ANIMAL ORGAN SYSTEMS AND HOMEOSTASIS

by Michael J. Farabee, Ph.D.,Estrella Mountain Community College, updated 12/06

Table of Contents

We are all familiar with many of the organ systems that comprise the body of advanced animals: such as the circulatory system, nervous system, etc. More of us are aware of the essential nature of the immune system in these days of HIV, AIDS, and emergent viral diseases such as Ebola and Hanta. Later chapters will focus on animals, such as sponges that have no organs at all, and other organisms that lack many of the organ systems we take for granted. Recall that in the Introduction chapter we discussed the levels of organization we see in biology, from atoms to organ systems that makeup a multicellular organism. We have also seen somewhat of the myriad cells and tissues that occur in humans (and by extension in other animals). This chapter will introduce you to the eleven organ systems that function within our own bodies, and how they coordinate to keep us functioning within a dynamic range of internal conditions we refer to as homeostasis.

Animal organs are usually composed of more than one cell type. Recall that the stomach contains all four animal tissue types: epithelium to line the stomach and secrete gastric juices; connective tissues to give the stomach flexibility to expand after a large meal; smooth muscle tissues to churn and digest that meal without the need for conscious thought (indeed, we are aware of that action only when we burp or suffer some sort of gastric distress!); and nervous tissues to monitor the progress of food as it is worked on by the stomach, and to direct secretion and muscle activity. Each organ typically performs a given function set. The stomach is an organ composed of tissues that aid in the mechanical and chemical breakdown of food. Most organs have functions in only one organ system. The stomach is involved only in the digestion of food as part of the digestive system. Organ systems, such as the digestive system, are collections of organs that perform a major function for the organism.

Homeostasis | Back to Top

Homeostasis is the maintenance of a stable internal environment. Homeostasis is a term coined in 1959 to describe the physical and chemical parameters that an organism must maintain to allow proper functioning of its component cells, tissues, organs, and organ systems.

Recall that enzymes function best when within a certain range of temperature and pH, and that cells must strive to maintain a balance between having too much or too little water in relation to their external environment. Both situations demonstrate homeostasis. Just as we have a certain temperature range (or comfort zone), so our body has a range of

environmental (internal as well as external) parameters within which it works best. Multicellular organisms accomplish this by having organs and organ systems that coordinate their homeostasis. In addition to the other functions that life must perform (recall the discussion in our Introduction chapter), unicellular creatures must accomplish their homeostasis within but a single cell!

Single-celled organisms are surrounded by their external environment. They move materials into and out of the cell by regulation of the cell membrane and its functioning. Most multicellular organisms have most of their cells protected from the external environment, having them surrounded by an aqueous internal environment. This internal environment must be maintained in such a state as to allow maximum efficiency. The ultimate control of homeostasis is done by the nervous system. Often this control is in the form of negative feedback loops. Heat control is a major function of homeostatic conditions that involves the integration of skin, muscular, nervous, and circulatory systems.

The difference between homeostasis as a single cell performs it and what a multicelled creature does derives from their basic organizational plan: a single cell can dump wastes outside the cell and just be done with it. Cells in a multicelled creature, such as a human or cat, also dump wastes outside those cells, but like the trash can or dumpster outside my house/apartment, those wastes must be carted away. The carting away of these wastes is accomplished in my body by the circulatory system in conjunction with the excretory system. For my house, I have the City of Phoenix sanitation department do that (and get to pay each month for their service!).

The ultimate control of homeostasis is accomplished by the nervous system (for rapid responses such as reflexes to avoid picking up a hot pot off the stove) and the endocrine system (for longer-term responses, such as maintaining the body levels of calcium, etc.). Often this homeostatic control takes the form of negative feedback loops. There are two types of biological feedback: positive and negative. Negative feedback turns off the stimulus that caused it in the first place. Your house's heater (or cooler for those of us in the Sun Belt) acts on the principle of negative feedback. When your house cools off below the temperature set by your thermostat, the heater is turned on to warm air until the temperature is at or above what the thermostat is set at. The thermostat detects this rise in temperature and sends a signal to shut off the heater, allowing the house to cool of until the heater is turned on yet again and the cycle (or loop) continues. Positive feedback causes an amplification of the stimulus by the reaction. Examples of each will be presented below.

