before the next stimulus arrives. This stacking of twitches causes a **sustained contraction**.

**235. Distinguish between a tetanic contraction and muscle tone.**
A **tetanic contraction** (*tetany*) results when a sustained forceful contraction lacks even partial relaxation. **Muscle tone** (*tonus*) is a response to nerve impulses originating repeatedly from the spinal cord, and traveling to small numbers of muscle fibers within a muscle. Muscle tone is responsible for maintaining posture. Muscle tone appears to be a conscious phenomenon because when the person is rendered unconscious, the body will collapse.

**236. Distinguish between concentric and eccentric contractions, and explain how each is used in body movements.**
**Concentric = Shortening occurs** If a person lifts an object, the muscles remain taut, their attached ends pull closer together, and the object is moved. The muscle contracts with force greater than resistance and shortens.

**Eccentric = lengthening occurs** The muscle contracts with less force than resistance and lengthens. Laying a book down on a table is an example.

**237. Distinguish between fast-contracting and slow-contracting muscles.**
**Fast-contracting muscles** (*white muscles*) contain less myoglobin and have a poorer blood supply in relation to **slow-contracting muscles** (*red muscles*). They have fewer mitochondria and a reduced respiratory capacity. They do have a better-developed sarcoplasmic reticulum and a higher ATPase activity. This allows them to contract rapidly. A slow-contracting muscle has a lot of myoglobin and a well-developed blood supply. They have many mitochondria to carry on aerobic respiration. As a result, they can generate the necessary ATP needed for contraction. They contract for long periods of time prior to muscle fatigue becoming a factor.

**238. Compare the structures of smooth and skeletal muscle fibers.**
**Smooth muscle fibers** are shorter than **skeletal muscle fibers**. Smooth muscle fibers have once centrally nucleus. They are elongated with tapering ends. The actin and myosin filaments are present throughout the length of smooth muscle fibers but are thinner and more random. The smooth muscle fibers also lack transverse tubules and their sarcoplasmic reticulum is not well developed.

**239. Distinguish between multiunit and visceral smooth muscles.**
**Multiunit smooth muscle** features fibers that are somewhat disorganized and occur as separate fibers rather than in sheets. It can be found in the iris of the eyes and in the walls of blood vessels. Multiunit smooth muscle tissue contracts only after stimulation by motor nerve impulses. **Visceral smooth muscle** is composed of sheets of spindle-shaped cells in close contact with one another. This type, which is more common, is found in the walls of hollow, visceral organs such as the stomach, intestines, urinary bladder, and uterus. The fibers of visceral smooth muscle are capable of stimulating each other. So, when one fiber is stimulated, the impulse may excite adjacent fibers that, in turn, may excite others. Visceral smooth muscle fibers also display rhythmicity—a pattern of repeated contractions. These two features of visceral smooth muscle are largely responsible for peristalsis.

**240. Define *peristalsis* and explain its function.**
**Peristalsis** consists of alternating contractions and relaxations of the longitudinal and circular muscle fibers. It functions to force the contents of a tube along its length.

**241. Compare the characteristics of smooth and skeletal muscle contractions.**
Both **smooth** and **skeletal muscle** contractions involve the reactions of actin and myosin, are triggered by membrane impulses and the release of calcium ions, and use energy from ATP molecules. The differences between their contractions are:

a. Skeletal muscles use acetylcholine as the neurotransmitter. Smooth muscle uses acetylcholine and norepinephrine as its neurotransmitters.
b. Several hormones that cause either contractions or alter the amount of response to the neurotransmitters affect smooth muscles.
c. Smooth muscle is slower to contract and relax than skeletal muscle. However, smooth muscle can maintain a forceful contraction for a longer period of time with a given amount of ATP.
d. Unlike skeletal muscle, smooth muscle fibers can change length without changes in tautness. As a result, as the hollow organs become filled, the muscles can stretch without internal pressure changing.

**242. Compare the structures of cardiac and skeletal muscle fibers.**
**Cardiac muscle** occurs only in the heart. It is made of striated muscle fibers joined end-to-end, forming three-dimensional networks. The internal components are the same, except that the cisternae of the cardiac fibers are not as well developed and contain fewer calcium ions than **skeletal muscle fibers**. The T-tubules of the cardiac muscle fibers are more developed and release more calcium ions, which comes from the extracellular fluid, in response to stimuli. This enables the cardiac muscle fibers to maintain contractions for a longer period of time. The cardiac muscle cells are joined to each other at the ends by means of intercalated disks. These disks help hold adjacent cells together and transmit the force of the contraction from cell to cell. The disks are also low in electrical resistance, so the muscle impulse travels from cell to cell rapidly. Cardiac muscle is self-exciting, rhythmic, and the entire network responds in an all-or-none manner.

**243. Compare the characteristics of cardiac and skeletal muscle contractions.**
**Skeletal muscle** can contract individually. **Cardiac muscle** works in a network. When one portion of the cardiac muscle network is stimulated, the impulse travels to the other fibers in the network. It then contracts as a unit. It is self-exciting and rhythmic, and the entire network responds in an all-or-none manner.

**244. Distinguish between a muscle's origin and its insertion.**
The **origin** of a muscle is the end of the muscle attached to an immovable part. The **insertion** is the end of a muscle attached to a moveable part. When a muscle contracts, the insertion is pulled toward the origin.

**245. Define *prime mover, synergist*, and *antagonist*.**
The **prime mover** is the muscle that is primarily responsible for a certain movement. A **synergist** is a muscle that aids the prime mover in its action to

move a part. An **antagonist** is a muscle that acts against the prime mover. For instance, if the prime mover raises the arm, the antagonist lowers it. The combination of both the prime mover and antagonist working at the same time will cause the part to remain rigid. This aids in maintaining posture, balance, and locomotion.

**Match the muscles in column I with the descriptions and functions in column II.**

| | I | | II |
|---|---|---|---|
| 1. | Buccinator | F. | Compresses the cheeks |
| 2. | Epicranius | E. | Consists of two parts—the frontalis and the occiptialis |
| 3. | Lateral pterygoid | H. | Pulls the jaw from side to side |
| 4. | Platysma | G. | Extends over the neck from the chest to the face |
| 5. | Rhomboideus major | C. | Can raise and adduct the scapula |
| 6. | Splenius capitis | D. | Can pull the head into an upright position |
| 7. | Temporalis | A. | Inserted on the coronoid process of the mandible |
| 8. | Zygomaticus | B. | Draws the corner of the mouth upward |
| 9. | Biceps brachii | P. | Strongest supinator of the forearm |
| 10. | Brachialis | O. | Strongest flexor of the elbow |
| 11. | Deltoid | K. | Abducts the arm |
| 12. | Latissimus dorsi | J. | Pulls the shoulder back and downward |
| 13. | Pectoralis major | M. | Pulls the arm forward and across the chest |
| 14. | Pronator teres | N. | Rotates the arm medially |
| 15. | Teres minor | L. | Rotates the arm laterally |
| 16. | Triceps brachii | I. | Primary extensor of the elbow |
| 17. | Biceps femoris | V. | A hamstring muscle |
| 18. | External oblique | T. | Compresses the contents of the abdominal cavity |
| 19. | Gastrocnemius | S. | A plantar flexor of the foot |
| 20. | Gluteus maximus | U. | Largest muscle in the body |
| 21. | Gluteus medius | X. | Abducts the thigh |
| 22. | Gracilis | W. | Adducts the thigh |
| 23. | Rectus femoris | R. | A member of the quadriceps group |
| 24. | Tibialis anterior | Q. | Inverts the foot |

**Part C**

**Which muscles can you identify in the bodies of these models whose muscles are enlarged by exercise?**

## Nervous System I: Basic Structure and Function

**246. Distinguish between neurons and neuroglial cells.**

**Neurons** are the structural and functional cells reacting to the physical and chemical changes in their environment. **Neuroglia** are the supporting cells necessary for nourishing and maintaining the neurons, among other functions.

