

Chapter 14

Integration and Regulation:

What can go wrong?

Throughout the past several chapters you have explored how various kinds of signals can be transported throughout the body. Some of these are done electrochemically, such as the nerve impulses within the central and peripheral nervous systems while others rely solely on the production and distribution of chemicals, as with the endocrine system.

In this chapter, we are going to explore a few of the problems that may occur within our nervous and endocrine systems and a few of the ways we can prevent or correct these issues.

Let's begin by taking a brief look at the topic of pain. If you have ever spent time in a doctor's office, you may have needed the use of **local anesthetics** (numbing agents) to reduce the amount of pain that you may experience. Local anesthetics block the sensation of pain by keeping sodium ions from entering and leaving the cell membranes of neurons. And as you learned back in Chapter 8, a nerve impulse cannot be created without the movement of sodium ions. Without this electrochemical signal, your central nervous system cannot detect any signal of pain. Two examples of local anesthetics include **novocain** for tooth pain and **lidocaine** which is used to numb an area of skin.



Since we are on the topic of neurons...

Back in Chapter 8 you also learned about the protective myelin covering which partially surrounds the axon of nerve cells. As you recall, gaps within the myelin covering allows nerve impulses to move much faster as sodium and potassium ions are forced in and out of the neuron at a faster rate.

If myelin is destroyed or is not present at all, neurons cannot function properly. This may cause serious problems within the muscular system by slowing down or completely blocking the ability of muscles to function. This condition occurs in patients diagnosed with the disease called **multiple sclerosis (MS)**. The term "sclerosis" means the "hardening of a body tissue" or "scarring" which affects the myelin covering. This debilitating disease is thought to be caused by the body's own immune system mistakenly identifying myelin as a foreign pathogen. A condition where the body attacks its own healthy cells is known as an **autoimmune disease**.

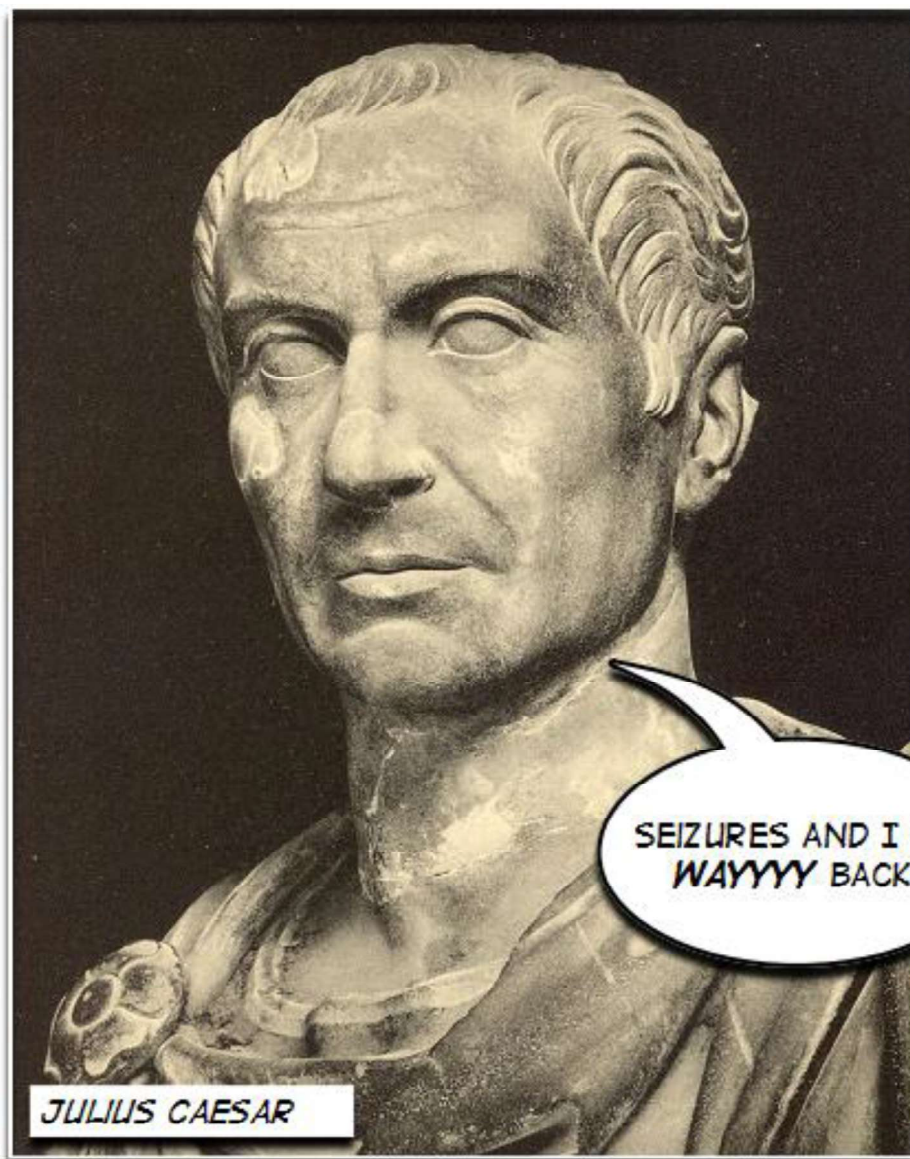
Alzheimer's disease is another example of how our bodies may inadvertently cause a destructive series of events in our health. This disease occurs when structural changes of neurons cause the unneeded death of a large number of cells within the brain. As brain cells continue to perish, an individual will likely begin to experience a loss of memory. This condition leads to more serious losses in function until the patient can no longer perform daily activities.