The Internal Environment | Back to Top

There are two types of extracellular fluids in animals:

- the extracellular fluid that surrounds and bathes cells
- plasma, the liquid component of the blood.

Internal components of homeostasis:

1. Concentration of oxygen and carbon dioxide

2. pH of the internal environment
3. Concentration of nutrients and waste products
4. Concentration of salt and other electrolytes
5. Volume and pressure of extracellular fluid

Control Systems | **Back to Top**

Open systems are linear and have no feedback, such as a light switch. Closed Systems has two components: a sensor and an effector, such as a thermostat (sensor) and furnace (effector). Most physiological systems in the body use feedback to maintain the body's internal environment.

Extrinsic

Most homeostatic systems are extrinsic: they are controlled from outside the body. Endocrine and nervous systems are the major control systems in higher animals.

The nervous system depends on sensors in the skin or sensory organs to receive stimuli and transmit a message to the spinal cord or brain. Sensory input is processed and a signal is sent to an effector system, such as muscles or glands, that effects the response to the stimulus.

The endocrine system is the second type of extrinsic control, and involves a chemical component to the reflex. Sensors detect a change within the body and send a message to an endocrine effector (parathyroid), which makes PTH. PTH is released into the blood when blood calcium levels are low. PTH causes bone to release calcium into the bloodstream, raising the blood calcium levels and shutting down the production of PTH.

Some reflexes have a combination of nervous and endocrine response. The thyroid gland secretes thyroxin (which controls the metabolic rate) into the bloodstream. Falling levels of thyroxin stimulate receptors in the brain to signal the hypothalamus to release a hormone that acts on the pituitary gland to release thyroid-stimulating hormone (TSH) into the blood. TSH acts on the thyroid, causing it to increase production of thyroxin.

Intrinsic

Local, or intrinsic, controls usually involve only one organ or tissue. When muscles use more oxygen, and also produce more carbon dioxide, intrinsic controls cause dilation of the blood vessels allowing more blood into those active areas of the muscles. Eventually the vessels will return to "normal".

Feedback Systems in Homeostasis | **Back to Top**

Negative feedback control mechanisms (used by most of the body's systems) are called negative because the information caused by the feedback causes a reverse of the response. TSH is an example: blood levels of TSH serve as feedback for production of TSH.

Positive feedback control is used in some cases. Input increases or accelerates the

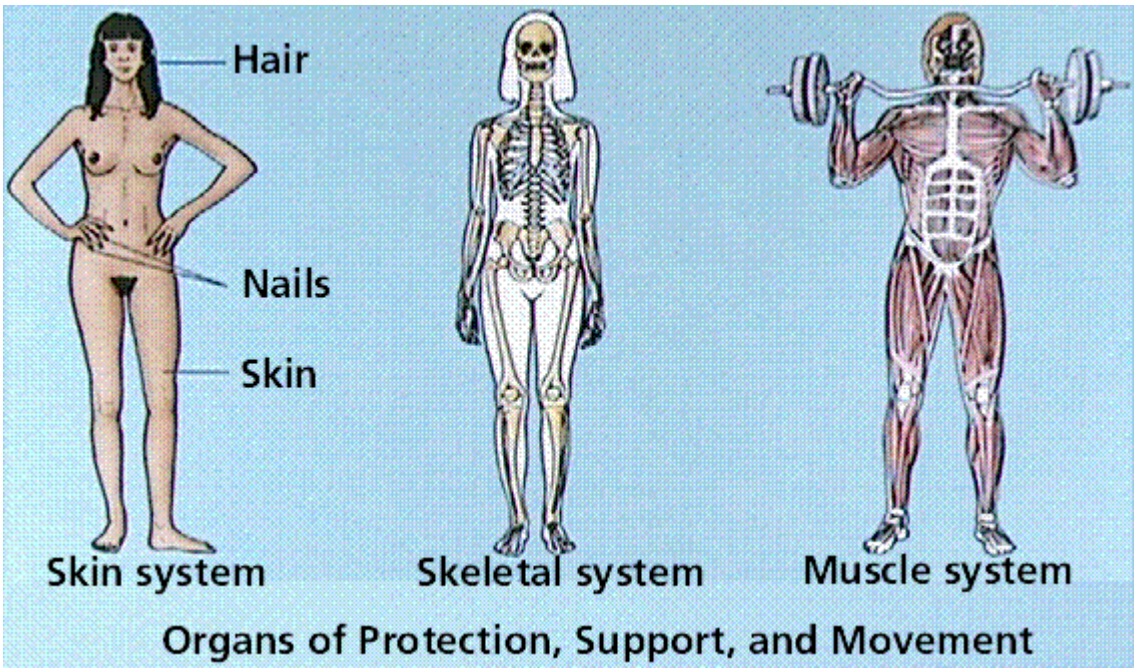
response. During uterine contractions, oxytocin is produced. Oxytocin causes an increase in frequency and strength of uterine contractions. This in turn causes further production of oxytocin, etc.

