Chapter 1

Introductory Chapter: Homeostasis

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1. Introduction

The human body is composed of several systems and organs, consisting of millions of cells that need relatively stable conditions to function and contribute to the survival of the body as a whole. The maintenance of stable conditions for the cells against the variations of the external environment is an essential function of the body and configures the homeostasis.

In 1870, Claude Bernard described the basic principles of physiological regulation, evidencing the body's need to maintain a stable internal environment. This allows life processes to function optimally during periods of environmental fluctuations and disturbances, and to this end, an array of reflexes and regulatory systems that allow the body to thrive and reproduce despite environmental challenges [1]. Later, Cannon [2] coined the term homeostasis to describe the collective activity of bodily systems that monitor and protect vital life parameters against harmful detours. Many of these processes are unnoticed at the conscious level and depend on behavioral, autonomous, endocrine responses among others to prevent the everyday challenges of the internal environment. Cannon defined homeostasis as "a condition that may vary but remains relatively constant." This balance is guaranteed thanks to the physiological processes that act in a coordinated way in the body and that prevent the changes in the environment interfere in its functioning. Factors such as pH, temperature, plasma osmolality, glucose and calcium are critical for the normal functioning of most organisms and therefore are controlled within narrow limits [3].

The importance of these factors is due to its universal biochemical effects. Temperature and pH may alter the spatial conformation of the structure and function of enzymes and functional RNAs; temperature and plasma osmolality are important in the integrity and function of the membranes; glucose is a key currency for moving and storing energy; and calcium plays key roles in muscle physiology and multiple signaling pathways. The variation of these factors constitutes a noise that affects all physiological systems, including the homeostatic systems themselves. Since the noise is global (affects all other physiological components in other homeostatic systems), cells cannot filter it or develop private channels to avoid it; instead, the options are to send redundant signals, minimize the spatial and temporal proximity between the transmitter and the receiver, or minimize the variation in the noise-inducing factors. Of all these events, minimizing noise is a key factor that drives the evolution of homeostasis [4].

Until the last decades, homeostasis was considered as a reaction to continuous disturbances in vital systems through negative feedback responses. According to Langley [5], homeostasis is a self-regulating negative feedback system that keeps the internal environment constant. Current views on the subject assume that negative feedback systems that are not activated until a disturbance of the regulated variable occurs may be inefficient and fail in its regulatory role. Negative feedback was the first underlying process used to explain how homeostasis works. This was a reactive strategy through which the perturbation of a regulated variable far from its optimal value was detected and, consequently, provoked corrective responses that served to return the variable back to the pre-disturbance levels. For example, a sudden drop in oxygen content in the blood is detected by sensors that are synaptically linked to areas of the brain that control respiratory rate, and respiration and oxygen in the blood are consequently increased. Although negative feedback is certainly an essential component of regulation, based on past experience, organisms learn to prepare early responses to impending disruption, thereby reducing their impact [4].

A fundamental principle of homeostatic regulation is that the answers work in a coordinated way to defend the body parameters critical to the well-being of an animal; that is, that homeostatic regulation is purposeful. Strategies that may appear to be anticipatory use the initial sensory information in an area of the body as the signal of an event that could potentially disrupt a critical regulated variable, activating corrective effectors and preventing the critical variable from being disturbed. For example, when entering a cold environment, skin temperature sensors are activated before there is any change in core temperature (the variable that is presumably homeostatically regulated); and an effect of increased activity of skin thermometers is to trigger a thermopreflection reflex cycle that induces increased metabolic rate or peripheral vasoconstriction that can stabilize central temperature [6].

If the body cannot maintain the homeostasis of the critical variables, normal function is interrupted and a state, or pathological condition, can develop. Diseases are characterized in two general groups according to their origin: those in which the problem arises from an internal insufficiency or failure of some normal physiological process, and those that originate from some external source. The critical patient develops a condition where the loss of organic homeostasis puts him at immediate risk of death. Therapeutic priorities are focused on correcting these imbalances, such as hemodynamic stabilization, restoration and maintenance of blood volume, stabilization of ventilation conditions and correction of other abnormalities such as electrolyte imbalance, metabolic changes and pain control. Thus, medicine can intervene to restore balance through the activation of self-regulating mechanisms, restoration of the pathways that are altered during the disease process and, finally, to achieve homeostasis in critical patients.

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