Chapter 1 – Communication, Control, and Homeostasis

Objectives

Given the synopsis in this chapter, competence in each objective will be demonstrated by responding to multiple choice, matching, put-in-order, or fill-in questions, at the level of 85% or greater proficiency for each student.

A. To explain the concept of communication among organ systems, including the hierarchy of communication among molecules, cells, tissues and organs.
B. To explain the concept of homeostasis, including internal condition, receptors, set point, controller, effectors, responses, and feedback.

Communication

The various organ systems of the body must communicate and function together, as shown in Figure 1-1. The nervous system (brain, spinal cord and nerves) and endocrine system (glands and hormones) are central to the integrative functioning of the body. In addition, each organ system is composed of separate organs; each organ is composed of various tissues; and each tissue is composed of innumerable cells. Furthermore, each cell contains cellular organelles and other cellular components that must communicate and function together in an orchestrated manner to carry out chemical reactions and other cellular functions.

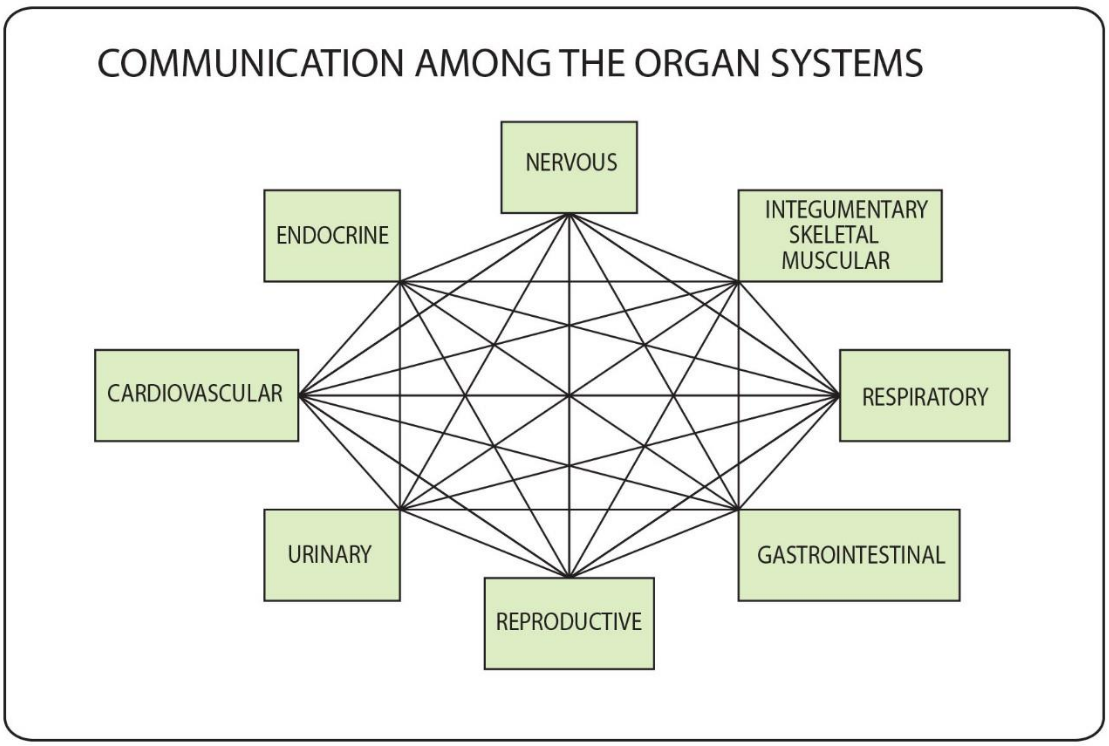

Figure 1-1 © 2014 David G. Ward, PhD

- The control of cellular and bodily functions requires cellular signaling, the passing of information from one cell to another.

Homeostatic Regulatory Systems

In order for the body to function properly, the activities of cells, tissues, and organs and the outcomes of those activities must be monitored and tightly controlled within acceptable ranges.

