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| Chapter I: Homeostasis – I |

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| *The Scope of Human Physiology*   * Physiology is the study of how living organisms work. Physiologists are interested in the regulation of body function. * The study of disease states is pathophysiology. |
| *How Is the Body Organized?*   * Cells are the simplest structural units into which a complex multicellular organism can be divided and still retain the functions characteristic of life * Cell differentiation results in the formation of four general categories of specialized cells:   + Muscle cells generate the mechanical activities that produce force and movement   + Neurons initiate and conduct electrical signals   + Epithelial cells form barriers and selectively secrete and absorb ions and organic molecules.   + Connective-tissue cells connect, anchor, and support the structures of the body. * Specialized cells associate with similar cells to form tissues: muscle tissue, nervous tissue, epithelial tissue, and connective tissue * Organs are composed of two or more of the four kinds of tissues arranged in various proportions and patterns. Many organs contain multiple, small, similar functional units. * An organ system is a collection of organs that together perform an overall function |
| *Body Fluid Compartments*   * The body fluids are enclosed in compartments.   + The extracellular fluid is composed of the interstitial fluid (the fluid between cells) and the blood plasma. Of the extracellular fluid, 75%–80% is interstitial fluid, and 20%–25% is plasma.   + Interstitial fluid and plasma have essentially the same composition except that plasma contains a much greater concentration of protein.   + Extracellular fluid differs markedly in composition from the fluid inside cells—the intracellular fluid.   + Approximately one-third of body water is in the extracellular compartment, and two-thirds is intracellular. * The differing compositions of the compartments reflect the activities of the barriers separating them. |
| *Homeostasis: A Defining Feature of Physiology*   * The body’s internal environment is the extracellular fluid. * The function of organ systems is to maintain a stable internal environment—this is called homeostasis. * Numerous variables within the body must be maintained homeostatically. When homeostasis is lost for one variable, it may trigger a series of changes in other variables. |

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| Chapter I: Homeostasis – II |

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| *General Characteristics of Homeostatic Control Systems*   * Homeostasis denotes the stable condition of the internal environment that results from the operation of compensatory homeostatic control systems. * In a negative feedback control system, a change in the variable being regulated brings about responses that tend to push the variable in the direction opposite to the original change. Negative feedback minimizes changes from the set point of the system, leading to stability. * Homeostatic control systems minimize changes in the internal environment but cannot maintain complete constancy. * Feedforward regulation anticipates changes in a regulated variable, improves the speed of the body’s homeostatic responses, and minimizes fluctuations in the level of the variable being regulated |
| *Components of Homeostatic Control Systems*   * The components of a reflex arc are the receptor, afferent pathway, integrating center, efferent pathway, and effector. The pathways may be neural or hormonal. * Local homeostatic responses are also stimulus–response sequences, but they occur only in the area of the stimulus, with neither nerves nor hormones involved. |
| *The Role of Intercellular Chemical Messengers in Homeostasis*   * Intercellular communication is essential to reflexes and local responses and is achieved by neurotransmitters, hormones, and paracrine or autocrine substances. Less common is intercellular communication through either gap junctions or cell-bound messengers. |
| *Processes Related to Homeostasis*   * Acclimatization is an improved ability to respond to an environmental stress. The improvement is induced by prolonged exposure to the stress with no change in genetic endowment. * Biological rhythms provide a feedforward component to homeostatic control systems.   + The rhythms are internally driven by brain pacemakers but are entrained by environmental cues, such as light, which also serve to phase-shift (reset) the rhythms when necessary.   + In the absence of cues, rhythms free-run. * The balance of substances in the body is achieved by matching inputs and outputs. Total-body balance of a substance may be negative, positive, or stable. |
| *General Principles of Physiology*   * Several fundamental, general principles of physiology are important in understanding how the human body functions at all levels of structure, from cells to organ systems. These include, among others, such things as homeostasis, information flow, coordination between the function of different organ systems, and the balance of matter and energy |

