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The Definitions and Explanations of the 14 Core Concepts of Physiology

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Term	Definition	Example
Cell-Cell Communication	In a living organism, cells must pass information to one another to coordinate their activities.	Cells communicate with one another using different mechanisms: • generation and transport of endocrine signals, • generation and transmission of neural (electrical) signals, and • cell-cell contact.
Cell Membrane	Cell plasma membranes are complex structures that determine what, and how, substances enter or leave the cell. Cell membranes also play an important role in generating and receiving signals from each other.	Every cell has a membrane separating the constituents of the cell from the extracellular compartment, and in general, from other cells. Every physiological phenomenon (function) ultimately depends on the behavior of cells and their membranes.
Cell Theory	All cells arise from other cells and thus, have the same DNA as their parent cell. All cells making up the organism have the same DNA. Cells have many functions in common, but cells also have many specialized functions that are required by the organism.	Cell theory is one of the oldest concepts in modern biology. Although physiology students are introduced to this concept in other biology courses, it has physiological implications that may not be obvious to students.
Energy	The maintenance of the life of the organism requires the constant expenditure of energy. The acquisition, transformation and transportation of energy are essential functions of the body.	Ingestion of food, digestion and the generation of ATP—the energy source for most biological processes—are steps in the process of providing every cell with the energy needed to function and survive. Students are introduced to this concept in other biology and science courses and should be able to apply it to physiological processes.

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Evolution	Evolution is genetic change within a population over time. Three mechanisms drive this change: variation (gene mutation), inheritance and selection.	Living organisms share a common ancestor and the process of evolution has resulted in the present-day variety of species. The mechanisms of evolution act at many levels of organization and result in adaptive changes that have produced the extant relationships between biological structure and physiological function. This concept is often not addressed in physiology courses. However, students are introduced to the concept of evolution in other biology courses.
Flow Down Gradients	The transport of “stuff” (ions, molecules, fluids and gas) is a central process at all levels of organization in the organism, and a simple model describes such transport.	Ions or other solutes crossing a cell membrane, blood flowing in blood vessels, gas flowing in airways and chyme moving down the gastrointestinal tract are all processes that result from the interaction of an energy gradient and the resistance to flow that is present. It is likely that students have encountered this concept in previous science courses, but they may need help transferring that understanding to physiology. This core concept does not incorporate active transport mechanisms.
Genes to Proteins	The genes (DNA) of every organism code for and contain information needed for the synthesis of proteins (enzymes and structural proteins). The genes that are expressed in a cell determine the structure and functions of that cell.	This is the central dogma of molecular biology. It explains the development of the individual organism from a fertilized ovum and changes that occur in the function and structure of organisms throughout life. Students are introduced to the central dogma in other biology courses. Although this concept may not be addressed explicitly in many physiology courses, students should be able to apply it in the context of physiology.
Homeostasis	The internal environment of the organism is actively maintained more or less constant by the function of cells, tissues and organs organized into negative feedback systems.	The role of negative feedback in regulating the functions of the body is a particularly powerful core concept because it describes so much of organ system physiology. We have limited this core concept to a description of negative feedback systems, although we recognize that a number of other kinds of control mechanisms contribute to determining system function.

Term	Definition	Example
Levels of Organization	Understanding physiological functions requires understanding the behavior of entities at every level of organization in the organism, from the molecules to organ systems, and on to society and the environment.	To understand physiological phenomena and solve problems in physiology, it is necessary to determine the organizational level(s) at which an answer is to be found. Students need frequent opportunities to apply this core concept in all physiological contexts.
Mass Balance	The contents of any system, or compartment in a system, is determined by the inputs to and the outputs from that system or compartment. This simple general model of "rates-in" and "rates-out" applies to all physical systems.	Mass (or matter) can be liquid (e.g., water, blood), gas (e.g., oxygen, carbon dioxide), solute within a liquid medium (e.g., ions, glucose, hormones) or solid (e.g., CaPO4 in bone). The region of interest may be considered a compartment with potentially multiple entry and exit paths. The quantity of mass within a compartment depends on the initial quantity of mass in the compartment, the rate of entry of mass into the compartment and the rate of exit of mass from the compartment.
Physical Properties of Matter	Living organisms are physical systems and are explainable by the application of the laws of physics and chemistry. Living organisms are causal mechanisms (machines) whose functions are explainable by a description of the cause-and-effect relationships that are present.	In this core concept, we attempt to capture the idea that the functions of the body arise from the interaction of atoms, ions and molecules, as described by the laws of chemistry and physics. A consideration of the physical properties of biological systems (elasticity, capacitance, viscosity, etc.) is necessary to understand physiological phenomena. Thus, an "explanation" for a physiological phenomenon or mechanism must include a set of statements outlining the cause-and-effect (causal) relationships between entities.
Scientific Reasoning	Physiology is a science. Our understanding of the functions of the body arises from the application of the process of science, including the scientific method; thus, our understanding is always tentative. It is scientific reasoning using inference, information literacy, observations, study design, data analysis and interpretation, that has generated the information that fills our textbooks. To fully understand physiology, one must understand how the results were generated and how future results will be generated.	Students are introduced to this core concept in other science courses. If this concept is a part of a physiology course or curriculum, it is usually taught as a discrete topic to be mastered by the students. However, scientific reasoning should be explicitly addressed in all physiology courses.

Term	Definition	Example
Structure ⟷ Function	Structure and function, from the molecular to the organ system level, are intrinsically related to each other. The functions of molecules, cells, tissues, or organs are determined by their form (structure), and function can alter structure. The use of the ⟷ connecting symbol is intended to indicate the bidirectionality of the relationship between structure and function.	This core concept is commonly used in two different ways: large-scale and molecular. Diffusion between body compartments is maximized when the surface area available is large and the diffusion distance is small. This structure ⟷ function relationship is an important feature of many physiological phenomena. This is only one of many macro-scale phenomena where anatomical structure facilitates physiological function of a system. However, on a molecular scale, the structure of proteins, such as hemoglobin and enzymes, determine their function. Changes in those structures alters their function in important ways. Thus, an understanding of a physiological mechanism requires some understanding of the structures that are involved. Understanding of structure requires understanding the function that those structures enable.
Systems Integration	Organ systems work together. Understanding the functions of the organism require a consideration of how multiple entities (cell, tissues, organs and organ systems) interact with one another to sustain the life of the organism.	Physiology is typically studied and taught one organ system at a time. It is particularly important that students be given opportunities to address physiological phenomena and solve problems that require them to apply their knowledge of several systems at the same time.