**247. Explain the relationship between the central nervous system and the peripheral nervous system.**

The **central nervous system** (**CNS**) is composed of the brain and the spinal cord. The **peripheral nervous system** (**PNS**) is composed of all of the peripheral nerves that connect all of the parts of the body with the CNS.

**248. List three general functions of the nervous system.**

The nervous system functions in three ways:

**Sensory**—The sensory function is accomplished by means of sensory receptors that note changes in their environment.

**Integrative**—The CNS can take the impulses from all of the sensory receptors and combine them to make perceptions and sensations about the environment.

**Motor**—The CNS can send impulses along some peripheral nerves to effectors in the muscles and glands in response to changes in the internal and external environment.

**249. Describe the generalized structure of a neuron.**

All neurons have a cell body and nerve fibers that are responsible for nerve impulse conduction to and from the cell body. The cell body (soma or perikaryon) contains granular cytoplasm, mitochondria, lysosomes, a Golgi apparatus, and many microtubules. Neurofibrils extend in a network throughout the microtubules and support them. Also found in the cytoplasm are Nissl bodies, which are membranous sacks of rough endoplasmic reticulum. Cytoplasmic inclusions contain glycogen, lipids, or pigments. The nucleus is large and spherical with a conspicuous nucleolus. The two kinds of nerve fibers extending from the cell body are called dendrites and axons. The many dendrites are typically highly branched to provide receptive surfaces (dendritic spines) for other neurons to communicate. A neuron usually has only one axon arising from the axon hillock. It is a nearly smooth cylindrical process with uniform diameter. It is filled with cytoplasm containing many mitochondria, microtubules, and neurofibrils. It is specialized to conduct nerve impulses away from the cell body. The axon starts as a single fiber but may branch off into collaterals, which may end in presynaptic terminals.

**250. Define *myelin.***

Surrounding larger axons and dendrites of peripheral nerves are sheaths of neuroglial cells called Schwann cells. These cells are wound tightly around the fibers and, as a result, the cell membranes are layered closely together with little or no cytoplasm between them. The layers are composed of a lipoprotein called **myelin**, which forms a myelin sheath on the outside of the fibers. The outermost Schwann cells contain most of the cytoplasm and their nuclei remain outside the myelin sheath. This layer is known as neurolemma or neurolemmal sheath.

**251. Distinguish between myelinated and unmyelinated nerve fibers.**

A **myelinated nerve fiber** is one, which is bound by Schwann cells longitudinally along its length. The Schwann cells wrap tightly around the nerve

fiber and form a myelin sheath. **Unmyelinated nerve fibers** lack these sheaths. In this case, these Schwann cells are not wound around the axons but simply for a grove or valley in which the axon sits. Myelinated (medullated) nerve fibers appear white. Unmyelinated nerve fibers appear gray.

**252. Explain how neurons are classified on the basis of their structure.**

Nerve fibers can be classified into three main groups:

**Bipolar**—Bipolar neurons have only two nerve fibers, one is the axon and one is the dendrite. They are from opposite sides of the cell body.

**Unipolar**—Unipolar neurons have a single nerve fiber extending from the cell body. From there it branches in two directions; one branch extends into a peripheral body part and serves as a dendrite. The other extends into the CNS and acts like an axon.

**Multipolar**—Multipolar neurons have one axon and many other extensions from the cell body that serve as dendrites.

**253. Explain how neurons are classified on the basis of their function.**

Nerve fibers can be classified into three groups:

**Sensory**—Sensory (afferent) neurons sense changes inside or outside the body by means of receptors ends or nearby receptor cells. They send impulses to the CNS in response to these changes. Most of these neurons are unipolar, with some bipolar.

**Interneurons**—Interneurons (association or internuncial neurons) are multipolar neurons found in the CNS. They link with other neurons and send impulses from one part of the CNS to another.

**Motor**—Motor (efferent) neurons are multipolar, and send impulses from the CNS to muscles or glands. There are two types of motor neurons that control smooth or cardiac muscle. Accelerator neurons increase muscle activity, while inhibitory neurons decrease muscle activity.

**254. Discuss the functions of each type of neuroglial cell.**

The PNS has only one type of neuroglial cell: the **Schwann cell**. The CNS has four different types of neuroglial cells. They are:

**Astrocyte**—Astrocytes are star-shaped cells located between neurons and blood vessels. They provide structural support and transport substances between the neurons and blood vessels. Astrocytes are joined together by gap junctions, providing a channel for circulating calcium ions. Other duties include metabolism of substances (such as glucose), keeping the synaptic clefts free of excess ions and neurotransmitters, and scar tissue formation after injury.

**Oligodendrocytes**—Oligodendrocytes function in myelin production. By extending numerous cellular processes, an oligodendroctye can provide myelin sheaths to several different axons. Because of this arrangement, no neurilemmal sheaths are formed.

**Microglia**—Microglia are small cells found throughout the CNS. They provide support and phagocytize bacteria and debris.

**Ependyma**—Ependyma are ciliated cuboidal or columnar cells found as the inner lining of the central canal and as a single-layered membrane covering the ventricles of the brain. They are joined together by gap and tight junctions, and provide a porous layer for substances to diffuse between the interstitial fluids of the brain and cerebrospinal fluid in the ventricles.

**255. Describe how an injured nerve fiber may regenerate.**

If the axon of a peripheral nerve is separated from the cell body, the distal portion deteriorates and the fragments are removed by macrophages. The proximal end then develops new sprouts, and nerve growth factors from surrounding neuroglia cause the sprouts to grow. At the same time, remaining Schwann cells proliferate and surround the new axon. If a sprout grows into the remaining basement membranes of the original tract, the new fiber may rejoin with its original connection. If the injured axon is from a neuron in the CNS, the lack of a myelin sheath prevents the new fiber from being guided to its original connection. Therefore, regeneration in the CNS is very unlikely. An injury to the cell body of a neuron usually causes death to the entire fiber, and no regeneration will occur.

**256. Explain how a membrane may become polarized.**

A cell, in its normal state, has a negatively charged interior with respect to the exterior. This is accomplished by transport mechanism channels that let potassium ions move easily in and out, and keep sodium and calcium ions under tight control.

**257. Define *resting potential.***

Because the movement of sodium ions into the cell is slower than the movement of potassium out of the cell, there are more positive ions (cations) outside and more negative ions (anaions) inside. The difference in the charges between the two sides of the cell's membrane is about –70 millivolts (in relation to the interior charge). This difference in charge is defined as the **resting potential** because it shows a potential to do the work (send a message).

**258. Distinguish between depolarizing and hyperpolarizing.**

If, in response to a stimulus, the resting potential becomes more negative, the cell is said to be **hyperpolarizing**. If the stimulus causes the resting potential to become less negative, the cell is said to be **depolarizing**.

**259. List the changes that occur during an action potential.**

When enough stimuli have accumulated to cause the threshold potential to be released, the area stimulated opens its sodium channels. As the sodium ions rush in, the inside of the cell becomes momentarily positive. At the same time, potassium channels open to allow the potassium ions out. This causes the inside of the cell to return to a negative charge (repolarization). The entire sequence takes less than 1/1,000$^{th}$ of a second.

**260. Distinguish between action potentials and nerve impulses.**

An action potential occurs at a specific site. When an action potential occurs at the trigger zone of a nerve cell, it sends an electrical impulse to the adjacent membrane. This causes an action potential at the next site. This occurs in a wavelike sequence, without losing amplitude, from the beginning of the fiber to the end, and is known as a nerve impulse.

**261. Define refractory period.**

After an action potential passes, the fiber needs time to return to its resting potential. This time is called the **refractory period**. The refractory period has two parts. The first is the absolute refractory period. This lasts about 1/2,500$^{th}$ of a second, and is the period when no new impulses can be sent. The second is called the relative refractory period. During this time, the fiber still has not returned to its resting potential, but enough sodium and potassium ions have moved to allow an action potential to occur to very strong stimuli.