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| Chapter I: Homeostasis -Vocabulary |

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| (pathophysiology) (physiology) (basement membrane) (cell differentiation) (cells) (collagen fibers)  (connective tissue) (connective-tissue cells) (elastin fibers) (epithelial cells) (epithelial tissue) (epithelium)  (extracellular matrix) (fibers) (functional units) (muscle cells) (muscle tissue) (nerve) (nervous tissue)  (neuron) (organ systems) (organs) (tissues) (extracellular fluid) (internal environment) (interstitial fluid)  (interstitium) (intracellular fluid) (plasma) (dynamic) (constancy homeostasis) (equilibrium) (feedforward)  (homeostatic control systems) (negative feedback) (positive feedback) (set point) (steady state)  (acquired reflexes) (afferent pathway) (effector) (efferent pathway) (hormone) (integrating center)  (learned reflexes) (local homeostatic responses) (receptor) (reflex) (reflex arc) (stimulus)  (autocrine substances) (endocrine glands) (neurotransmitters) (paracrine substances) (target cells)  (acclimatization) (adaptation) (circadian rhythm) (entrainment) (free-running rhythm) (melatonin)  (negative balance) (pacemaker) (phase-shift) (pineal gland) (pool) (positive balance) (stable balance) |

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| Chapter II: Chemical Composition of the Body – I |

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| *Atoms*   * Atoms are composed of three subatomic particles: positive protons and neutral neutrons, both located in the nucleus, and negative electrons revolving around the nucleus in orbitals contained within electron shells. * The atomic number is the number of protons in an atom, and because atoms (except ions) are electrically neutral, it is also the number of electrons. * The atomic mass of an atom is the ratio of the atom’s mass relative to that of a carbon-12 atom. * One gram atomic mass is the number of grams of an element equal to its atomic mass. One gram atomic mass of any element contains the same number of atoms: 6\*1023. * When an atom gains or loses one or more electrons, it acquires a net electrical charge and becomes an ion |
| *Molecules*   * Molecules are formed by linking atoms together. * A covalent bond forms when two atoms share a pair of electrons. Each type of atom can form a characteristic number of covalent bonds: Hydrogen forms one; oxygen, two; nitrogen, three; and carbon, four. In polar covalent bonds, one atom attracts the bonding electrons more than the other atom of the pair. Nonpolar covalent bonds are between two atoms of similar electronegativities. * Molecules have characteristic shapes that can be altered within limits by the rotation of their atoms around covalent bonds. * The electrical attraction between hydrogen and an oxygen or nitrogen atom in a separate molecule, or between different regions of the same molecule, forms a hydrogen bond. * Molecules may have ionic regions within their structure. VI. Free radicals are atoms or molecules that contain atoms having an unpaired electron in their outer electron orbital. |
| *Solution*   * Water, a polar molecule, is attracted to other water molecules by hydrogen bonds. Water is the solvent in which most of the chemical reactions in the body take place. * Substances dissolved in a liquid are solutes, and the liquid in which they are dissolved is the solvent. * Substances that have polar or ionized groups dissolve in water by being electrically attracted to the polar water molecules. * In water, amphipathic molecules form clusters with the polar regions at the surface and the nonpolar regions in the interior of the cluster. * The molecular weight of a molecule is the sum of the atomic weights of all its atoms. One mole of any substance is its molecular weight in grams and contains 6\*1023 molecules. * Substances that release a hydrogen ion in solution are called acids. Those that accept a hydrogen ion are bases.   + The acidity of a solution is determined by its free hydrogen ion concentration; the greater the hydrogen ion concentration, the greater the acidity.   + The pH of a solution is the negative logarithm of the hydrogen ion concentration. As the acidity of a solution increases, the pH decreases. Acid solutions have a pH less than 7.0, whereas alkaline solutions have a pH greater than 7.0 |

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| Chapter II: Chemical Composition of the Body – II |