Homeostasis depends on the action and interaction of a number of body systems to maintain a range of conditions within which the body can best operate.

Body Systems and Homeostasis | **Back to Top**

Eleven major organ systems are present within animals, although some animals lack one or more of them. The vertebrate body has two cavities: the thoracic, which contains the heart and lungs; and the abdominal, which contains digestive organs. The head, or cephalic region, contains four of the five senses as well as a brain encased in the bony skull. These organ systems can be grouped according to their functions.

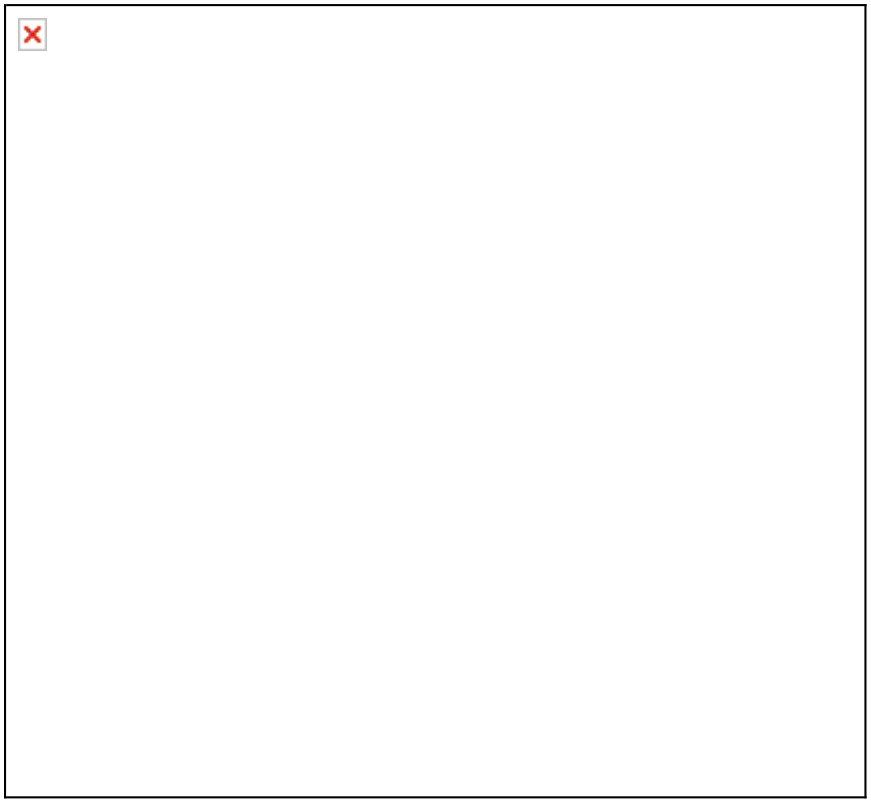
Figure 1. The integumentary, skeletal, and muscular systems. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.