**262. Define *saltatory conduction.***
The Schwann cells surrounding a myelinated nerve fiber serve as an insulator and prevent most ions from passing through. Between adjacent Schwann cells is a small gap called a node of Ranvier, where the nerve fiber is exposed. When a nerve impulse is conducted along a myelinated fiber, it "jumps" from node to node. This type of conduction is called **saltatory conduction**.

**263. Define *synapse*.**
The ends of axons and dendrite are not directly connected to other neurons or effects. Instead, they terminate very close to them, leaving a space. The terminal end of the axon is called a presynaptic terminal and it communicates with a postsynaptic neuron. This "connection" is called a **synapse**.

**264. Explain how a nerve impulse is transmitted from one neuron to another.**
When a nerve impulse reaches the end of the presynaptic neuron, it enters several synaptic knobs that contain synaptic vesicles filled with neurotransmitters. The neurotransmitters are released into the synaptic cleft and trigger an action potential in the postsynaptic neuron.

**265. Explain the role of calcium in the release of neurotransmitters.**
An action potential moving across a synaptic knob's membrane causes calcium channels to open and increases the membrane's permeability. As the calcium ions move inward, some of the synaptic vesicles fuse with the presynaptic membrane and release their neurotransmitters. The number of vesicles that fuse to the membrane is directly related to the amount of calcium ions that move inward.

**266. Define *neuropeptide.***
**Neuropeptides** are chains of amino acids found in the CAN and/or PNS that act as neurotransmitters or *neuromodulators* (substances that block neurotransmitters or alter a neuron's response). Among the neuropeptides are two found only in the CNS that are potent natural pain relievers (enkephalins and beta endorphin) and one found throughout both the CNS and PNS that transmits pain impulses (substance P).

**267. Distinguish between excitatory and inhibitory postsynaptic potentials.**
Different neurotransmitters cause distinctly different responses in the postsynaptic neuron. If a neurotransmitter binding to the postsynaptic neuron causes sodium ion channels to open, the ions move inward and depolarize the membrane, possibly causing an action potential. Because this reaction causes the membrane to be closer to the threshold potential, it is said to be an **excitatory postsynaptic potential** (**EPSP**). If the neurotransmitter causes the potassium receptors to open, the postsynaptic membrane becomes hyperpolarized in response to an influx of potassium ions. This reaction makes an action potential less likely and is called an **inhibitory postsynaptic potential** (**IPSP**).

**268. Describe the "trigger zone" of a neuron.**
A **trigger zone** is an area at the proximal end of an axon at the axonal hillock that starts a nerve impulse from the action potential.

**269. Describe the relationship between an input nerve fiber and its neuronal pool.**
A **neuronal pool** is a group of neurons in the CNS that has special characteristics. It responds to impulses from **input** (*afferent*) **nerve fibers**. These fibers branch many times upon entering the neuronal pool to form hundreds of synapses with dendrites and cell bodies in a certain region of the pool.

**270. Define *facilitation.***
Because a neuron in a region of a neuronal pool may receive excitatory and inhibitory impulses at the same time, the net effect may be either excitatory or inhibitory. If the net effect is excitatory enough to pass the threshold potential, an action potential will occur. If the net effect is excitatory but subthreshold, the neuron becomes more excitable and easier to push over the threshold. This state is called **facilitation**.

**271. Distinguish between convergence and divergence.**
When input nerve fibers from different areas of the body send impulses to the same neuron, they are said to **converge**. When a neuron sends impulses out on an output (*efferent*) nerve fiber, the impulse may stimulate others. These, in turn, may stimulate still others, and so on. **Divergence** works with input nerve fibers as well. For instance, the impulse form a sensory receptor may diverge and reach several different areas of the CNS for processing.

**272. Explain how nerve impulses are amplified.**
When a nerve impulse is diverged, it is carried on several nerve fibers. This amplifies its effect and causes a more forceful response.

Nervous System II: Divisions of the Nervous System

**273. Name the layers of the meninges and explain their functions.**
The layers of the **meninges** surround the brain and spinal cord. They are, from the outermost to the innermost layers:

**Dura mater**—The dura mater is a tough, fibrous connective tissue layer containing many blood vessels and nerves. It functions as a protective layer, surrounding the brain and spinal cord.

**Arachnoid mater**—The arachnoid mater is a thin weblike membrane that lacks blood vessels and nerves. It is attached to the pia mater by thin strands.

**Pia mater**—The pia mater is a thin membrane containing many nerves and blood vessels that provide nourishment to the underlying brain cells and spinal cord. It is attached directly to the surface of the brain and spinal cord.

**274. Describe the location of cerebrospinal fluid within the meninges.**
**Cerebrospinal fluid** (**CSF**) is found between the arachnoid and pia mater of the brain and spinal cord in the space called the subarachnoid space.

**275. Describe the location of the ventricles of the brain.**

The **lateral ventricles** (*first and second ventricles*) extend into the cerebra hemispheres and occupy part of the frontal, temporal, and occipital lobes. The **third ventricle** is found in the midline of the brain, below the corpus callosum, and connects the lateral ventricles through openings in the anterior ends. The **fourth ventricle** is found in the brain stem in front of the cerebellum. The cerebral aqueduct connects openings in its roof that lead into the subarachnoid space of the meninges.

**276. Explain how cerebrospinal fluid is produced and how it functions.**
**Cerebrospinal fluid** (**CSF**) is secreted by tiny reddish cauliflower-like masses of specialized capillaries in the pia mater called choroid plexuses that project into the ventricles. CSF is important in the protection and support of the CNS by absorbing the forces of impact, maintaining a stable ion concentration, and providing a route for waste products to be removed.

**277. Describe the structure of the spinal cord.**
The **spinal cord** is a long slender column of nerve fibers that begins at the foramen magnum of the skull and extends downward to a point near the first and second lumbar vertebrae. The cord is actually a group of thirty-one segments that give rise to pairs of *spinal nerves*. These nerves connect all of the body to the CNS.

A thickening in the neck region, called the *cervical enlargement*, supplies the nerves to the arms and a similar thickening, the *lumbar enlargement*, supplies the nerves to the legs. Inferior to the lumbar enlargement, the spinal cord tapers into a structure (*conus medullaris*) that is connected to the coccyx by a thin cord of connective tissue (*filum terminale*).

Along the length of the cord are two grooves, the anterior median fissure and posterior median sulcus, which divide the cord into left and right halves. A cross section of the cord shows a gray matter core surrounded by white matter. The gray matter resembles a butterfly. The upper wings are called the *posterior horns* and the lower wings are called the *anterior horns*. Between these horns is a small protuberance called the *lateral horn*. A horizontal bar of gray matter surrounds the central canal and connects the wings on both sides. The white matter is divided on each side into three regions, the *anterior*, *lateral*, and *posterior funiculi*.

**278. Describe a reflex arc.**
A **reflex arc** is the simplest response to a stimulus. It begins with a receptor at the end of sensor nerve fibers. It travels to a reflex center in the CNS and an impulse is sent to an effector along a motor nerve fiber.

**279. Define *reflex*.**
A **reflex** is an automatic, subconscious response to stimuli inside or outside the body.

**280. Describe a withdrawal reflex.**
When a person touches something painful, receptors in the skin send impulses to interneurons in a reflex center in the spinal cord. The reflex center sends impulses to the flexor muscles of the affected part causing the part to be moved away. At the same time this is happening, impulses to the extensor muscles of the affected part are inhibited, so that the flexors can work more effectively. A phenomenon, called a crossed extensor reflex, occurs simultaneously with the initial reflex that causes the extensors of the opposite limb to contract.

**281. Name the major ascending and descending tracts of the spinal cord, and list the functions of each.**
The major ascending tracts are:

**Fasiculus gracilis** and **fasiculus cuneatus**—These tracts are found in the posterior funiculi and conduct sensory impulses from the skin, muscles, tendons, and joints. Most of the nerve fibers cross over in the medulla oblongata to their opposite sides.

**Lateral** and **anterior spinothalamic**—These tracts are located in the lateral and anterior funiculi. The lateral tracts conduct pain and temperature sensations from the body. The anterior tract conducts touch and pressure sensations from the body.

