

# Stress and the Body: How Does the Body Respond to Stressful Challenges

## Learning Outcomes

- Define and explain Homeostasis
- Compare the different levels of regulation in the maintenance of homeostasis
- Explain how set point operates in normal homeostasis and in adaptive homeostasis and the role of feedback mechanisms in maintaining homeostasis
- Explain the difference between stressor and stress response
- Summarise the three different types of stress response, and provide examples of the responses
- Explain the difference between autonomic and automatic responses
- Describe the importance of time course in the adaptive response

## Homeostasis

### Definition of Physiology

Physiology is derived from the ancient Greek words "physikos" meaning nature or origin, and "logia" meaning study. It is the scientific study of the functions and mechanisms in living systems. In simple terms, physiology is about understanding how living organisms work together, often described as the "life logic." It explores the processes that sustain life and how various systems coordinate to maintain normal functioning.

### Importance of Terms and Definitions in Science

Grasping key terms and their precise definitions is crucial in science, especially in physiology, to ensure clear communication and understanding of complex concepts. Accurate terminology helps in understanding how biological systems operate and adapt.

### Understanding Homeostasis

Homeostasis is a fundamental concept in physiology that refers to the body's ability to maintain a stable internal environment despite external changes. The term was first coined by Walter Cannon in the 1930s, a prominent figure in physiology often called the father of experimental physiology. Cannon derived the term from Greek roots "homoios" meaning similar, and "stasis" meaning standing still, emphasizing the idea of maintaining stability.

## **Historical Background and Origin of the Term**

Walter Cannon's interest in homeostasis was influenced by the work of Claude Bernard, a French physiologist who introduced the concept of the "milieu intérieur," meaning a stable internal environment. Bernard emphasized that despite external fluctuations, internal conditions remain relatively constant, which is vital for survival.

## **What Homeostasis Is and Is Not**

Homeostasis does not imply that conditions are unchanging or stagnant. Instead, it involves dynamic processes that constantly adjust to maintain a set of optimal conditions. Physiology is inherently about change and adaptation, and homeostasis is a mechanism that ensures internal stability through these adjustments.

## **Key Aspects of Homeostasis**

- Maintains normal conditions or setpoints for various physiological parameters.
- Is a self-regulating process involving coordinated responses to environmental changes.
- Allows organisms to adapt to external challenges while preserving internal stability.

## **Analogy of Homeostasis: The Steam Train**

To understand homeostasis, consider a steam train. The train's smooth operation depends not just on the driver but also on various supporting systems. These include maintaining adequate water levels, sufficient coal supply, proper fire temperature, and functioning mechanical parts. Each system must be checked and maintained to keep the train running efficiently. Similarly in living organisms, multiple systems work together, constantly adjusting to keep internal conditions within optimal ranges.

## **Complexity and Coordination in Physiology**

Just like the steam train requires a team of engineers and systems working in harmony, the physiology of living organisms involves complex, coordinated responses. These responses ensure that despite external changes, internal conditions as temperature, pH, and fluid balance remain within a certain range.

# Regulatory Systems

## Introduction to Regulatory Systems

Regulatory systems are essential mechanisms that maintain homeostasis, ensuring the body's internal environment remains balanced despite external and internal challenges. These systems involve complex feedback and feedforward processes that operate at multiple organizational levels, from cellular to systemic and even higher cognitive functions. Proper regulation allows for normal functioning and adaptation, while failure to maintain this balance can lead to pathology and dysfunction.

- **Adaptation:** shifts from 'set point' but function is maintained
- **Pathology:** sustained upset in 'balance' resulting in dysfunction

## Feedback and Feedforward Systems

Feedback systems are the primary focus, involving a loop where a change in a variable triggers a response to restore it to its set point. Feedforward systems, which will be discussed later with specific examples, anticipate changes to adjust responses proactively. Feedback mechanisms are fundamental in maintaining stability across various physiological processes.

## Components of a Feedback System

A typical feedback system includes several key components:

- **Challenge or Stimulus:** External or internal factors that disturb the variable.
- **Variable:** The physiological parameter that is being regulated.
- **Sensor:** Detects changes in the variable.
- **Integrator or Comparator:** Compares the current value to the set point.
- **Effector:** Executes responses to correct deviations.

## Levels of Regulation in Organisms

Regulatory mechanisms operate at multiple levels:

1. **Cellular level:** Regulation of biochemical pathways within cells.
2. **Organ and tissue level:** Control of organ functions affecting systemic variables.
3. **System level:** Integration of multiple organs and systems to maintain overall balance.
4. **Central nervous system and higher cognitive functions:** Influence behavior and decision-making, impacting regulation indirectly.

External environmental factors can influence all these levels, creating a dynamic and interconnected regulatory network.

## **Example: Glucose Regulation During Eating**

When food is ingested, digestion begins, leading to absorption of nutrients like glucose. This increase in blood glucose acts as a stimulus, triggering pancreatic beta cells to release insulin. Insulin promotes glucose uptake by cells, especially muscle cells, reducing plasma glucose levels back toward the set point.

Digestion and absorption involve feedback mechanisms that regulate the rate of digestion and glucose entry into the bloodstream. The process is complex, involving cellular regulation within muscle cells, including the activity of like glucokinase, which phosphorylates glucose, and the regulation of glucose transporters.

## **Cellular Regulation of Glucose Uptake**

Within muscle cells, glucose uptake is controlled by several factors:

- Presence of insulin, which translocates glucose transporters to the cell membrane.
- Blood flow or perfusion to the tissue, affecting glucose delivery
- Glucose concentration gradient between blood and cells.
- Intracellular regulation, such as phosphorylation by glucokinase, which is itself regulated by glucose-6-phosphate levels.

High levels of glucose-6-phosphate inhibit further phosphorylation, slowing glucose entry and metabolism, exemplifying cellular feedback regulation.

## **Role of the Brain and Behavior in Regulation**

The brain plays a crucial role in regulating food intake and energy balance. Hormonal signals like insulin and sensors in the digestive tract send information to the hypothalamus, which influences appetite and energy expenditure. The limbic system, including reward pathways, also contributes to the pleasurable aspect of eating, affecting behavior and food choices.

This multi-layered regulation involves both physiological signals and behavioral responses, demonstrating the integration of cellular, systemic, and cognitive regulation in maintaining homeostasis.

## **Maintaining Homeostasis: Set Points and Feedback**

Regulatory systems rely on the concept of a set point—a target value for a physiological parameter. The integrator compares the current value to this set point, activating feedback mechanisms when deviations occur. These mechanisms work within an acceptable range, allowing for natural fluctuations but correcting when parameters go outside this range.

For example, blood pressure is maintained within a range through feedback involving the sympathetic and parasympathetic nervous systems. When blood pressure rises above the