- The **outcomes** of those activities will hereafter be called **internal conditions**.

Internal conditions include, for example, the concentrations of water, proteins, glucose, sodium, chloride, potassium in extracellular and intracellular fluids. Internal conditions also include the rate of delivery of blood and oxygen to cells and the level of metabolic activity in the body. As a matter of fact, the outcomes of almost all activities in the body can be viewed as internal conditions that are controlled by homeostatic regulatory systems.

Homeostatic regulatory systems **measure** (monitor) internal conditions by way of **receptors**, **assess** the status of the internal condition by way of a **controller**, and **activate responses** by way of effectors to maintain internal conditions within acceptable ranges.

The organization of a generic homeostatic regulatory system is shown in Figure 1-2.

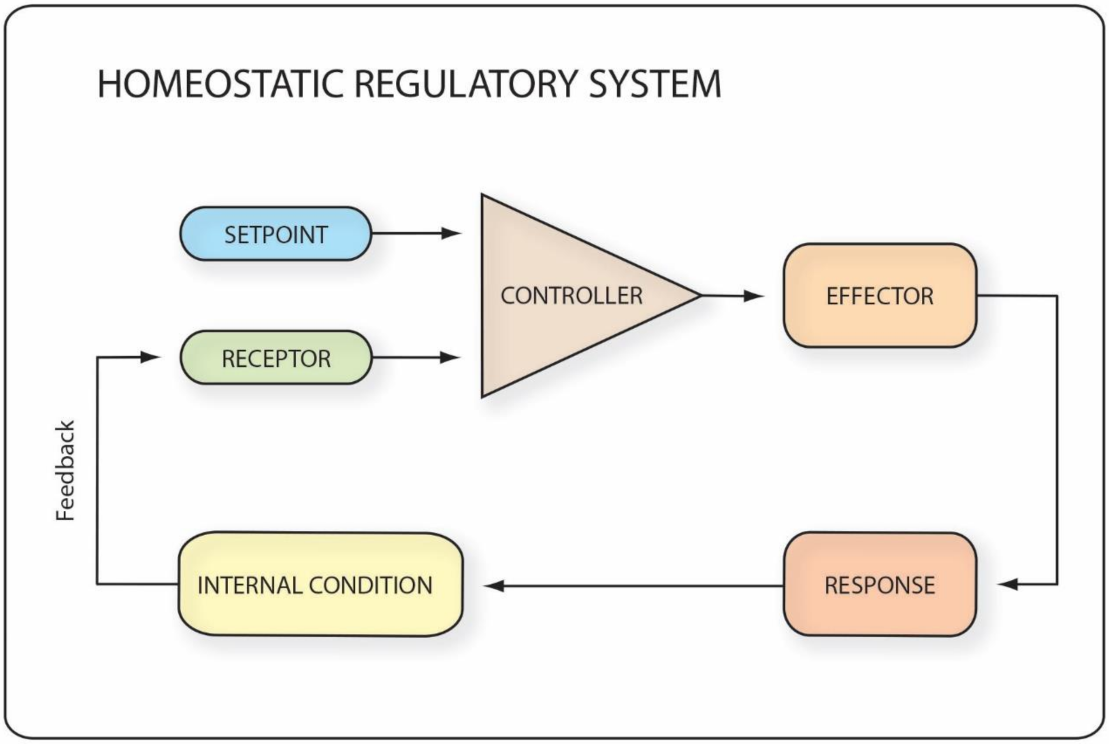

Figure 1-2 © 2016 David G. Ward, PhD

- **Internal Condition** – the outcome to be maintained within a particular range
- **Receptor** – measures the internal condition
- **Set Point** – the desired range for the internal condition
- **Controller** – assesses the difference between the measured value of the internal condition and the desired range; and controls effectors
- **Effector** – produces responses
- **Response** – changes the internal condition (outcome)

Negative feedback: Example of regulation of body temperature

Typically, a regulatory system will utilize **Negative Feedback**.