**Posterior** and **anterior spinocerebellar**—Both tracts are located near the surface of the lateral funiculi. The anterior tracts cross over in the spinal cord, while the posterior tracts do not. Both tracts conduct impulses from the legs and trunk to the cerebellum and aid in muscle coordination.

The major descending tracts are:

**Lateral** and **anterior corticospinal**—These tracts are found in the lateral and anterior funiculi. Most of the fibers in the lateral tracts cross over in the spinal cord, while the anterior tracts' fibers do not. Both of these tracts conduct impulses through the spinal nerves to various skeletal muscles to control voluntary movements. These tracts are also called pyramidal tracts because they pass through pyramid-shaped regions in the medulla oblongata.

**Lateral**, **anterior**, and **medial reticulospinal**—The lateral tracts are found in the lateral funiculi and the anterior and medial tracts are found in the anterior funiculi. Some of the nerve fibers in the lateral tracts are the only ones that cross over. None of the other tracts do. These tracts conduct impulses that control muscle tone and sweat gland activity.

**Rubrospinal**—These fibers are found in the lateral funiculi and cross over in the brain. These fibers conduct impulses to skeletal muscles to aid in muscle coordination and control posture.

**282. Explain the consequences of nerve fibers crossing over.**
Crossing over causes the impulses from one side of the body to be received and controlled by the opposite side of the brain.

**283. Describe how the brain develops.**
During embryonic development, the brain begins as a neural tube that gives rise to the CNS. At one end there are three major cavities or vesicles: the forebrain (prosencephalon), midbrain (mesencephalon), and hindbrain (rhombencephalon). The forebrain divides into the anterior (telencephalon) and posterior (diencephalon) portions. The hindbrain partially divides into the metencephalon and myelencephalon. These five cavities in the mature brain become the ventricles and the tubes that connect them. The tissue of the telencephalon becomes the cerebrum and basal ganglia while the diencephalon remains unchanged. The midbrain continues to mature and is still called the midbrain in the adult structure. The hindbrain matures into the cerebella, pons, and medulla oblongata. The brain stem is comprised of the midbrain, pons, and medulla oblongata and connects the brain to the spinal cord.

**284. Describe the structure of the cerebrum.**
The **cerebrum** consists of two cerebral hemispheres separated by a layer of dura mater called the falx cerebri and connected deeply by a nerve fiber bundle called the corpus callosum. The hemispheres are marked by many convolutions separated by shallow grooves called sulci (sing. sulcus) and deep grooves called fissures. These grooves form distinct patterns. For instance, the longitudinal fissure separates left and right hemispheres, and the transverse fissure separates the cerebrum from the cerebellum.

Various sulci divide each hemisphere into lobes names after the skull bones they underlie. They are:

**Frontal lobe**—The frontal lobe forms the anterior portion of each cerebral hemisphere, and lies in front of the central sulcus (fissure of Rolando) and above the lateral sulcus (fissure of Sylvius).

**Parietal lobe—**The parietal lobe lies behind the central sulcus and frontal lobe.

**Temporal lobe**—The temporal lobe lies below the frontal and parietal lobes, separated by the lateral sulcus.

**Occipital lobe**—The occipital lobe is the posterior portion of each hemisphere separated from the cerebellum by the tentorium cerebelli. There is no clear boundary between the temporal, parietal, and occipital lobes.

**Insula**—The insula (island of Reil) is found deep in the lateral sulcus and is separated from the frontal, parietal, and temporal lobes by a circular sulcus.

**285. Define *cerebral cortex*.**
The **cerebral cortex** is the outermost layer of the cerebrum and is a layer of gray matter that contains 75 percent of all neuron bodies in the nervous system.

**286. Describe the location and function of the primary motor areas of the cortex.**
The primary motor areas of the cerebral cortex lie in the frontal lobes along the anterior wall of the central gyrus. Large pyramidal cells are responsible for nerve impulses sent through the corticospinal tracts to voluntary muscles. Impulses from the upper parts of the motor areas control muscles in the legs and thighs; the middle portion control muscles in the shoulders and arms; and the lower portions control the muscles of the head, face, and tongue.

**287. Describe the location and function of Broca's area.**
**Broca's area** is found just anterior to the primary motor cortex usually in the left hemisphere. It is responsible for complex muscular coordination of the mouth, tongue, and larynx, which make speech possible.

**288. Describe the location and function of the sensory areas of the cortex.**
The sensory areas for temperature, touch, pressure, and pain in the skin are found in the anterior portion of the parietal lobes along the central sulcus. Vision sensory areas are found in the posterior portion of the occipital lobes. The sensory areas for hearing are found in the dorsal posterior portion of the temporal lobes. The sensory areas for taste are found near the base of the central sulci along the lateral sulci and the sense of smell arises from deep in the cerebrum.

**289. Explain the function of the association areas of the lobes of the cerebrum.**
The association areas are found in the anterior frontal lobes, and in the lateral areas of the parietal, temporal, and occipital lobes. These function to analyze and interpret sensory experiences involving memory, reasoning, verbalizing, judgement, and emotions. The association areas of the frontal lobes deal with concentration, planning, problem solving, and judging the consequences of behavior. The areas of the parietal lobes deal with the understanding speech and word choice for thought expression. The areas of the temporal lobes deal with complex sensory interpretation, such as reading, music, and memories of visual scenes. The areas of the occipital lobes deal with visual pattern analysis and combining these images with other sensory experiences.

**290. Define *hemisphere dominance*.**
Although both hemispheres participate in basic functions, in most people, one hemisphere is dominant over the other. For instance, in over 90 percent of the population, the left hemisphere controls language activities such as reading, speech, and writing as well as complex intellectual functions requiring verbal, analytical, and computational skills. The nondominant hemisphere seems to be more in control of the nonverbal activities such as spacial orientation, interpreting musical patterns, visual experiences, and emotional and intuitive thought.

**291. Explain the function of the corpus callosum.**
The nerve fibers of the **corpus callosum** allow the dominant hemisphere to receive sensory information sent to the nondominant hemisphere for use in decision making by the general interpretive areas. It also allows the dominant hemisphere to control the motor cortex of the nondominant one.

**292. Distinguish between short-term and long-term memory.**
**Short-term memories** are thought to be electrical in nature such that the neurons are connected in a circuit so that the last in the series stimulates the first. As long as the stimulation continues, the thought is remembered. When it ceases, so does the memory, unless it enters long-term memory.

**Long-term memories** appear to change the structure or function of certain neurons that enhance synaptic transmission. The synaptic patterns must meet two requirements of long-term memory. First, there must be enough synapses to encode an almost infinite number of memories. Second, the pattern of synapses can remain unchanged for years.

**293. Describe the location and function of the basal nuclei.**
The **basal ganglia** (basal nuclei) are masses of gray matter found deep in the cerebral hemispheres. They are the caudate nucleus, the putamen, and the globus pallidus and are responsible for producing most of the inhibitory neurotransmitter dopamine. Impulses from the basal ganglia inhibit motor functions, controlling certain muscular activities.

**294. Name the parts of the diencephalon, and describe the general functions of each.**
**Diencephalon**—The diencephalon contains many parts:

**Thalamus**—The thalamus serves as a central relay for sensory impulses ascending from other parts of the body. It receives all impulses except for smell, and routes them to the appropriate areas of the cortex. It also interprets general feelings such as pain, touch, and temperature. The thalamus also transmits sensory information by synchronizing action potentials. In this way, it serves as a messenger and an editor.

**Hypothalamus**—The hypothalamus is interconnected to the cortex and all areas of the brain stem so that it can send and receive impulses to and from these areas. It plays a key role in maintaining homeostasis by regulating visceral activities and serving as a link between the nervous and endocrine system.

**Optic tracts** and **optic chiasma**—These are formed as the optic nerve fibers cross over.

**Infundibulum**—The infundibulum attaches the pituitary gland to the brain stem.

Other parts include the: **posterior pituitary gland, mammillary bodies,** and the **pineal gland**.

