Case Study Conclusion: Under Pressure

As you learned in this chapter, the human body consists of many complex systems that normally work together efficiently like a well-oiled machine to carry out life’s functions. For example, Figure 1 illustrates how the brain and spinal cord are protected by layers of membrane called meninges and fluid that flows between the meninges and in spaces called ventricles inside the brain. This fluid is called cerebrospinal fluid (CSF) and as you have learned, one of its important functions is to cushion and protect the brain and spinal cord, which make up most of the central nervous system (CNS). CSF additionally circulates nutrients and removes waste products from the CNS. CSF is produced continually in the ventricles, circulates throughout the CNS, and then is reabsorbed by the bloodstream. If too much CSF is produced, its flow blocked, or if not enough is reabsorbed, the system becomes out of balance and CSF can build up in the ventricles. This causes an enlargement of the ventricles called hydrocephalus that can put pressure on the brain, resulting in the types of neurological problems that former professional football player, Jason, described at the beginning of this chapter, is suffering from.
Recall that Jason’s symptoms included loss of bladder control, memory loss, and difficulty walking. The cause of his symptoms was not immediately clear, although his doctors suspected that it related to the nervous system since the nervous system acts as the control center of the body, controlling and regulating many other organ systems. Jason’s memory loss directly implicated the involvement of the brain, since that is the site of thoughts and memory. The urinary system is also controlled in part by the nervous system, and the inability to hold urine appropriately can be a sign of a neurological issue. Jason’s trouble walking involved the muscular system, which works alongside the skeletal system to enable movement of the limbs. In turn, the contraction of muscles is regulated by the nervous system. You can see why a problem in the nervous system can cause a variety of different symptoms by affecting multiple organ systems in the human body.

To try to find the exact cause of Jason’s symptoms, his doctors performed a lumbar puncture, or spinal tap, which is the removal of some CSF through a needle inserted into the lower part of the spinal canal. They then analyzed Jason’s CSF for the presence of pathogens such as bacteria to determine whether an infection was the cause of his neurological symptoms. When no evidence of infection was found, they used an MRI to observe the structures of his brain. This is when they discovered his enlarged ventricles, which are a hallmark of hydrocephalus.

To treat Jason’s hydrocephalus, a surgeon implanted a device called a shunt in his brain to remove the excess fluid (Figure \(\PageIndex{2}\)). One side of the shunt consists of a small tube, called a catheter, which was inserted into Jason’s ventricles. Excess CSF is then drained through a one-way valve to the other end of the shunt, which was threaded under his skin to his abdominal cavity, where the CSF is released and can be reabsorbed by the bloodstream.
Implantation of a shunt is the most common way to treat hydrocephalus, and for some people, it can allow them to recover almost completely. However, there can be complications associated with a brain shunt. The shunt can have mechanical problems or cause an infection. Also, the rate of draining must be carefully monitored and adjusted to balance the rate of removal of CSF with the rate of its production. If it is drained too fast, it is called overdraining, and if it is drained too slowly, it is called underdraining. In the case of underdraining, the pressure on the brain and associated neurological symptoms will persist. In the case of overdraining, the ventricles can collapse, which can cause serious problems such as the tearing of blood vessels and hemorrhaging. To avoid these problems, some shunts have an adjustable pressure valve where the rate of draining can be adjusted by placing a special magnet over the scalp. You can see how the proper balance between CSF production and removal is so critical – both in the causes of hydrocephalus and in its treatment.

In what other ways does your body regulate balance, or maintain a state of homeostasis? In this chapter, you learned about the feedback loops that keep body temperature and blood glucose within normal ranges. Other important examples of homeostasis in the human body are the regulation of the pH in the blood and the balance of water in the body. You will learn more about homeostasis in different body systems in the coming chapters.