- An *increase* in an internal condition will stimulate a response that *decreases* (-) the internal condition in order to *normalize* it.
- A *decrease* in an internal condition will stimulate a response that *increases* (+) the internal condition in order to *normalize* it.

For example, if body temperature is high, then a response is produced that lowers body temperature. In this case sweating and blood flow to the skin both increase to remove heat from the body. A system for regulation of body temperature is shown in Figure 1-3.

- Internal Condition – the body temperature
- Receptors – thermoreceptors in the nervous system
- Set Point – the desired body temperature
- Controller – hypothalamus of the central nervous system
- Effectors – blood vessels and sweat glands
- Responses when body temperature is too high
    - Increased blood flow to skin and increased sweating
    - Therefore, body temperature decreases

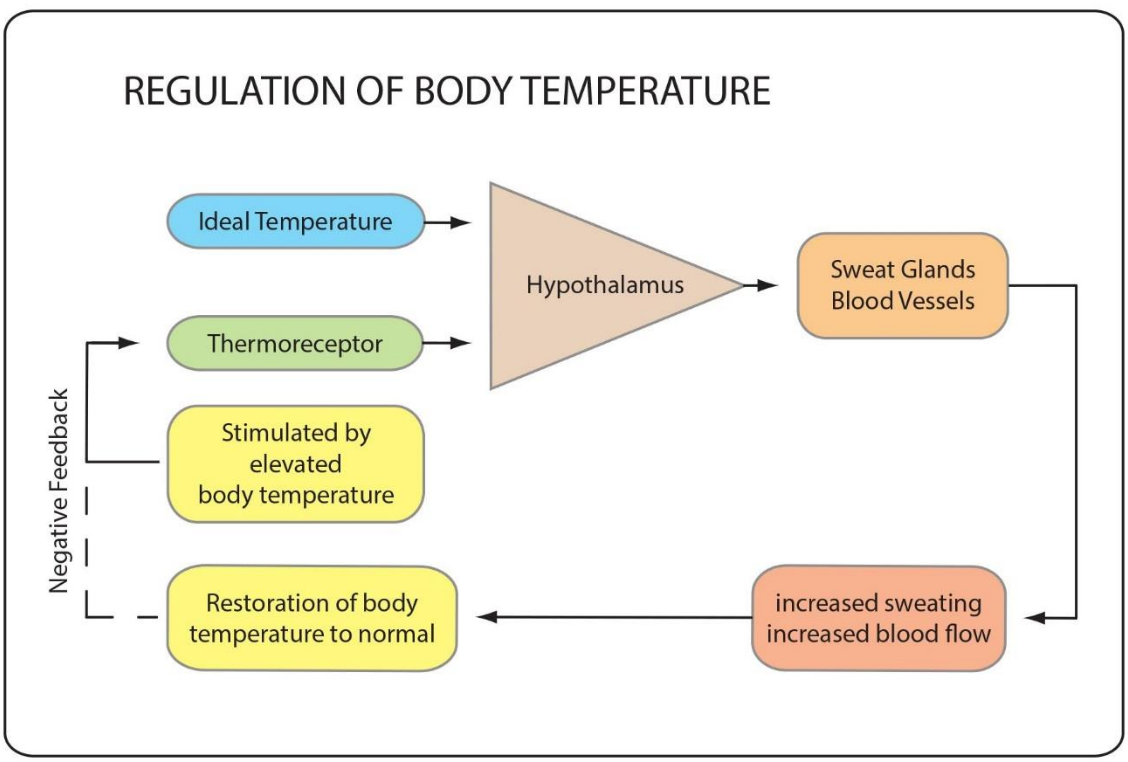

Figure 1-3 © 2019 David G. Ward, PhD

Negative feedback: Example of the regulation of blood glucose controlled by insulin

If blood glucose is high, then a response is produced that lowers blood glucose. In this case secretion of the hormone insulin increases which stimulates the transport of glucose from blood into cells. The transport of glucose into cells provides glucose for use in metabolism. Therefore, glucose in blood will decrease. A system for regulation of blood glucose controlled by insulin is shown in Figure 1-4.