**295. Define the limbic system, and explain its functions.**
The **limbic system** controls emotional experience and expression. It produces feelings of fear, anger, pleasure, and sorrow. It apparently recognizes upsets in a person's physical or psychological condition that could be life threatening. By relating pleasant or unpleasant feelings about experiences, it guides behaviors that may increase the chance of survival. It also interprets sensory impulses from the olfactory receptors.

**296. Name the parts of the midbrain, and describe the general functions of each.**
The **midbrain** joins the lower parts of the brain stem and spinal cord with the higher parts of the brain. It also contains certain reflex centers. Two bundles of nerve fibers called the cerebral peduncles lie on the underside of the midbrain and form the corticospinal tracts, which are the main motor pathways between the cerebrum and lower parts of the nervous system. Two pairs of rounded knobs called the corporal quadrigemina provide centers for certain visual reflexes and the auditory reflex centers. In the center of the midbrain is a mass of gray matter called the red nucleus, which provides posture-maintaining reflexes.

**297. Describe the pons and its functions.**
The **pons** is a rounded bulge on the inferior side of the brain stem where it separates the midbrain from the medulla oblongata. The dorsal portion of the pons relays impulses between the medulla oblongata and the cerebrum. The ventral portion relays impulses from the cerebrum to the cerebellum. The pons also relays impulses from the peripheral nerves to higher brain centers. It also works with the medulla oblongata to regulate rate and depth of breathing.

**298. Describe the medulla oblongata and its functions.**
The **medulla oblongata** is an enlarged continuation of the spinal cord at its superior end. It extends from the foramen magnum to the pons. Because of its location, all ascending and descending nerve fibers connecting the brain and the spinal cord must pass through it. Some of the nuclei in the gray matter relay ascending impulses to the other side of the brain stem and higher brain centers. Other nuclei control vital visceral activities and are called the cardiac center, the vasomotor center, and the respiratory center.

**299. Describe the location and function of the reticular formation.**
The **reticular formation** is scattered throughout the medulla oblongata, pons, and midbrain as a complex network of nerve fibers associating with small islands of gray matter. It extends from the superior portion of the spinal cord through to the diencephalon and connects the hypothalamus, basal ganglia, cerebellum, and cerebrum with fibers in all the major ascending and descending tracts.
Because of the cerebral cortex is totally dependent on sensory impulses for its awareness of the external environment, the reticular formation is responsible for activating it into a state of wakefulness. Decreased activity in the reticular formation causes sleep. The reticular formation also filters incoming sensory impulses to prevent the cortex from being constantly bombarded by sensory stimulation, and allows it to concentrate on the significant information. The cerebra cortex can also activate the reticular formation during intense cerebral activities, keeping a person awake.

**300. Distinguish between normal and paradoxical sleep.**
**Normal sleep** (*slow wave or non-REM*) occurs when a person is very tired and is caused by decreased activity of the reticular formation. It is restful, dreamless, and accompanied by reduced blood pressure and respiratory rate. **Paradoxical sleep** (*REM sleep*) is so named because some areas of the brain are active. It is identified by dreaming, rapid eye movement beneath the eyelids, and irregular respiratory and heart rates.

**301. Describe the functions of the cerebellum.**
The main function of the **cerebellum** is to serve as the reflex center for control of body part positions in response to sensory information from various nerve centers. It is the primary area for control of the complex skeletal movements involved in posture and locomotion. To accomplish this, the cerebellum communicates with the body and brain via three pairs of nerve tracts:

*Inferior peduncles*—This pair receives sensory information concerning limb, joint, and other body part positions.

*Middle peduncles*—This pair sends impulses concerning the desired position of these body parts from the cerebrum to the cerebellum.

*Superior peduncles*—This pair sends the newly integrated information through the pons, medulla oblongata, and spinal cord as motor impulses to the skeletal muscles concerned.

Damage to the cerebellum will cause tremors, muscle tone loss, reeling walk, loss of equilibrium, and inaccurate muscle movements.

**302. Distinguish between the somatic and autonomic nervous systems.**
The **somatic nervous system** is a division of the peripheral nervous system (PNS) and consists of cranial and spinal nerves that oversee conscious activities. The **autonomic nervous system** is the other division of the PNS and includes the fibers that connect the central nervous system (CNS) to the viscera. It controls unconscious activities.

**303. Describe the structure of a peripheral nerve.**

A **peripheral nerve** consists of nerve fiber bundles surrounded by connective tissue. Each bundle of nerve fibers (fascicle) is encased in a sleeve of connective tissue called the perineurium, which is in turn, enclosed by dense collagenous fibers called the epineurium. The individual nerve fibers are surrounded by loose connective tissue called the endoneurium within the perineurium.

**304. Distinguish between sensory, motor, and mixed nerves.**
Nerves that carry impulses to the CNS are called **sensory nerves**. Nerves that carry impulses from the CNS to muscles or glands are called **motor nerves**. Nerves that perform both functions are called **mixed nerves**.

**305. List four general types of nerve fibers.**
The four general types of nerve fibers are: **general somatic efferent fibers**, **general somatic afferent fibers**, **general visceral efferent fibers**, and **general visceral afferent fibers**.

**306. Name, locate, and describe the major functions of each pair of cranial nerves.**
**Olfactory nerves (I)**—This pair serves as olfactory receptor nerve fibers that being as olfactory bulbs in the nasal linings. They pass through the cribriform places as olfactory tracts to cerebral centers for interpretation as sensations of smell.

**Optic nerves (II)**—These lead from the eyes to the brain and are associated with the sense of sight.

**Oculomotor nerves (III)**—These arise from the midbrain and pass into the orbits of the eyes. These function to raise the eyelid, innervate muscles that move the eye, and allow the eye to adjust the amount of light entering the eyes and allow the lens to focus.

**Trochlear nerves (IV)**—These arise from the midbrain and carry motor impulses to certain voluntary muscles that move the eyes but are not supplied by the oculomotor nerves.

**Trigeminal nerves (V)**—These are the largest and arise from the pons. These are mixed nerves that have three major branches:

*Opthalmic division*—Bring sensory impulses to the brain from the surface of the eyes, the tear glands, and the skin of the anterior scalp, forehead, and upper eyelids.

*Maxillary division*—Carry sensory impulses from the upper teeth, upper gum, and upper lip, as well as from the mucous lining of the palate and the skin of the face.

*Mandibular division*—Transmits impulses from the scalp behind the ears, the skin of the jaw, the lower teeth, the lower gum, and the lower lip. It has motor branches that supply the muscles of mastication, and certain muscles in the floor of the mouth.

**Abducens nerve (VI)**—These originate from the pons and enter the orbits of the eyes and supply motor impulses to a pair of muscles that move the eyes.

**Facial nerves (VII)**—These arise from the lower part of the pons and emerge on the sides of the face. The sensory branches are associated with taste receptors on the tongue. The motor fibers transmit impulses to the muscles of facial expression while others function in the autonomic nervous system and stimulate secretions from the tear glands and salivary glands.

**Vestibulocochlear nerves (VIII)**—These sensory nerves that arise from the medulla oblongata. There are two distinct parts:

*Vestibular branch*—Located in the ganglia associated with the parts of the inner ear and serve to help to maintain equilibrium.

*Cochlear branch*—Located in parts of the inner ear that house the hearing receptors. Impulses from this branch pass through the pons and medulla oblongata on their way to the temporal lobes for interpretation.

**Glossopharyngeal nerves (IX)**—These arise from the medulla oblongata and are associated with the tongue and pharynx. These are mixed nerves but are predominantly sensory. They carry impulses from the linings of the pharynx, tonsils and posterior third of the tongue to the brain. The motor portion innervates muscles of the pharynx that function in swallowing.

**Vagus nerves (X)**—These originate in the medulla oblongata and extend downward into the chest and abdomen. These are mixed nerves containing both autonomic and somatic branches. The autonomic are the predominate ones, associated with speech, swallowing, and motor activity of the smooth muscles and glands in the thorax and abdomen.