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| *Classes of Organic Molecules*   * Carbohydrates are composed of carbon, hydrogen, and oxygen atoms.   + The presence of the polar hydroxyl groups makes carbohydrates soluble in water.   + The most abundant monosaccharide in the body is glucose, which is stored in cells in the form of the polysaccharide glycogen. * Most lipids have many fewer polar and ionized groups than carbohydrates, a characteristic that makes them nearly or completely insoluble in water   + Triglycerides (fats) form when fatty acids are bound to each of the three hydroxyl groups in glycerol.   + Phospholipids contain two fatty acids bound to two of the hydroxyl groups in glycerol, with the third hydroxyl bound to phosphate, which in turn is linked to a small charged or polar compound. The polar and ionized groups at one end of phospholipids make these molecules amphipathic.   + Steroids are composed of four interconnected rings, often containing a few hydroxyl and other groups.   + One fatty acid (arachidonic acid) can be converted to a class of signaling substances called eicosanoids * Proteins, macromolecules composed primarily of carbon, hydrogen, oxygen, and nitrogen, are polymers of 20 different amino acids.   + Amino acids have an amino and a carboxyl group bound to their terminal carbon atom.   + Amino acids are bound together by peptide bonds between the carboxyl group of one amino acid and the amino group of the next.   + The primary structure of a polypeptide chain is determined by   (1) the number of amino acids in sequence  (2) the type of amino acid at each position   * Hydrogen bonds between peptide bonds along a polypeptide force much of the chain into an alpha helix or beta pleated sheet (secondary structure) * Covalent disulfide bonds can form between the sulfhydryl groups of cysteine side chains to hold regions of a polypeptide chain close to each other; together with hydrogen bonds, ionic bonds, hydrophobic interactions, and van der Waals forces, this creates the final conformation of the protein (tertiary structure). * Multimeric proteins have multiple polypeptide chains (quaternary structure). * Nucleic acids are responsible for the storage, expression, and transmission of genetic information   + Deoxyribonucleic acid (DNA) stores genetic information.   + Ribonucleic acid (RNA) is involved in decoding the information in DNA into instructions for linking amino acids together to form proteins.   + Both types of nucleic acids are polymers of nucleotides, each containing a phosphate group; a sugar; and a base of carbon, hydrogen, oxygen, and nitrogen atoms.   + DNA contains the sugar deoxyribose and consists of two chains of nucleotides coiled around each other in a double helix. The chains are held together by hydrogen bonds between purine and pyrimidine bases in the two chains.   + Base pairings in DNA always occur between guanine and cytosine and between adenine and thymine.   + RNA consists of a single chain of nucleotides, containing the sugar ribose and three of the four bases found in DNA. The fourth base in RNA is the pyrimidine uracil rather than thymine. Uracil base-pairs with adenine |

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| Chapter II: Chemical Composition of the Body – III |

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| (anions) (atomic mass) (atomic nucleus) (atomic number) (atoms) (cations) (chemical element)  (electrolytes) (electrons) (gram atomic mass) (ion) (isotopes) (mineral elements) (neutrons) (protons)  (radioisotopes) (trace elements) (amino group) (carboxyl group) (covalent bond) (electronegativity)  (free radical) (hydrogen bond) (hydroxyl group) (ionic bond) (molecule) (nonpolar covalent bonds)  (nonpolar molecules) (polar covalent bonds) (polar molecules) (acidic solutions) (acidity) (acids)  (alkaline solutions) (amphipathic) (base) (concentration) (dehydration) (hydrolysis) (hydrophilic)  (hydrophobic) (mole) (molecular weight) (pH) (solutes) (solution) (solvent) (strong acids) (weak acids)  (adenine) (alpha helix) (amino acids) (amino acid side chain) (beta pleated sheet) (carbohydrates)  (conformation) (cytosine) (deoxyribonucleic acid (DNA)) (deoxyribose) (disaccharides) (fatty acid)  (glucose) (glycerol) (glycogen) (glycoproteins) (guanine) (hexoses) (lipids) (macromolecules)  (monosaccharides) (monounsaturated fatty acid) (mutation) (nucleic acids) (nucleotide) (pentoses)  (peptide bond) (phospholipids) (polymers) (polypeptide) (polysaccharides) (polyunsturated fatty acid)  (primary structure) (protein) (purine) (pyrimidine) (quaternary structure) (ribonucleic acid (RNA)) (ribose)  (saturated fatty acid) (secondary structure) (steroids) (sucrose)(tertiary structure)  (thymine) (trans fatty acids) (triglyceride) (unsaturated fatty acids) (uracil) |