Thanks to Jason’s shunt, his symptoms are starting to improve, but he has not fully recovered. Time may tell whether the removal of the excess CSF from his ventricles will eventually allow him to recover normal functioning or whether permanent damage to his nervous system has already been done. The flow of CSF might seem simple but when it gets out of balance, it can easily wreak havoc on multiple organ systems because of the intricate interconnectedness of the systems within the human “machine.”
Chapter Summary

This chapter provided an overview of the organization and functioning of the human body. You learned that:

• The human body consists of multiple parts that function together to maintain life. The biology of the human body incorporates the body's structure, or anatomy, and the body's functioning, or physiology.

• The organization of the human body is a hierarchy of increasing size and complexity, starting at the level of atoms and molecules and ending at the level of the entire organism.

• Cells are the level of organization above atoms and molecules, and they are the basic units of structure and function of the human body. Each cell carries out basic life functions as well as other specific roles. Cells of the human body show a lot of variation.
  ◦ Variations in cell function are generally reflected in variations in cell structure.
  ◦ Some cells are unattached to other cells and can move freely; others are attached to each other and cannot move freely. Some cells can divide readily and form new cells; others can divide only under exceptional circumstances. Many cells are specialized to produce and secrete particular substances.
  ◦ All the different cell types within an individual have the same genes. Cells can vary because different genes are expressed depending on the cell type.
  ◦ Many common types of human cells consist of several subtypes of cells, each of which has a special structure and function. For example, subtypes of bone cells include osteocytes, osteoblasts, osteogenic cells, and osteoclasts.

• A tissue is a group of connected cells that have a similar function. There are four basic types of human tissues that make up all the organs of the human body: epithelial, muscle, nervous, and connective tissues.
  ◦ Connective tissues, such as bone and blood, are made up of cells that are separated by non-living material, called the extracellular matrix.
  ◦ Epithelial tissues, such as skin and mucous membranes, protect the body and its internal organs and secrete or absorb substances.
  ◦ Muscle tissues are made up of cells that have the unique ability to contract. They include skeletal, smooth, and cardiac muscle tissues.
  ◦ Nervous tissues are made up of neurons, which transmit electrical messages, and glial cells of various types, which play supporting roles. Types of nervous tissues include gray matter, white matter, nerves, and ganglia.

• An organ is a structure that consists of two or more types of tissues that work together to do the same job. Examples include the brain and heart.
  ◦ Many organs are composed of a major tissue that performs the organ’s main function, as well as other tissues that play supporting roles.
  ◦ The human body contains five organs that are considered vital for survival. They are the heart, brain, kidneys, liver, and lungs. If any of these five organs stops functioning, the death of the organism is imminent without medical intervention.

• An organ system is a group of organs that work together to carry out a complex overall function. For example, the skeletal system provides structure to the body and protects internal organs.
  ◦ There are 11 major organ systems in the human organism. They are the integumentary, skeletal, muscular, nervous, endocrine, cardiovascular, lymphatic, respiratory, digestive, urinary, and reproductive systems. Only the reproductive system varies significantly between males and females.

• The human body is divided into a number of body cavities. A body cavity is a fluid-filled space in the body that holds and protects internal organs. The two largest human body cavities are the ventral cavity and the dorsal cavity.
  ◦ The ventral cavity is at the anterior, or front, of the trunk. It is subdivided into the thoracic cavity and...
abdominopelvic cavity.
  ◦ The dorsal cavity is at the posterior, or back, of the body, and includes the head and the back of the trunk. It is subdivided into the cranial cavity and spinal cavity.

• Organ systems of the human body must work together to keep the body alive and functioning normally. This requires communication among organ systems. This is controlled by the autonomic nervous system and endocrine system. The autonomic nervous controls involuntary body functions, such as heart rate and digestion. The endocrine system secretes hormones into the blood that travel to body cells and influence their activities.
  ◦ Cellular respiration is a good example of organ system interactions because it is a basic life process that occurs in all living cells. It is the intracellular process that breaks down glucose with oxygen to produce carbon dioxide and energy. Cellular respiration requires the interaction of the digestive, cardiovascular, and respiratory systems.
  ◦ The fight-or-flight response is a good example of how the nervous and endocrine systems control other organ system responses. It is triggered by a message from the brain to the endocrine system and prepares the body for flight or a fight. Many organ systems are stimulated to respond, including the cardiovascular, respiratory, and digestive systems.
  ◦ Digesting food requires teamwork between the digestive system and several other organ systems, including the nervous, cardiovascular, and muscular systems.
  ◦ Playing softball or doing other voluntary physical activities may involve the interaction of nervous, muscular, skeletal, respiratory, and cardiovascular systems.