**Accessory nerves (XI)**—These originate in the medulla oblongata and the spinal cord. The cranial branch joins a vagus nerve and carries impulses to muscles of the soft palate, pharynx and larynx.

**Hypoglossal nerves (XII)**—These arise from the medulla oblongata and pass into the tongue. These work on tongue muscles that function in speaking, chewing, and swallowing.

**307. Explain how the spinal nerves are grouped and numbered.**
They are grouped according to the level from which they arise, and each nerve is numbered in sequence. There are eight pairs of *cervical spinal nerves*, twelve pairs of *thoracic spinal nerves*, five pairs of *sacral spinal nerves*, and one pair of *coccygeal nerves*.

**308. Define *cauda equina*.**
The **cauda equina** is so named because in the adult, the spinal cord ends between the first and second lumbar vertebrae. Because of this the lumbar, sacral, and coccygeal nerves must descend down the spinal column to the exit points resembling a horse's tail.

**309. Describe the structure of a spinal nerve.**
Each **spinal nerve** emerges from the spinal cord by two short branches that lie within the vertebral column. The dorsal root is also called the posterior or sensory root. It can be identified by the dorsal root ganglion. This root conducts sensory impulses inward from the peripheral body parts. The ventral root is also called the anterior or motor root. It consists of axons from the motor neurons. The roots unite to form a spinal nerve, which extends outward from the vertebral canal through and intervertebral foramen. Each spinal nerve splits into three parts called the meningeal, posterior, and anterior branches. Spinal nerves in the thoracic and lumbar regions have a fourth or visceral branch, which supplies the autonomic nerve fibers.

**310. Define *plexus*, and locate the major plexuses of the spinal nerves.**

A **plexus** is the main portion of the spinal nerves that have combined to form complex networks. Except in the thoracic region, anterior branches of the spinal nerves provide the network for the plexus. In a plexus, the fibers of various spinal nerves are sorted and recombined so that the fibers associated with a particular peripheral body part reach it in the same nerve, even though the fibers originate from different spinal nerves. There are three main plexuses:

*Cervical plexuses*—Supply the muscles of the skin and neck and the phrenic nerves innervate the diaphragm.

*Brachial plexuses*—Supply the muscles and skin of the arm, forearm, and hand.

*Lumbosacral plexuses*—Give rise to motor and sensory fibers associated with the muscles and skin of the lower abdominal wall, external genitalia, buttocks, thighs, legs, and feet.

**311. Distinguish between the sympathetic and parasympathetic division of the autonomic nervous system.**

The **sympathetic division** of the autonomic nervous system is concerned primarily with preparing the body for energy-expending, stressful, or emergency situations. The **parasympathetic division** is active under ordinary, restful conditions. It counterbalances the effects of the sympathetic division and restores the body to a resting state following a stressful experience.

**312. Explain how autonomic ganglia provide a degree of independence from the central nervous system.**

Sensory impulses from the viscera and skin are sent along afferent nerve fibers to centers in the brain or spinal cord. The CNS reacts by sending motor impulses out of these centers on efferent nerve fibers along spinal and cranial nerves. These efferent fibers join the ganglia outside the CNS and integrate within the ganglia to affect various organs. This integration within the ganglia provides some independence from the CNS by deciding to what degree these organs will respond.

**313. Distinguish between a preganglionic fiber and a postganglionic fiber.**

The **preganglionic fiber** is the axon of the first neuron in the two neuron autonomic system. Its cell body is located in the CNS and forms a synapse with one or more nerve fibers whose cell bodies are housed within an autonomic ganglion. The axon of the second neuron is called the **postganglionic fiber**, because it extends from the ganglia to a visceral effector.

**314. Define *paravertebral ganglion*.**

**Paravertebral ganglia** are two groups of ganglia whose preganglionic fibers split from the spinal nerves of the thoracolumbar division at branches called white rami. They are located as chains along the sides of the vertebral column and comprise part of the sympathetic trunks.

**315. Trace a sympathetic nerve pathway through a ganglion to an effector.**

The pathway begins with the neuron in the lateral horn of the spinal cord. Its preganglionic fiber exits through the ventral roots of spinal nerves. It branches off in segments called white rami and enters the paravertebral ganglia (forming sympathetic trunks). Some fibers synapse with these ganglia while others pass through to other paravertebral ganglia or on to, or beyond, the collateral ganglia. The postganglionic fibers extend out to the visceral effectors. The fibers leaving the paravertebral ganglia usually pass through gray rami and return to a spinal nerve before synapsing with an effector.

**316. Explain why the effects of the sympathetic and parasympathetic autonomic divisions differ.**

This is due to the differing postganglionic neurotransmitters from the sympathetic and parasympathetic ganglionic nerve fibers.

**317. Distinguish between cholinergic and adrenergic nerve fibers.**

With a few exceptions, the preganglionic fibers of both the sympathetic and parasympathetic divisions, and the postganglionic fibers of the parasympathetic division, secrete acetylcholine, and are thus called **cholinergic fibers**. The postganglionic sympathetic fibers secrete norepinephrine (noradrenalin), and are thus called **adrenergic fibers**.

**318. Define *sympathetic tone*.**

**Sympathetic tone** is a maintained state of partial contraction of muscles stimulated by only the sympathetic division.

**319. Explain how autonomic neurotransmitters influence the actions of effector cells.**

**Autonomic transmitters** act by binding to protein receptors of effect cell membranes. This receptor binding alters the membrane in certain ways to produce the desired effect. Muscarinic receptors are found in the membranes of all effector cells at the end of postganglionic parasympathetic and cholinergic sympathetic nerve fibers. Nicotinic receptors are found in the synapses between the pre- and postganglionic neurons of the postganglionic neurons of the sympathetic and parasympathetic pathways.

**320. Distinguish between alpha adrenergic and beta adrenergic receptors.**

**Alpha adrenergic receptors** are responsible for smooth muscle contraction causing vasoconstriction. Stimulation of the **beta receptors**, however, will cause smooth muscle relaxation leading to bronchodilation in the lungs. In essence, stimulation of alpha receptors is constrictive in nature, which stimulation of beta receptors will cause dilation.

**321. Describe three examples in which the central nervous system employs autonomic nerve pathways.**

The central nervous system (CNS) uses the autonomic nervous system to control the cardiac, vasomotor, and respiratory activities in the medulla oblongata by reacting to impulses from the vagus nerve and sending impulses along autonomic nerve pathways to stimulate motor responses in muscles and glands. The hypothalamus helps to regulate body temperature, hunger, thirst, and water and electrolyte balance by influencing autonomic pathways. The limbic system and cerebral cortex use the autonomic nervous system to regulate various behaviors during emotional stress.

## Somatic and Special Senses

322. List five groups of sensory receptors, and name the kind of change to which each is sensitive.

**Chemical concentration** (*chemoreceptors*)—Stimulated by changes in the chemical concentration of substances.
**Tissue damage** (*pain receptors*)—Stimulated by tissue damage.
**Temperature change** (*thermoreceptors*)—Stimulated by changes in temperature.
**Mechanical receptors** (*mechanoreceptors*)—Stimulated by changes in pressure or movement of fluids.
There are three types of mechanoreceptors; they are:
*Proprioceptors*—Send changes in tension of muscles and tendons
*Baroreceptors*—Detect changes in blood pressure
*Stretch receptors*—Sense degree of inflation
**Light intensity** (*photoreceptors*)—Stimulated by light energy.

**323. Explain how sensory receptors stimulate sensory impulses.**
**Sensory receptors** can either be nerve endings or special cells located next to them. Stimulation causes local changes in their membrane potentials and generates a graded electrical current showing the intensity of the stimulation.

**324. Define *sensation.***
A **sensation** is a feeling that occurs when the brain interprets sensory impulses.

**325. Explain the projection of a sensation.**
At the time when a sensation is created, the cerebral cortex causes the feeling to come from the stimulated receptors. It is called **projection** because the brain projects the sensation back to its apparent source.