- Muscular System (shown in Figure 1) facilitates movement and locomotion. The muscular system produces body movements, body heat, maintains posture, and supports the body. Muscle fibers are the main cell type. Action of this system is closely tied to that of the skeletal system.
- Skeletal System (shown in Figure 1) provides support and protection, and attachment points for muscles. The skeletal system provides rigid framework for movement. It supports and protects the body and body parts, produces blood cells, and stores minerals.
- Skin or Integument (shown in Figure 1) is the outermost protective layer. It prevents water loss from and invasion of foreign microorganisms and viruses into the body. There are three layers of the skin. The epidermis is the outer, thinner layer of skin. Basal cells continually undergo mitosis. Skin is waterproof because keratin,

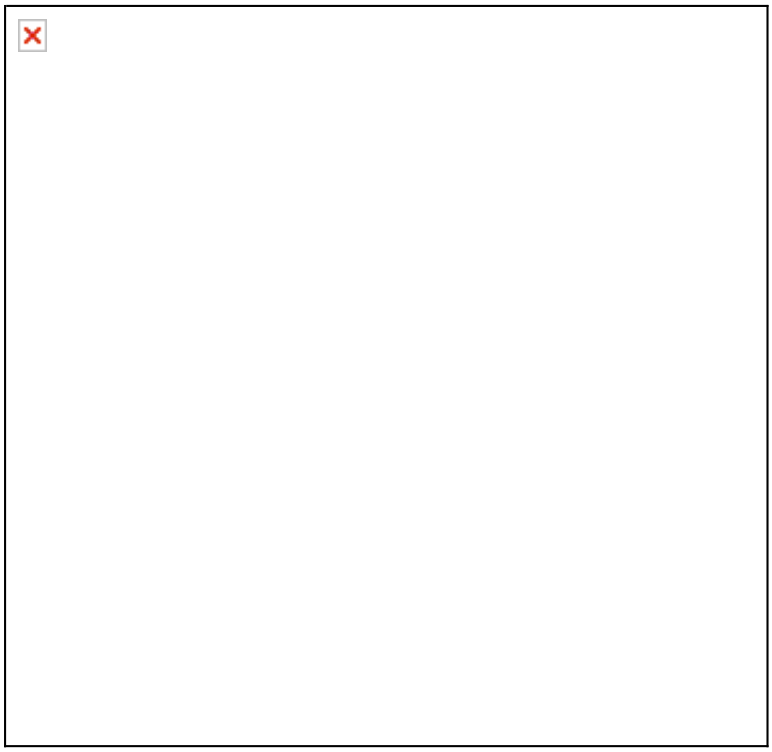
a protein is produced. The next layer is the dermis a layer of fibrous connective tissue. Within the dermis many structures are located, such as sweat glands, hair follicles and oil glands. The subcutaneous layer is composed of loose connective tissue. Adipose tissue occurs here, serving primarily for insulation. Nerve cells run through this region, as do arteries and veins.

Figure 2. The digestive and respiratory systems. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.



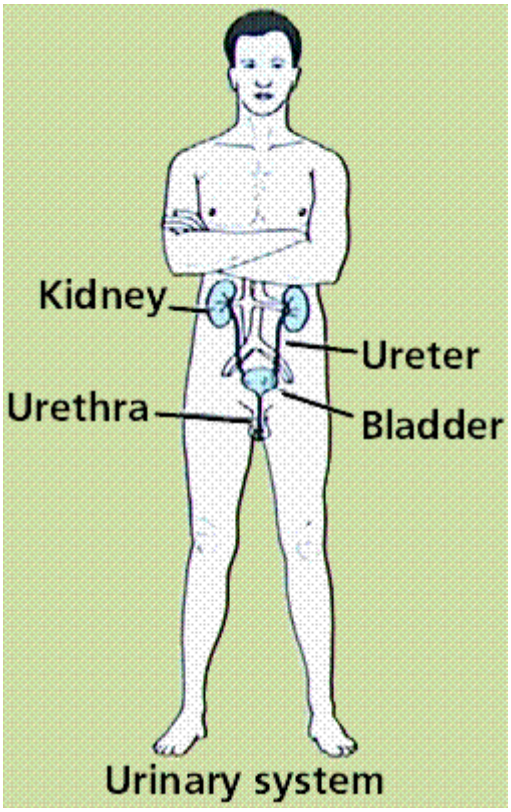
- Respiratory System moves oxygen from the external environment into the internal environment; also removes carbon dioxide. The respiratory system exchanges gas between lungs (gills in fish) and the outside environment. It also maintains pH of the blood and facilitates exchange of carbon dioxide and oxygen. The system is summarized in Figure 2.
- Digestive System digests and absorbs food into nutrient molecules by chemical and mechanical breakdown; eliminates solid wastes into the environment. Digestion is accomplished by mechanical and chemical means,breaking food into particles small enough to pass into bloodstream. Absorbtion of food molecules occurs in the small intestine and sends them into circulatory system. The digestive system also recycles water and reclaims vitamins from food in the large intestine. The system is summarized in Figure 2.