- Internal Condition – the blood glucose
- Receptors – glucose receptors in the pancreas
- Set Point – the desired blood glucose
- Controller – beta cells of pancreas
- Effectors – beta cells of pancreas secrete insulin
- Responses when blood glucose is too high
  - Increased transport of glucose from blood into cells
  - Therefore, blood glucose decreases

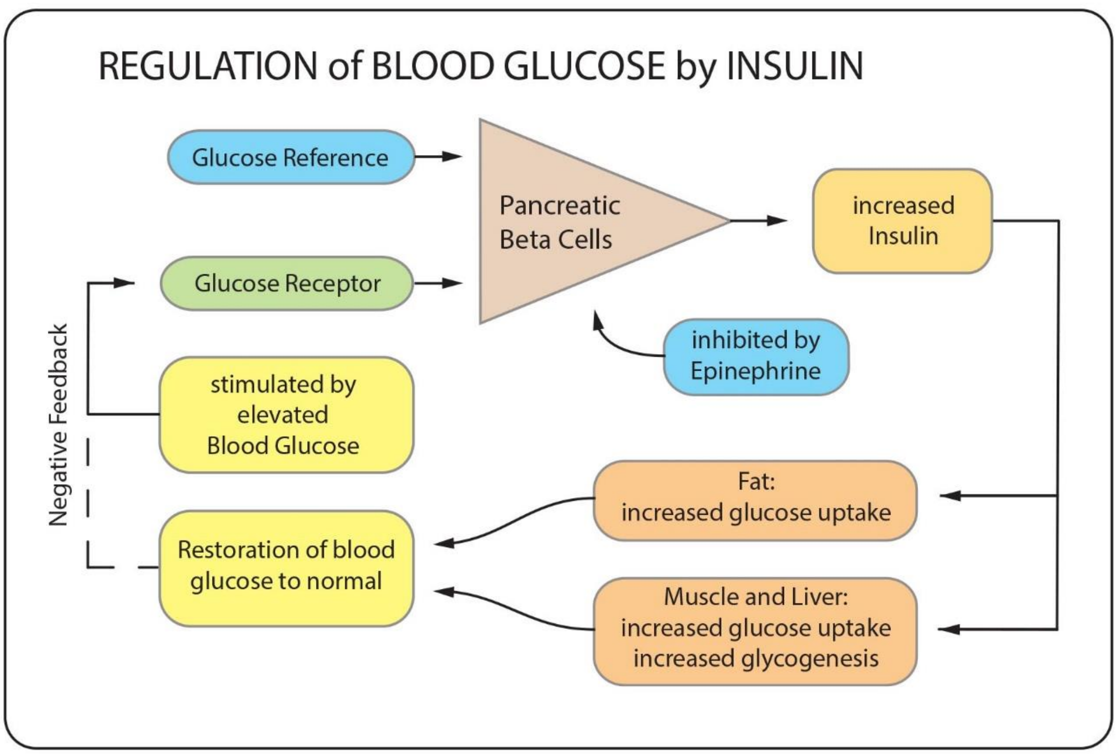

Figure 1-4 © 2016 David G. Ward, Ph.D.

We will address the role of insulin in more detail when we consider absorptive metabolism in chapter 23.

Negative feedback: Example of the regulation of blood glucose controlled by glucagon

If blood glucose is low, then a response is produced that raises blood glucose. In this case secretion of the hormone glucagon increases, which stimulates the breakdown of glycogen (stored in cells) into glucose. The glucose is used in metabolism or transported out of cells and into blood. Therefore, glucose in blood will increase. A system for regulation of blood glucose by glucagon is shown in Figure 1-5.