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| Chapter III: Cellular Structure, Protein, and Metabolic Pathway – I |

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| *Cellular Energy Transfer*   * The end products of glycolysis under aerobic conditions are ATP and pyruvate; the end products under anaerobic conditions are ATP and lactate.   a. Carbohydrates are the only major nutrient molecules that can enter the glycolytic pathway, and the enzymes that facilitate this pathway are located in the cytosol.  b. Hydrogen atoms generated by glycolysis are transferred either to NAD1, which then transfers them to pyruvate to form lactate, thereby regenerating the original coenzyme molecule; or to the oxidative-phosphorylation pathway.  c. The formation of ATP in glycolysis occurs by substrate-level phosphorylation, a process in which a phosphate group is transferred from a phosphorylated metabolic intermediate directly to ADP.   * The Krebs cycle catabolizes molecular fragments derived from nutrient molecules and produces carbon dioxide, hydrogen atoms, and ATP. The enzymes that mediate the cycle are located in the mitochondrial matrix.   a. Acetyl coenzyme A, the acetyl portion of which is derived from all three types of nutrient macromolecules, is the major substrate entering the Krebs cycle. Amino acids can also enter at several places in the cycle by being converted to cycle intermediates.  b. During one rotation of the Krebs cycle, two molecules of carbon dioxide are produced, and four pairs of hydrogen atoms are transferred to coenzymes. Substrate-level phosphorylation produces one molecule of GTP, which can be converted to ATP.   * Oxidative phosphorylation forms ATP from ADP and Pi, using the energy released when molecular oxygen ultimately combines with hydrogen atoms to form water.   a. The enzymes for oxidative phosphorylation are located on the inner membranes of mitochondria.  b. Hydrogen atoms derived from glycolysis, the Krebs cycle, and the breakdown of fatty acids are delivered, most bound to coenzymes, to the electron-transport chain. The electron transport chain then regenerates the hydrogen-free forms of the coenzymes NAD1 and FAD by transferring the hydrogens to molecular oxygen to form water.  c. The reactions of the electron-transport chain produce a hydrogen ion gradient across the inner mitochondrial membrane. The flow of hydrogen ions back across the membrane provides the energy for ATP synthesis. |
| *Essential Nutrients*   * Approximately 50 essential nutrients are necessary for health but cannot be synthesized in adequate amounts by the body and must therefore be provided in the diet. * A large intake of water-soluble vitamins leads to their rapid excretion in the urine, whereas a large intake of fat-soluble vitamins leads to their accumulation in adipose tissue and may produce toxic effects. |

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| Chapter III: Cellular Structure, Protein, and Metabolic Pathway – II |