Figure 3. The circulatory and lymphatic systems. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.



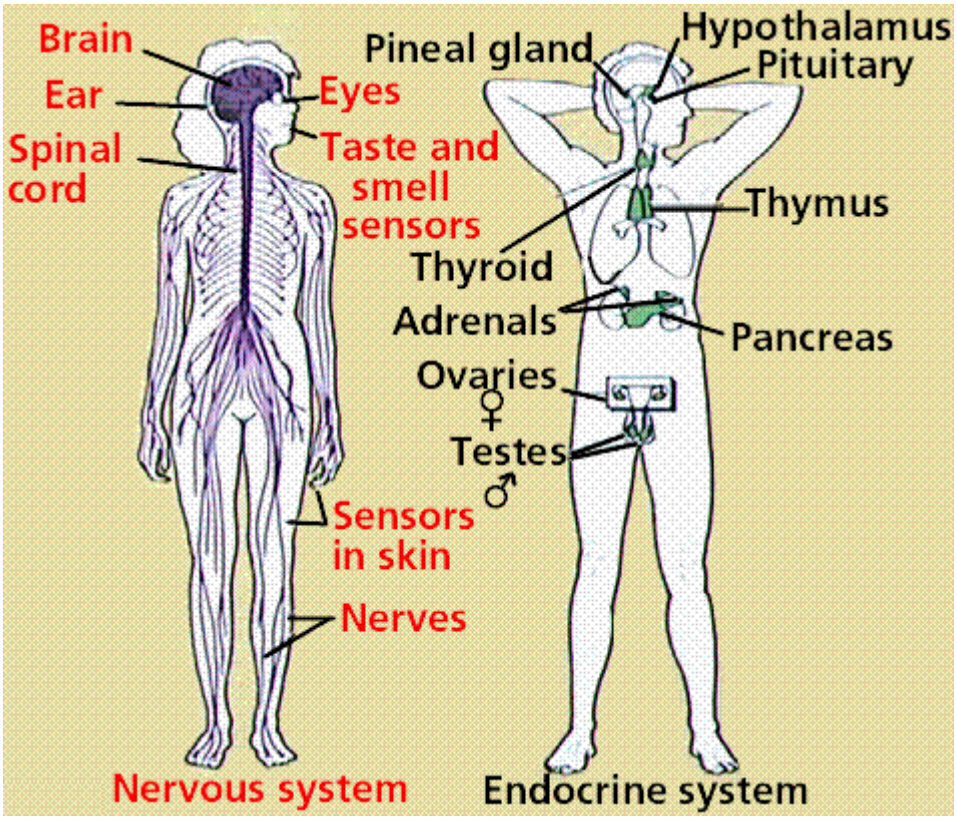
- Circulatory System (Figure 3) transports oxygen, carbon dioxide, nutrients, waste products, immune components, and hormones. Major organs include the heart, capillaries, arteries, and veins. The lymphatic system also transports excess fluids to and from circulatory system and transports fat to the heart.
- Immune System (Lymphatic system, Figure 3) defends the internal environment from invading microorganisms and viruses, as well as cancerous cell growth. The immune system provides cells that aid in protection of the body from disease via the antigen/antibody response. A variety of general responses are also part of this system.

Figure 4. The excretory system. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.