- Internal Condition – the blood glucose
- Receptors – glucose receptors in the pancreas
- Set Point – the optimal (desired) blood glucose
- Controller – alpha cells of pancreas
- Effectors – alpha cells of pancreas secrete glucagon
- Responses when blood glucose is low
  - Increased breakdown of glycogen into glucose
  - Increased transport of glucose from cells into blood
  - Therefore, blood glucose increases

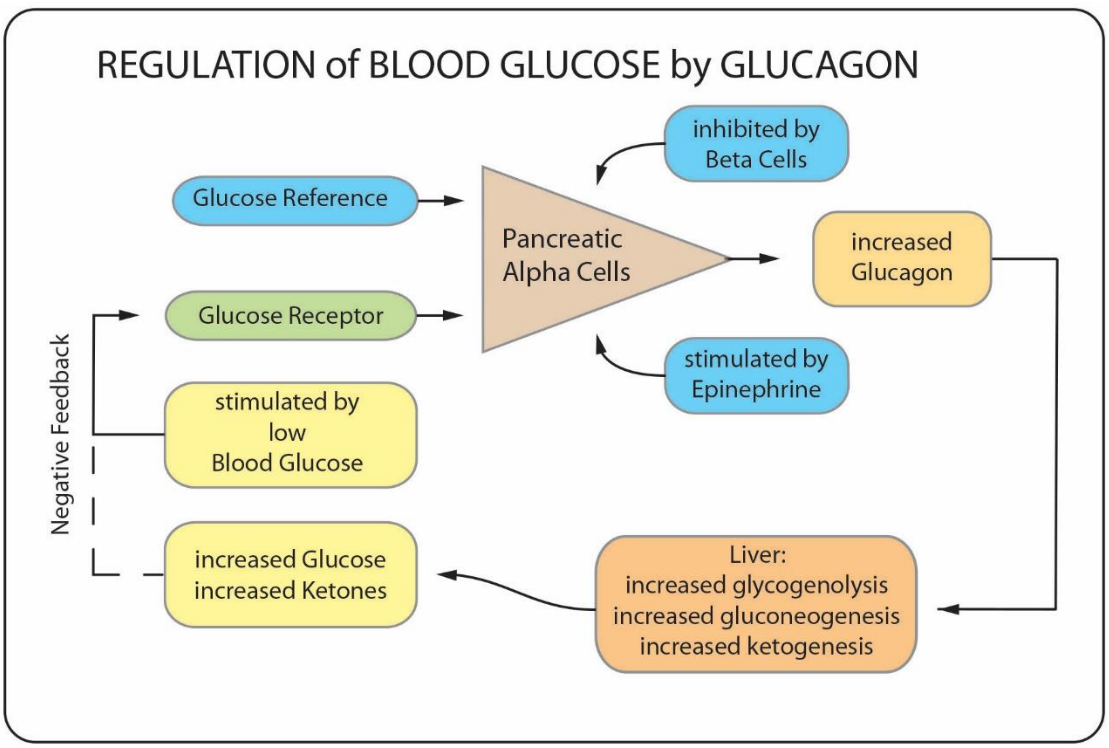

Figure 1-5 © 2016 David G. Ward, Ph.D.

We will address the role of glucagon in more detail when we consider post-absorptive metabolism in chapter 23.

Positive feedback: Example of regulation of LH surge

Sometimes it is necessary to utilize **Positive Feedback**.

- An *increase* in an internal condition will stimulate a response that further *increases* (+) the internal condition in order to *maximize* it.

Prior to ovulation, estrogen increases and this stimulates increases in luteinizing hormone (LH). The increase in LH stimulates a further increase in estrogen which in turn stimulates a further increase in LH. The basic organization of the system for the regulation of the LH surge is shown in Figure 1-6.