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| *Carbohydrate, Fat, and Protein Metabolism*   * The aerobic catabolism of carbohydrates proceeds through the glycolytic pathway to pyruvate. Pyruvate enters the Krebs cycle and is broken down to carbon dioxide and hydrogens, which are then transferred to coenzymes.   a. About 40% of the chemical energy in glucose can be transferred to ATP under aerobic conditions; the rest is released as heat.  b. Under aerobic conditions, a maximum of 38 molecules of ATP can form from one molecule of glucose: up to 34 from oxidative phosphorylation, two from glycolysis, and two from the Krebs cycle.  c. Under anaerobic conditions, two molecules of ATP can form from one molecule of glucose during glycolysis.   * Carbohydrates are stored as glycogen, primarily in the liver and skeletal muscles.   a. Different enzymes synthesize and break down glycogen. The control of these enzymes regulates the flow of glucose to and from glycogen.  b. In most cells, glucose 6-phosphate is formed by glycogen breakdown and is catabolized to produce ATP. In liver and kidney cells, glucose can be derived from glycogen and released from the cells into the blood.   * New glucose can be synthesized (gluconeogenesis) from some amino acids, lactate, and glycerol via the enzymes that catalyze reversible reactions in the glycolytic pathway. Fatty acids cannot be used to synthesize new glucose. * Fat, stored primarily in adipose tissue, provides about 80% of the stored energy in the body.   a. Fatty acids are broken down, two carbon atoms at a time, in the mitochondrial matrix by beta oxidation to form acetyl coenzyme A and hydrogen atoms, which combine with coenzymes.  b. The acetyl portion of acetyl coenzyme A is catabolized to carbon dioxide in the Krebs cycle, and the hydrogen atoms generated there, plus those generated during beta oxidation, enter the oxidative-phosphorylation pathway to form ATP  c. The amount of ATP formed by the catabolism of 1 g of fat is about 2½ times greater than the amount formed from 1 g of carbohydrate.  d. Fatty acids are synthesized from acetyl coenzyme A by enzymes in the cytosol and are linked to glycerol 3-phosphate, produced from carbohydrates, to form triglycerides by enzymes in the smooth endoplasmic reticulum   * Proteins are broken down to free amino acids by proteases.   a. The removal of amino groups from amino acids leaves keto acids, which can be either catabolized via the Krebs cycle to provide energy for the synthesis of ATP or converted into glucose and fatty acids.  b. Amino groups are removed by  (i) oxidative deamination, which gives rise to ammonia; or by  (ii) transamination, in which the amino group is transferred to a keto acid to form a new amino acid.  c. The ammonia formed from the oxidative deamination of amino acids is converted to urea by enzymes in the liver and then excreted in the urine by the kidneys.   * Some amino acids can be synthesized from keto acids derived from glucose, whereas others cannot be synthesized by the body and must be provided in the diet. |

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| Chapter III: Cellular Structure, Protein, and Metabolic Pathway – Vocabulary |

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| [acetyl coenzyme A (acetyl CoA)] [aerobic] [ATP synthase] [chemiosmosis] [citric acid cycle]  [cytochromes] [electron-transport chain] [glycolysis] [Krebs cycle] [lactate] [oxidative phosphorylation]  [pyruvate] [substrate-level phosphorylation] [tricarboxylic acid cycle] [adipocytes] [adipose tissue]  [beta oxidation] [essential amino acids] [gluconeogenesis] [glycerol] [glycogen] [glycogenolysis]  [keto acid] [negative nitrogen balance] [oxidative deamination] [positive nitrogen balance] [proteases]  [proteolysis] [transamination] [urea] [essential nutrients] [fat-soluble vitamins] [water-soluble vitamins] |

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| Chapter IV: Movement of Molecule across the cell membrane – I |