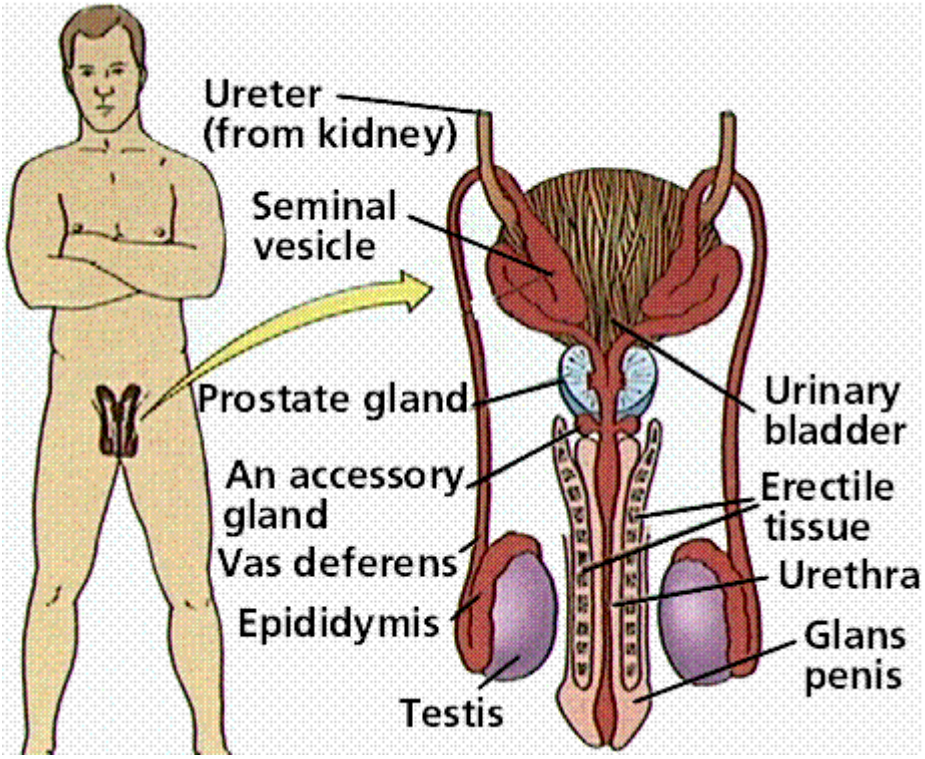
- Excretory System regulates volume of internal body fluids as well as eliminates metabolic wastes from the internal environment. The excretory system removes organic wastes from the blood, accumulating wastes as urea in the kidneys. These wastes are then removed as urine. this system is also responsible for maintaining fluid levels.

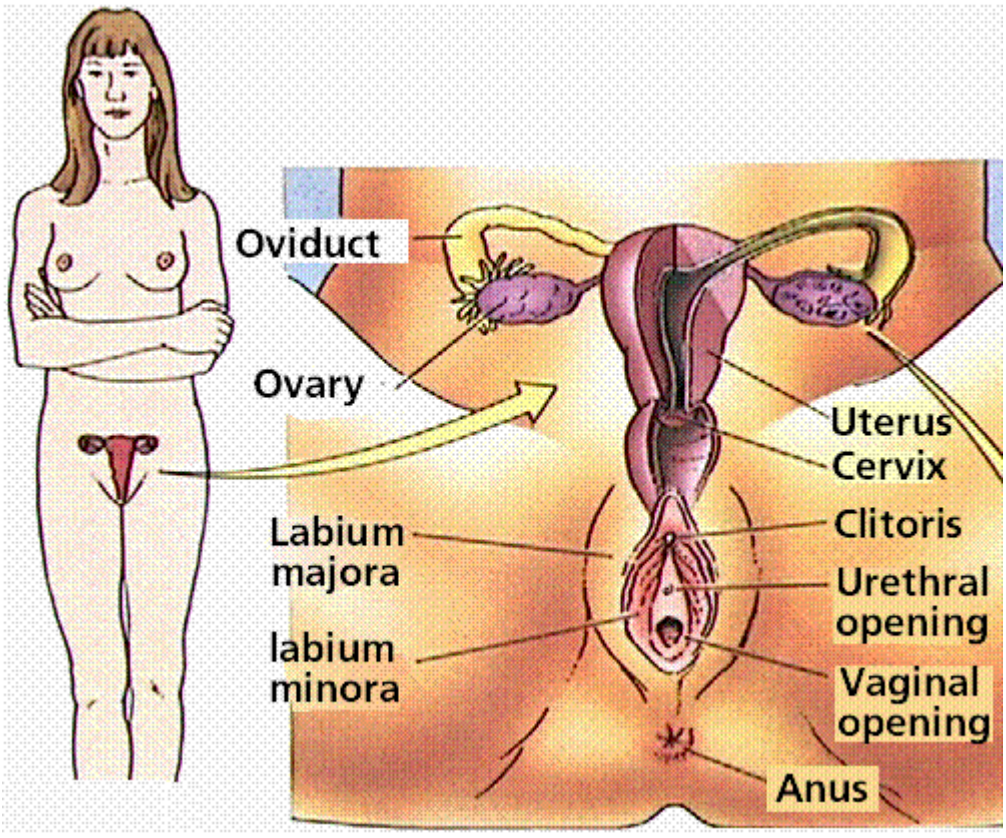
Figure 5. The nervous and endocrine systems. Image from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.