**326. Define *sensory adaptation*.**
**Sensory adaptation** occurs when sensory receptors are subjected to continuous stimulation. As the receptors adapt, impulses leave them at decreasing rates, until finally these receptors may completely fail to send signals. Once receptors have adapted, impulses can be triggered only if the strength of the stimulus is unchanged.

**327. Explain how somatic senses can be grouped.**
Somatic senses can be divided into three groups:

**Exteroceptive senses**—These senses are associated with changes at the body surface.

**Proprioceptive senses**—These senses are associated with changes in muscle, tendons, and in body positions.

**Visceroceptive senses**—These senses are associated with changes in the viscera.

**328. Describe the functions of free nerve endings, Meissner's corpuscles, and Pacinian corpuscles.**
The **free nerve endings** (*sensory nerve fibers*) are common in epithelial tissue. They are associated with the sensations of touch and pressure.

**Meissner's corpuscles** are common in hairless portions of the skin. These are sensitive to touch.

**Pacinian corpuscles** are common in the deeper subcutaneous tissues and occur in the tendons of the muscles and the ligaments of joints. These are associated with the sensation of deep pressure.

**329. Explain how thermoreceptors function.**
**Thermoreceptors** are actually two types of free nerve endings located in the skin. The receptors responding to heat are called heat receptors. Those, which respond to cooler temperature, are called cold receptors. Heat receptors are most sensitive to temperatures above $25^{o}$ C. Cold receptors are most sensitive to temperatures between $10^{o}$ C and $20^{o}$ C. At intermediate temperatures, the brain interprets sensory input from different combinations of these receptors.

**330. Compare pain receptors with other types of somatic receptors.**
Most pain receptors can react to more than one type of change. In other words, pain receptors may react directly to mechanical damage, chemical changes, by-products of metabolism, ischemia, hypoxia, or stimulation of other receptors such as mechanoreceptor. So, pain receptors are not usually limited to the specific types of stimulation that other somatic receptors are.

**331. List the factors that are likely to stimulate visceral pain receptors.**
Factors that stimulate visceral pain receptors include: widespread stimulation of visceral tissues, stimulation of mechanoreceptors, and decrease blood flow accompanied by lower oxygen concentration and accumulation of pain-stimulating chemicals.

**332. Define *referred p*ain.**
**Referred pain** is a phenomenon that occurs when the pain feels as if it is coming from some part of the body other than the part being stimulated. An example would be pain that originates from the heart may actually be felt in the left shoulder or left arm.

**333. Explain how neuropeptides relieve pain.**
**Neuropeptides** called enkephalins and monoamine serotonin inhibit pain sensations by blocking the impulses from the presynaptic nerve fibers in the spinal cord. Enkephalins suppress both acute and chronic pain impulses much like morphine does. Serotonin stimulates other neurons to release enkephalins. Another group of neuropeptides are the endorphins. They are found in the pituitary gland, hypothalamus, and other regions of the nervous system. These act as pain suppressor with a morphine-like action.

**334. Distinguish between muscle spindles and Golgi tendon organs.**
**Muscle spindles** are found in skeletal muscles near their junctions with tendons. Each spindle contains one or more modified skeletal muscle fibers enclosed in connective muscle tissue. Each fiber has a non-striated region with the end of a sensory nerve fiber wrapped around it. **Golgi tendon organs** are found in the tendons close to their muscle attachment and each is connected to a set of muscle fibers and innervated by a sensory neuron.

**335. Explain how the senses of smell and taste function together to create the flavors of foods.**
Both olfactory and taste receptors are sensitive to chemical sensations. Because of this, we smell the food at the same time we taste it. Often, it is impossible to tell whether the sensation is mostly from the smell of a food or from the actual taste.

**336. Describe the olfactory organ and its function.**
The **olfactory organs** include yellowish-brown masses of olfactory receptor cells and epithelial supporting cells all wrapped by a mucous membrane. They are found in the superior parts of the nasal cavity, superior nasal conchae, and part of the nasal septum. They function to provide the sense of smell.

**337. Trace a nerve impulse from the olfactory receptor to the interpreting centers of the brain.**
An olfactory receptor that has been stimulated causes nerve impulses to be triggered and travel along the axons of the receptor cells that are the fibers of the olfactory nerves. These fibers lead to neurons located in the olfactory bulbs that like on either side of the crista galli of the ethmoid bone. In the olfactory bulbs, the impulses are analyzed and additional impulses are located within the temporal lobes and at the base of the frontal lobes just anterior to the hypothalamus.

**338. Explain how an olfactory code distinguishes odor stimuli.**
Although the mechanism is unknown, certain subsets of receptors may only be stimulated by a certain odor. The brain then will interpret those specific receptors stimulated to a specific odor.

**339. Explain how the salivary glands aid the taste receptors.**
Before the taste of a particular chemical can be detected, the chemical must be dissolved in the watery fluid surrounding the taste buds. This fluid is supplied by the salivary glands.

**340. Name the four primary taste sensations, and describe the patterns in which the taste receptors are roughly distributed on the tongue.**
**Sweet** as produced by table sugar. These receptors are most plentiful near the tip of the tongue.

**Sour** as produced by vinegar. These receptors occur primarily along the margins of the tongue.

**Salty** as produced by table salt. These receptors are most abundant in the tip and the upper front part of the tongue.

**Bitter** as produced by caffeine or quinine. These receptors are located toward the back of the tongue.

**341. Explain why taste sensation is less likely to diminish with age than olfactory sensation.**
This is due to the fact that the taste cells reproduce continually and only function for about three days. Damaged olfactory neurons are not replaced.

**342. Trace the pathway of a taste impulse from the receptor to the cerebral cortex.**
Sensory impulses from the taste receptors located in various regions of the tongue travel on fibers of the facial, glossopharyngeal, and vagus nerves into the medulla oblongata. From there, the impulses ascend to the thalamus and are directed to the gustatory cortex, which is located in the parietal lobe of the cerebrum along a deep portion of the lateral sulcus.

**343. Distinguish among the external, middle, and inner ears.**
The external ear consists of two parts: an outer funnel-like structure, called the auricle or pinna, and S-shaped tube, called the external auditory meatus, which leads into the temporal bone for about 2.5 centimeters.

The middle ear includes an air-filled space in the temporal bone, called the tympanic cavity, tympanic membrane (eardrum), and three small bones called auditory ossicles. These bones are the **malleus** (*hammer*), **incus** (*anvil*), and **stapes** (*stirrup*).

The inner ear consists of a complex system of intercommunicating chambers and tubes called a labyrinth. There are, in fact, two such structures in each ear—the osseous labyrinth and the membranous labyrinth. Perilymph is a fluid that is between the two labyrinths. It also includes three semi-circular canals and cochlea.

**344. Trace the path of a sound vibration from the tympanic membrane to the hearing receptors.**
The sound waves enter the external auditory meatus. Changes of wave pressures cause the eardrum to reproduce the vibrations coming from the sound wave source. Auditory ossicles amplify and transmit the vibrations to the end of the stapes. Movement of the stapes at the oval window transmits vibrations to the perilymph in the scala vestibuli. Vibrations pass through the vestibular membrane and enter the endolymph of the cochlear duct. Different frequencies in the endolymph stimulate different sets of receptor cells.

**345. Describe the functions of the auditory ossicles.**
The bones form a bridge connecting the tympanic membrane to the inner ear. They function to transmit vibrations between these parts.

**346. Describe the tympanic reflex, and explain its importance.**
The **tympanic reflex** consists of two skeletal muscles associated with the middle ear that are controlled involuntarily. The reflex is elicited by long, external sounds causing the bridge of the ossicles to become more rigid, reducing its effectiveness in transmitting vibrations to the inner ear. The tympanic reflex reduces pressure from loud sounds that might otherwise damage the hearing receptors.

**347. Explain the function of the auditory tube.**
The function of the **auditory tube** (*Eustachian tube*) is to maintain equal air pressure on both sides of the tympanic membrane, which is necessary for normal hearing.

**348. Distinguish between the osseous and the membranous labyrinths.**
The **osseous labyrinth** is a bony canal in the temporal bone. The membranous labyrinth is a tube that lies within the osseous labyrinth and has a similar shape.