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| *Diffusion*   * Simple diffusion is the movement of molecules from one location to another by random thermal motion.   a. The net flux between two compartments always proceeds from higher to lower concentrations.  b. Diffusion equilibrium is reached when the concentrations of the diffusing substance in the two compartments become equal.   * The magnitude of the net flux J across a membrane is directly proportional to the concentration difference across the membrane Co-Ci, the surface area of the membrane A, and the membrane permeability coefficient P. * Nonpolar molecules diffuse through the hydrophobic portions of membranes much more rapidly than do polar or ionized molecules because nonpolar molecules can dissolve in the fatty acyl tails in the lipid bilayer. * Ions diffuse across membranes by passing through ion channels formed by integral membrane proteins.   a. The diffusion of ions across a membrane depends on both the concentration gradient and the membrane potential.  b. The flux of ions across a membrane can be altered by opening or closing ion channels. |
| *Mediated-Transport Systems*   * The mediated transport of molecules or ions across a membrane involves binding the transported solute to a transporter protein in the membrane. Changes in the conformation of the transporter move the binding site to the opposite side of the membrane, where the solute dissociates from the protein   a. The binding sites on transporters exhibit chemical specificity, affinity, and saturation.  b. The magnitude of the flux through a mediated-transport system depends on the degree of transporter saturation, the number of transporters in the membrane, and the rate at which the conformational change in the transporter occurs   * Facilitated diffusion is a mediated-transport process that moves molecules from higher to lower concentrations across a membrane by means of a transporter until the two concentrations become equal. Metabolic energy is not required for this process. * Active transport is a mediated-transport process that moves molecules against an electrochemical gradient across a membrane by means of a transporter and an input of energy.   a. Primary active transport uses the phosphorylation of the transporter by ATP to drive the transport process.  b. Secondary active transport uses the binding of ions (often Na+) to the transporter to drive the secondary-transport process.  c. In secondary active transport, the downhill flow of an ion is linked to the uphill movement of a second solute either in the same direction as the ion (cotransport) or in the opposite direction of the ion (countertransport). |

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| Chapter IV: Movement of Molecule across the cell membrane – II | Chapter IV: Movement of Molecule across the cell membrane – II |

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| *Osmosis*   * Water crosses membranes by   (a) diffusing through the lipid bilayer, and  (b) diffusing through protein channels in the membrane.   * Osmosis is the diffusion of water across a membrane from a region of higher water concentration to a region of lower water concentration. The osmolarity—total solute concentration in a solution—determines the water concentration: The higher the osmolarity of a solution, the lower the water concentration. * Osmosis across a membrane that is permeable to water but impermeable to solute leads to an increase in the volume of the compartment on the side that initially had the higher osmolarity, and a decrease in the volume on the side that initially had the lower osmolarity. * Application of sufficient pressure to a solution will prevent the osmotic flow of water into the solution from a compartment of pure water. This pressure is called the osmotic pressure. The greater the osmolarity of a solution, the greater its osmotic pressure. Net water movement occurs from a region of lower osmotic pressure to one of higher osmotic pressure. * The osmolarity of the extracellular fluid is about 300 mOsm. Because water comes to diffusion equilibrium across cell membranes, the intracellular fluid has an osmolarity equal to that of the extracellular fluid.   a. Na+ and Cl- are the major effectively nonpenetrating solutes in the extracellular fluid; K+ and various organic solutes are the major effectively nonpenetrating solutes in the intracellular fluid.  b. Table 4.3 lists the terms used to describe the osmolarity and tonicity of solutions containing different compositions of penetrating and nonpenetrating solutes. |
| *Endocytosis and Exocytosis*   * During endocytosis, regions of the plasma membrane invaginate and pinch off to form vesicles that enclose a small volume of extracellular material.   a. The three classes of endocytosis are  (i) fluid endocytosis,  (ii) phagocytosis, and  (iii) receptor-mediated endocytosis.  b. Most endocytotic vesicles fuse with endosomes, which in turn transfer the vesicle contents to lysosomes for digestion by lysosomal enzymes.  c. Potocytosis is a special type of receptor-mediated endocytosis in which vesicles called caveolae deliver their contents directly to the cytosol.   * Exocytosis, which occurs when intracellular vesicles fuse with the plasma membrane, provides a means of adding components to the plasma membrane and a route by which membrane-impermeable molecules, such as proteins the cell synthesizes, can be released into the extracellular fluid |

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| Chapter IV: Movement of Molecule across the cell membrane – III & Vocabulary |  |