- Nervous System, illustrated in Figure 5, coordinates and controls actions of internal organs and body systems. Memory, learning, and conscious thought are a few aspects of the functions of the nervous system. Maintaining autonomic functions such as heartbeat, breathing, control of involuntary muscle actions are performed by some of the parts of this system.
- Endocrine System, illustrated in Figure 5, works with the nervous system to control the activity internal organs as well as coordinating long-range response to external stimuli. The endocrine system secretes hormones that regulate body metabolism, growth, and reproduction. These organs are not in contact with each other, although they communicate by chemical messages dumped into the circulatory system.

Figure 6. The urogenital and reproductive systems of males (top) and females). Images from Purves et al., Life: The Science of Biology, 4th Edition, by Sinauer Associates (www.sinauer.com) and WH Freeman (www.whfreeman.com), used with permission.





- Reproductive System, shown in Figure 6, is mostly controlled by the endocrine system, and is responsible for survival and perpetuation of the species. Elements of the reproductive system produce hormones (from endocrine control) that control and aid in sexual development. Organs of this system produce gametes that combine in the female system to produce the next generation (embryo).

Learning Objectives | Back to Top

- List the principal organ systems in humans and match each to its main task.
- Explain how, if each cell can perform all its basic activities, organ systems contribute to cell survival.
- Draw a diagram that illustrates the mechanism of homeostatic control.
- Be able to diagram an example of positive feedback as well as an example of negative feedback, either from everyday life or dealing with specific body systems.
- List one body system and the types of interactions it has with other body organ systems.
- Explain what a reflex is by drawing and labeling a diagram and telling how it functions.

Terms | Back to Top

abdominal cavity	central nervous system	Circulatory system	cranial cavity	dermis	Digestive system
dorsal	Endocrine system	epidermis	Excretory system	external environment	gonads
homeostasis	hormones	Integumentary system	internal environment	Lymphatic system	lymphocytes
Muscular system	negative feedback	Nervous system	organs	organ systems	ovaries
peripheral nervous system	plasma	positive feedback	Reproductive system	Respiratory system	Skeletal system
testes	thoracic cavity	ventral	zygote		

Review Questions | Back to Top

1. Which of these is not a characteristic of living things? a) reproduction and heredity; b) metabolism; c) response to stimulus d) all of the are characteristics of life ANS is d
2. Control of homeostasis in the body is accomplished by ____. a) Nervous system; b) Circulatory system; c) Endocrine system; d) both a and c control homeostasis ANS is d
3. Which of these would be the effector for a negative feedback system to heat your house? a) thermostat; b) wiring; c) heater; d) air conditioner ANS is d
4. When we are cold we shiver. This releases heat from which organ system? a) Skeletal system; b) Muscular system; c) Digestive system; d) Circulatory system ANS is b
5. Heat released when we shiver is transported from its source to the rest of the body by which of these organ systems? a) Skeletal system; b) Muscular system; c) Digestive system; d) Circulatory system ANS is d
6. The digestive process consists of three subprocesses. Which of these is not part of the digestive process? a) mechanical breakdown of food; b) circulation of food in the blood and lymph; c) absorption of food into the blood or lymph; d) assimilation