- Internal Conditions – blood estrogen and LH levels
- Receptors (Sensors) – estrogen receptors in the anterior pituitary
- Set Point – influenced by GnRH
- Controller – anterior pituitary
- Effector – ovary
- Response – as estrogen increases, LH increases

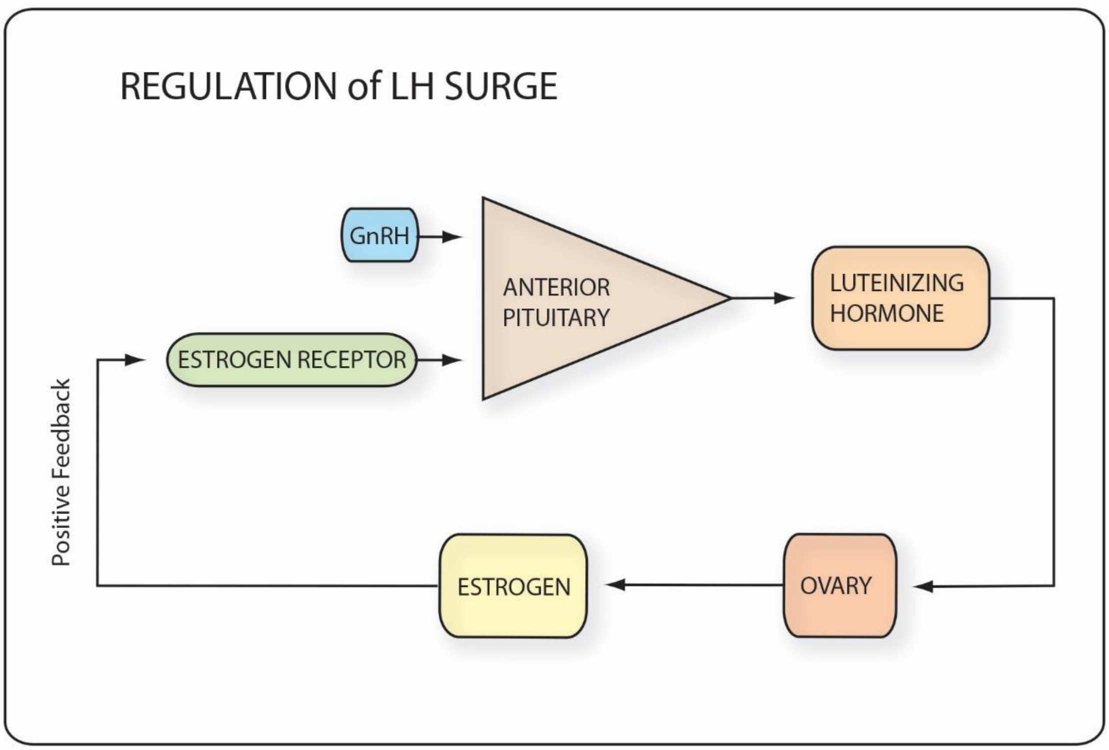

Figure 1-6 © 2016 David G. Ward, PhD

This positive feedback system is imbedded inside of a larger and more complex negative feedback system that involves the hypothalamus, gonadotropin releasing hormone (GnRH) and additional steroid hormones. We will examine these issues when we consider reproductive physiology in chapter 24.

Quiz Yourself

1-5. Matching

A)	Internal Condition	produces relevant responses	1) _____
B)	Receptor	measures the internal condition	2) _____
C)	Set Point	the optimal value for the internal condition	3) _____
D)	Controller	the variable to be maintained within an acceptable range	4) _____
E)	Effector	determines the difference between the measured and optimal value	5) _____

Fill in

6. The ___________ change the internal condition.

7. In negative feedback, an *increase* in an internal condition will stimulate a response that _____________ the internal condition in order to *normalize* it.

8. In positive feedback, an *increase* in an internal condition will stimulate a response that _____________ the internal condition in order to *maximize* it.

Study Questions

1. Explain the organization of homeostatic regulatory systems. Include the concepts of internal conditions, receptors, controllers, effectors, responses, negative feedback, and positive feedback.