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| *Epithelial Transport*   * Molecules can cross an epithelial layer of cells by two pathways:   (a) through the extracellular spaces between the cells—the paracellular pathway; and  (b) through the cell, across both the apical and basolateral membranes as well as the cell’s cytoplasm— the transcellular pathway.   * In epithelial cells, the permeability and transport characteristics of the apical and basolateral plasma membranes differ, resulting in the ability of cells to actively transport a substance between the fluid on one side of the cell and the fluid on the opposite side. * The active transport of Na+ through an epithelium increases the osmolarity on one side of the cell and decreases it on the other, causing water to move by osmosis in the same direction as the transported Na+. |

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| [channel gating] [diffusion equilibrium] [electrochemical gradient] [Fick’s first law of diffusion] [flux]  [ion channels] [ligand-gated ion channels] [mechanically gated ion channels] [membrane potential]  [net flux] [simple diffusion] [voltage-gated ion channels] [active transport] [cotransport] [countertransport]  [facilitated diffusion] [mediated transport] [Na+/K+s-ATPase pump] [primary active transport]  [secondary active transport] [transporters] [aquaporins] [hyperosmotic] [hypertonic] [hypoosmotic]  [hypotonic] [isoosmotic] [isotonic] [nonpenetrating solutes] [osmol] [osmolarity] [osmosis]  [osmotic pressure] [semipermeable membrane] [caveolae] [clathrin] [clathrin-coated pit] [endocytosis]  [exocytosis] [fluid endocytosis] [phagocytosis] [phagosomes] [pinocytosis]  [potocytosis] [receptor-mediated endocytosis] [receptors] [apical membrane]  [basolateral membrane] [paracellular pathway] [transcellular pathway] |

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| Chapter V: Cell Signaling in Physiology |

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| *Receptors*   * Receptors for chemical messengers are proteins or glycoproteins located either inside the cell or, much more commonly, in the plasma membrane. The binding of a messenger by a receptor manifests specificity, saturation, and competition. * Receptors are subject to physiological regulation by their own messengers. This includes down- and up-regulation. * Different cell types express different types of receptors; even a single cell may express multiple receptor types. |
| *Signal Transduction Pathways*   * Binding a chemical messenger activates a receptor, and this initiates one or more signal transduction pathways leading to the cell’s response. * Lipid-soluble messengers bind to receptors inside the target cell. The activated receptor acts in the nucleus as a transcription factor to alter the rate of transcription of specific genes, resulting in a change in the concentration or secretion of the proteins the genes encode. * Water-soluble messengers bind to receptors on the plasma membrane. The pathways induced by activation of the receptor often involve second messengers and protein kinases.   a. The receptor may be a ligand-gated ion channel. The channel opens, resulting in an electrical signal in the membrane and, when Ca2+ channels are involved, an increase in the cytosolic Ca2+ concentration.  b. The receptor may itself be an enzyme. With one exception, the enzyme activity is that of a protein kinase, usually a tyrosine kinase. The exception is the receptor that functions as a guanylyl cyclase to generate cyclic GMP.  c. The receptor may activate a cytosolic janus kinase associated with it.  d. The receptor may interact with an associated plasma membrane G protein, which in turn interacts with plasma membrane effector proteins—ion channels or enzymes.   * The membrane effector enzyme adenylyl cyclase catalyzes the conversion of cytosolic ATP to cyclic AMP. Cyclic AMP acts as a second messenger to activate intracellular cAMP-dependent protein kinase, which phosphorylates proteins that mediate the cell’s ultimate responses to the first messenger. * The plasma membrane enzyme phospholipase C catalyzes the formation of diacylglycerol (DAG) and inositol trisphosphate (IP3). DAG activates protein kinase C, and IP3 acts as a second messenger to release Ca2+ from the endoplasmic reticulum. * The calcium ion is one of the most widespread second messengers.   a. An activated receptor can increase cytosolic Ca2+ concentration by causing certain Ca2+ channels in the plasma membrane and/or endoplasmic reticulum to open.  b. Ca2+ binds to one of several intracellular proteins, most often calmodulin. Calcium-activated calmodulin activates or inhibits many proteins, including calmodulin-dependent protein kinases.   * The signal transduction pathways triggered by activated plasma membrane receptors may influence genetic expression by activating transcription factors. * Eicosanoids are derived from arachidonic acid, which is released from phospholipids in the plasma membrane. They exert widespread intracellular and extracellular effects on cell activity. * Cessation of receptor activity occurs when the first-messenger molecule concentration decreases or when the receptor is chemically altered or internalized, in the case of plasma membrane receptors |