of the food into cells of the body ANS is c

7. Which of these is not a function carried out by the Integumentary system? a) protection from invaders; b) storage of fats; c) prevention of water loss; d) removal of excess heat by sweating ANS is b
8. Hormones are produced directly by organs and tissues of which of these body systems? a) Endocrine; b) Circulatory; c) Reproductive; d) Nervous ANS is a
9. The removal of organic wastes from the body is accomplished by the ___ system? a) Digestive; b) Excretory; c) Circulatory; d) Lymphatic ANS is b
10. Which of these is part of the central nervous system? a) brain; b) nerve ganglia; c) spinal cord; d) a and b; e) a and c ANS is e
11. The spinal cord is located on which side of the body? a) dorsal; b) ventral; c) abdominal; d) cranial ANS is a
12. Which of these is not part of the male reproductive system? a) testis; b) penis; c) ovary; d) vas deferens ANS is C
13. Gametes are produced by which of these cell division processes? a) mitosis; b) binary fission; c) photosynthesis; d) meiosis ANS is d
14. Blood leaves the heart through which of these types of blood vessels? a) capillaries; b) arteries; c) veins; d) lymphatic vessels ANS is b
15. Storage of important ions such as phosphorous and calcium is done by which of these organ systems? a) Skeletal; b) Muscular; c) Digestive; d) Excretory ANS is a
16. Movement of the body is accomplished directly by the actions of which of these organ systems? a) Muscular; b) Skeletal; c) Digestive; d) a and b e) b and c ANS is d

Links | Back to Top

- Organ Systems of the Body A health-related view of the body organ systems.
- How the Body Works A Canadian site with way cool "fig" leaves!
- Homeostasis A collection of links dealing with organ systems and homeostasis.
- The Atlas of the Human Body An online atlas from the American Medical Association. Check out the system of your choice.
- The Virtual Body This site presents information about the Brain, Digestive System, Heart, and Skeleton through use of a series of Shockwave® animations. You will need the plugin to view those animations, but can access it from the Virtual Body site.
- Human Anatomy Online This site offers some Java-assisted fun activities about the human body.
- Human Anatomy and Physiology Case Study Project Learn about human anatomy and physiology by studying actual cases.
- Vesalius, an online graphical resource for the medical and surgical communities This site provides anatomical illustrations, many of which are posted for your viewing. An interesting feature is the mark up section, allowing registered users (registrations is currently free) to annotate posted drawings.
- Virtual Pig Dissection No fuss, no muss, no smell, no wastes to dispose of. This site, intended for high school level, offers systemic information about a commonly dissected specimen, Babe the Pig!
- Atlas Plus Virtual demonstrations covering aspects of anatomy and body systems, but not the histology section (University of Michigan). This site uses Java, so your browser will need to be Java-compliant.
- Click the Bones and They Will Speak Not just for Haloween fun, this site offers some very well done information about the bones and how to properly pronounce them. Maybe with this site I might not have left animals for plant science!

- Online Biology Book chapters covering the human body and its organ systems.
  - **THE INTEGUMENTARY SYSTEM**
  - **THE CIRCULATORY SYSTEM**
  - **LYMPHATIC SYSTEM AND IMMUNITY**
  - **THE DIGESTIVE SYSTEM**
  - **THE NERVOUS SYSTEM**
  - **THE ENDOCRINE SYSTEM**
  - **THE REPRODUCTIVE SYSTEM**
  - **THE MUSCULAR AND SKELETAL SYSTEMS**
  - **THE RESPIRATORY SYSTEM**
  - **THE EXCRETORY SYSTEM**

Back to Table of Contents | **THE INTEGUMENTARY SYSTEM**

Email: mj.farabee@emcmail.maricopa.edu

Last modified: Tuesday May 18 2010

The URL of this page is:
www.emc.maricopa.edu/faculty/farabee/biobk/biobookanimorgsys.html