**349. Describe the cochlea and its function.**
The **cochlea** contains a bony core and a thin bony shelf that winds around the core like the threads of a screw. It functions in hearing by allowing the sound vibrations from the perilymph to travel along the scala vestibuli and pass through the vestibular membrane and into the endolymph of the cochlear duct where they cause movements in the basilar membrane. It then stimulates the organ of Corti, which contains the hearing receptors.

**350. Describe a hearing receptor.**
A **hearing receptor** cell is an epithelial cell. These cells act like a neuron. The cell membrane is polarized when the cell is at rest. Upon stimulation the cell membrane depolarizes and the ion channels open. This makes the membrane more permeable to calcium. The cell releases a neurotransmitter that stimulates the nearby sensory nerve fibers, and they transmit impulses along the cochlear branch of the vestibulocochlear nerve to the auditory cortex of the temporal lobe of the brain.

**351. Explain how a hearing receptor stimulates a sensory neuron.**

The cell releases a neurotransmitter that stimulates the nearby sensory nerve fibers, and they transmit impulses along the cochlear branch of the vestibulocochlear nerve to the auditory cortex of the temporal lobe of the brain.

**352. Trace a nerve impulse from the organ of Corti to the interpreting centers of the cerebrum.**
Once the sound is converted into a nerve impulse at the organ of Corti, it travels along the cochlear branch of the vestibulocochlear nerve to the auditory cortex of the temporal lobe of the brain. On the way, some of the nerve branches cross over, so that impulses from both ears will be interpreted by both sides of the brain.

**353. Describe the organs of static and dynamic equilibrium and their functions.**
The **organs of static equilibrium** are located within the vestibule, a bony chamber between the semicircular canals and cochlea. The membranous labyrinth inside the vestibule consists of two expanded chambers—an utricle and a saccule. The macula is on the anterior wall of the utricle that contains numerous hair cells and supporting cells. These sense the positions of the head and help in maintaining the stability and posture of the head and body when these parts are motionless.

The **organs of dynamic equilibrium** are located within the three semicircular canals. Suspended in the perilymph of the bony portion of each semicircular canal is a membranous canal that ends in a swelling called the ampulla. The sensory organs are located here. These organs are called the crista ampullaris and contain a number of hair cells and supporting cells. These function to detect motion of the head and aid in balancing the head and body when they are moved suddenly.

**354. Explain how the sense of vision helps maintain equilibrium.**
The eyes detect the body's position relative to its surroundings. For this reason, the eyes help the brain maintain equilibrium, especially if the other organs of equilibrium are damaged.

**355. List the visual accessory organs, and describe the functions of each.**
**Eyelids**—protection of the eye

**Lacrimal apparatus**—secretions keep the surface of the eye and the lining of the lids moist and lubricated. An enzyme within the tears functions as an antibacterial agent, reducing the chance of eye infections.

**Extrinsic muscles**—movement of the eye

**356. Name the three layers of the eye wall, and describe the functions of each.**
Outer **fibrous tunic**—serves as the cornea and sclera. The cornea functions as a window to the eye and helps focus entering light rays. The sclera provides protection and serves as an attachment for the extrinsic muscles

Middle **vascular tunic**—includes the choroid coat, which helps to absorb excess light so the inside of the eye is dark; the ciliary body, which forms the ciliary muscles and processes; and the iris, whose smooth muscle control the pupil size.

Inner **nervous tunic**—consists of the retina, which contains the visual receptor cells.

**357. Describe how accommodation is accomplished.**
**Accommodation** results from the suspensory ligaments either relaxing or pulling due to decreased or increased tension from the suspensory muscles. This allows people to see objects either close up or more distant.

**358. Explain how the iris functions.**
The smooth muscle fibers of the **iris** are arranged into two groups, a circular set and a radial set. The circular muscles act as a sphincter to decrease pupil size. The radial muscles contract to increase the diameter of the pupil.

**359. Distinguish between aqueous humor and vitreous humor.**
The **aqueous humor** fills the space between the cornea and lens, helps to nourish these parts, and aids in maintaining the shape of the front of the eye.

The **vitreous humor** fills the posterior cavity, and together with some collagenous fibers, comprises the vitreous body. This supports the internal parts of the eye and helps maintain its shape.

**360. Distinguish between the macula lutea and optic disk.**
The **macula lutea** is a small spot on the retina. In its center is a depression called the fovea centralis, which has the sharpest vision.

The **optic disk** is just medial to the macula lutea and is the area where the optic nerve begins and blood vessels enter and exit. This area has no receptors, and is known as the blind spot of the eye.

**361. Explain how light waves focus on the retina.**
As light enters the eye, it is refracted, or bent, by the cornea and lens and is focused sharply on the retina. The image is projected upside down and reversed from left to right. The visual cortex somehow corrects this when it interprets the images.

**362. Distinguish between rods and cones.**
**Rods** are receptor cells that have long thin projections at their terminal ends. Rods are hundreds of times more sensitive to light than cones. This enables people to see in relatively dim light. Rods produce colorless vision.

**Cones** are receptor cells that have short, blunt projections. Cones allow for increased visual acuity—the sharpness of images perceived. Cones make up the entire fovea centralis. Cones also detect colors of light.

**363. Explain why cone vision is generally more acute than rod vision.**
When the images are being sent from the rods and cones to the brain, the nerve fibers of the rods converge and send all of the images on a single tract. The brain can interpret the images, but cannot tell specifically from which rod a particular part came from. The cones converge their nerve fibers to a much lesser degree. This allows the brain to interpret the images more accurately and sharply.

**364. Describe the function of rhodopsin.**
**Rhodopson** (*visual purple*) is the light-sensitive substance in the rods. Bright light decomposes rhodopsin rapidly so the sensitivity in the rods is greatly reduced. Thus, this pigment allows us to see in dim light.

**365. Explain how the eye adapts to light and dark.**
Light comes in the form of many different wavelengths. The color perceived is an

interpretation of its specific wavelength. The shortest visible wavelengths are perceived as violet. The longest is perceived as red. The cones are designed to be stimulated by one of three different visual pigments. An erythrolabe cone is sensitive to red light waves, a chlorolabe to green light waves, and a cyanolabe to blue light waves. In this way the combinations of light waves entering the eye can be detected by the cones and relayed to the brain.

**366. Describe the relationship between light wavelengths and color vision.**
The wavelength of a particular kind of light determines the color perceived. The cones in the eyes each have a certain pigment that is stimulated by certain wavelengths. Some cones have erythrolabe pigment that is sensitive to red light waves, some have chlorolabe which is sensitive to green, and some have cyanolabe which is sensitive to blue. The combinations of these stimulations gives us color vision.

**367. Define *stereoscopic visio*n.**
**Steropsis** allows a person with binocular vision (using both eyes) to perceive distance, depth, width, and height of an object.

**368. Explain why a person with binocular vision is able to judge distance and depth of close objects more accurately than a one-eyed person.**
This happens because the eyes are separated and see slightly more of one side than the other (the left eye sees more left and the right eye sees more right). The impulses are superimposed in the brain and gives us a three-dimensional view of the object. A person using only one eye cannot see “both sides” of the object at the same time. Thus, the object appears two-dimensional.

**369. Trace a nerve impulse from the retina to the visual cortex.**
The axons of the retinal neurons for the optic nerves. These nerves enter the X-shaped optic chiasma just anterior to the pituitary gland and the fibers from the medial (nasal) half cross over (the lateral or temporal sides do not). For instance, the nerves from the nasal half of the left eye cross over and join the temporal half of the right eye to form the right optic tract. The nasal half of the right eye crosses over and joins the temporal half of the left eye to form the left optic tract. The impulses travel these tracts until just before the thalamus, when some of the nerve fibers branch off and enter the areas that control visual reflexes. The rest enter the thalamus and synapse in the posterior portion (lateral geniculate body) and continue on through the optic radiations into the visual cortex in the occipital lobes.