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| Chapter V: Cell Signaling in Physiology – Vocabulary |  |

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| [affinity] [agonists] [antagonist] [competition] [down-regulation] [internalization] [receptors] [saturation] [signal transduction] [specificity] [up-regulation] [adenylyl cyclase] [calmodulin]  [calmodulin-dependent protein ] [kinases] [cAMP-dependent protein kinase] [cAMP phosphodiesterase]  [cGMP-dependent protein kinase] [cyclic AMP (cAMP)] [cyclic endoperoxides] [cyclic GMP (cGMP)] [cyclooxygenase (COX)] [diacylglycerol (DAG)] [eicosanoids] [first messengers]  [G-protein-coupled receptors] [G proteins] [guanylyl cyclase] [inositol trisphosphate (IP3)]  [janus kinases (JAKs)] [leukotrienes] [lipoxygenase] [nuclear receptors] [phospholipase A2]  [phospholipase C] [prostaglandins] [protein kinase] [protein kinase C] [receptor activation]  [receptor tyrosine kinases] [second messengers] [signal transduction pathways] [thromboxanes] |

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| Chapter VI: Neuronal Signaling and the Structure of the Nervous System |

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| *Structure and Maintenance of Neurons*   * The nervous system is divided into two parts. The central nervous system (CNS) consists of the brain and spinal cord, and the PNS consists of nerves outside of the CNS. * The basic unit of the nervous system is the nerve cell, or neuron. * The cell body and dendrites receive information from other neurons. * The axon (nerve fiber), which may be covered with sections of myelin separated by nodes of Ranvier, transmits information to other neurons or effector cells. |
| Functional Classes of Neurons   * Neurons are classified in three ways:   a. Afferent neurons transmit information into the CNS from receptors at their peripheral endings.  b. Efferent neurons transmit information out of the CNS to effector cells.  c. Interneurons lie entirely within the CNS and form circuits with other interneurons or connect afferent and efferent neurons.   * Neurotransmitters, which are released by a presynaptic neuron and combine with protein receptors on a postsynaptic neuron, transmit information across a synapse. |
| *Glial Cells*   * The CNS also contains glial cells, which help regulate the extracellular fluid composition, sustain the neurons metabolically, form myelin and the blood–brain barrier, serve as guides for developing neurons, provide immune functions, and regulate cerebrospinal fluid. |
| *Neural Growth and Regeneration*   * Neurons develop from stem cells, migrate to their final locations, and send out processes to their target cells. * Cell division to form new neurons and the plasticity to remodel after injury markedly decrease between birth and adulthood. * After degeneration of a severed axon, damaged peripheral neurons may regrow the axon to their target organ. Functional regeneration of severed CNS axons does not usually occur |

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| Chapter VI: Neuronal Signaling and the Structure of the Nervous System - Vocabulary |

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| [central nervous system (CNS)] [glial cells] [neuron] [neurotransmitters] [peripheral nervous system (PNS)]  [anterograde] [axon] [axonal transport] [axon terminal] [cell body] [collaterals] [dendrites]  [dendritic spines] [dyneins] [initial segment] [kinesins] [myelin] [nerve fiber] [nodes of Ranvier]  [oligodendrocytes] [retrograde] [Schwann cells] [varicosities] [afferent neurons] [efferent neurons]  [interneurons] [nerves] [postsynaptic neuron] [presynaptic neuron] [sensory receptors]  [synapse] [astrocyte] [blood–brain barrier] [ependymal cells] [microglia] [growth cone plasticity] |