• Homeostasis is the condition in which a system such as the human body is maintained in a more-or-less steady state. It is the job of cells, tissues, organs, and organ systems throughout the body to maintain homeostasis.
  ◦ For any given variable, such as body temperature, there is a particular set point that is the physiological optimum value. The spread of values around the set point that is considered insignificant is called the normal range.
  ◦ Homeostasis is generally maintained by a negative feedback loop that includes a stimulus, sensor, control center, and effector. Negative feedback serves to reduce an excessive response and to keep a variable within the normal range. Negative feedback loops control body temperature and the blood glucose level.
  ◦ Sometimes homeostatic mechanisms fail, resulting in homeostatic imbalance. Diabetes is an example of a disease caused by homeostatic imbalance. Aging can bring about a reduction in the efficiency of the body’s control system, making the elderly more susceptible to disease.

• Positive feedback loops are not common in biological systems. Positive feedback serves to intensify a response until an end point is reached. Positive feedback loops control blood clotting and childbirth.

The severe and broad impact of hydrocephalus on the body’s systems highlights the importance of the nervous system and its role as the master control system of the body. In the next chapter, you will learn much more about the structures and functioning of this fascinating and important system.

Chapter Summary Review

1. Compare and contrast tissues and organs.
2. Osteocyte cells are part of which type of tissue and organ system?
3. Adipose tissue, or body fat, is the same general type of tissue as:
   A. mucous membranes
   B. gray matter
   C. skin
   D. blood
4. Which type of tissue lines the inner and outer surfaces of the body?

5. True or False. The extracellular matrix that surrounds cells is always solid.

6. True or False. Skin is an organ.

7. What is a vital organ? What happens if a vital organ stops working?

8. Name three organ systems that transport or remove wastes from the body.

9. Name two types of tissue in the digestive system.

10. For each of the following body functions, choose the organ system that is most associated with the function. Organ systems: integumentary; skeletal; muscular; nervous; endocrine; cardiovascular; lymphatic; respiratory; digestive; urinary; reproductive
   A. Processes sensory information
   B. Secretes hormones
   C. Releases carbon dioxide from the body to the outside world
   D. Produces gametes
   E. Controls water balance in the body

11. The spleen is part of which organ system?
   A. Digestive
   B. Lymphatic
   C. Integumentary
   D. Urinary

12. Describe one way in which the integumentary and cardiovascular systems work together to regulate homeostasis in the human body.

13. Name the two largest body cavities in humans and describe their general locations.

14. What are the names given to the three body cavity divisions where the reproductive organs are located?

15. True or False. There are two pleural cavities.

16. True or False. Body cavities are filled with air.

17. A. The pituitary gland is in which organ system?
   B. Describe how the pituitary gland increases metabolism.

18. When the level of thyroid hormone in the body gets too high, it acts on other cells to reduce production of more thyroid hormone. What type of feedback loop does this represent?

19. Hypothetical organ A is the control center in a feedback loop that helps maintain homeostasis. It secretes molecule A1 which reaches organ B, causing organ B to secrete molecule B1. B1 negatively feeds back onto organ A, reducing the production of A1 when the level of B1 gets too high.
   A. What is the stimulus in this feedback loop?
   B. If the level of B1 falls significantly below the set point, what do you think happens to the production of A1? Why?
   C. What is the effector in this feedback loop?
   D. If organs A and B are part of the endocrine system, what type of molecules do you think A1 and B1 are likely to be?

20. What are the two main systems that allow various organ systems to communicate with each other?

21. The hypothalamus is part of the:
A. spinal cord  
B. thoracic cavity  
C. kidneys  
D. brain  

22. What are two functions of the hypothalamus that you learned about in this chapter?