Damage does not have to occur to neurons for a person to experience a problem...

If the nerve impulses within your brain travel much faster than normal, a brain disorder may exist which is known as **epilepsy**. Under normal circumstances, neurons can carry nerve impulses at a rate of 80 impulses per second. During an epileptic seizure, these same nerve impulses may travel six times faster than its normal rate. This increased activity can cause a range of

behaviors ranging from relatively minor changes in sensations and behaviors to severe reactions including convulsions, seizures, or loss of consciousness.

Although a specific cause for epilepsy is not known, scientists have connected an imbalance in the amount of neurotransmitters (chemicals which allow neurons to communicate with each other or with neighboring muscle tissue) within the brain to this disorder.



What could happen if your head gets hit really hard?

Many problems can occur with a strong blow to the head. Let's first look at a couple situations that are not life-threatening...

Concussions and Amnesia

The term "concussion" is a general name given to any minor injury to the brain that is caused by a blow to the head. Typically, these injuries are not life-threatening and may cause a wide range of symptoms which may occur immediately or after a period of several days. A few of these symptoms may include the following:

Headaches, neck pain, confusion, difficulty remembering things, exhaustion, mood changes, loss of sleep, blurred vision, and ringing in the ears

A severe concussion can also cause **amnesia** which is the complete loss of memory that may be caused by a blow to the head. On some occasions, a patient may not be able to recall the moments before the trauma to their head has occurred. Other times, a patient is able to remember all of their previous memories up to the point of the trauma; however, they are unable to store any new long-term memories. In this second form of amnesia, a patient may have a partial or complete inability to recall the recent past. It is even possible for a patient to have both of these symptoms as well.

Since we are on the topic of the brain...

A huge amount of blood is needed by your brain to replenish the nutrients and remove wastes from all of its nerve cells. When a blood vessel that supplies blood to the brain becomes blocked, a condition called a **stroke** can occur.

Without a fresh supply of nutrients or a method of disposing of wastes, nerve cells immediately begin to suffer. This causes a series of symptoms including headaches, numbness on one side of the body, confusion or trouble speaking, seeing, walking, talking, and/or balancing. A stroke is to be considered very dangerous to a person's health. Medical treatment must be administered to any stroke victim immediately.

Let's look at some of the problems that can occur with our human senses!

Smell and Taste

Unfortunately, our ability to smell and taste our favorite foods begins to decline as we age. Of the two, our sense of smell takes a nose dive much faster (no pun intended) as the chemoreceptors in our nose are constantly exposed to the harsh conditions of the outside environment. Our sense of smell is also reduced as the number of taste buds in our mouth decreases beyond the age of 50. The interconnection between smell and taste is easy to discover when we have a cold. During this time the chemoreceptors in our nose are typically covered in a thick layer of **mucus** to protect our body from further infection. Without our ability to smell different odors, most food tastes bland. Mucus is a thick, slippery solution that is produced in several areas of the body and performs several different functions.



Hearing

Sound waves can be blocked from the central nervous system in two different ways:

Conduction deafness and Sensorineural deafness

In **conduction deafness**, damage within the middle ear prevents a nerve impulse from being created entirely. Injury to the three bones of the middle ear or the eardrum itself can be the cause of this type of deafness. If an injury occurs within or beyond the inner ear, a nerve impulse may be generated, but the damage prevents the signal from reaching the central nervous system. This blockage creates **sensorineural deafness** within the patient.

Both of these forms of deafness can be caused by a variety of sources. A few of these include disease, exposure to damaging chemicals, injury to the middle/inner ear from loud sounds, and genetic disorders.

A less serious condition with our hearing also exists for individuals who suffer from...**motion sickness**. This ailment takes place when our body undergoes rapid changes in speed and/or direction. This can also occur in some people when they not able to see a horizon in front of them such as when traveling along a hilly, winding road. Dizziness, fatigue, nausea, and vomiting can occur in people with motion sickness. These rapid changes in velocity can fool the mechanoreceptors within our middle ears which inform the central nervous system about our body position. These receptors may inform our brain that we are falling at times when a horizon line cannot be seen or when we accelerate rapidly. The results of this sensation can induce any of the conditions mentioned above.



Vision

There are a large amount of problems which may affect our sense of vision. For example, an individual with high blood sugar (known as *diabetes*) has an increased risk of damaging ones vision. The increased amount of sugar within the blood scratches the blood vessel walls within the retinas of the eyes. This damage can cause the blood vessels to burst within the eye which can cause scar tissue to form near the retina. If too much scarring builds up, the retina can detach from the eye causing blindness.

A different problem with our vision may occur which can be blamed on our DNA. Disorders within our genetic code are responsible for the inability to perceive one or more colors. This is known as **color blindness** and, as you learned in Chapter 11, is connected to the proper functioning of cones (photoreceptors within the retina) in our eyes. Without a proper way to detect the colors red, blue, and green, our central nervous system cannot accurately determine the various shades or blends of individual colors in the environment.

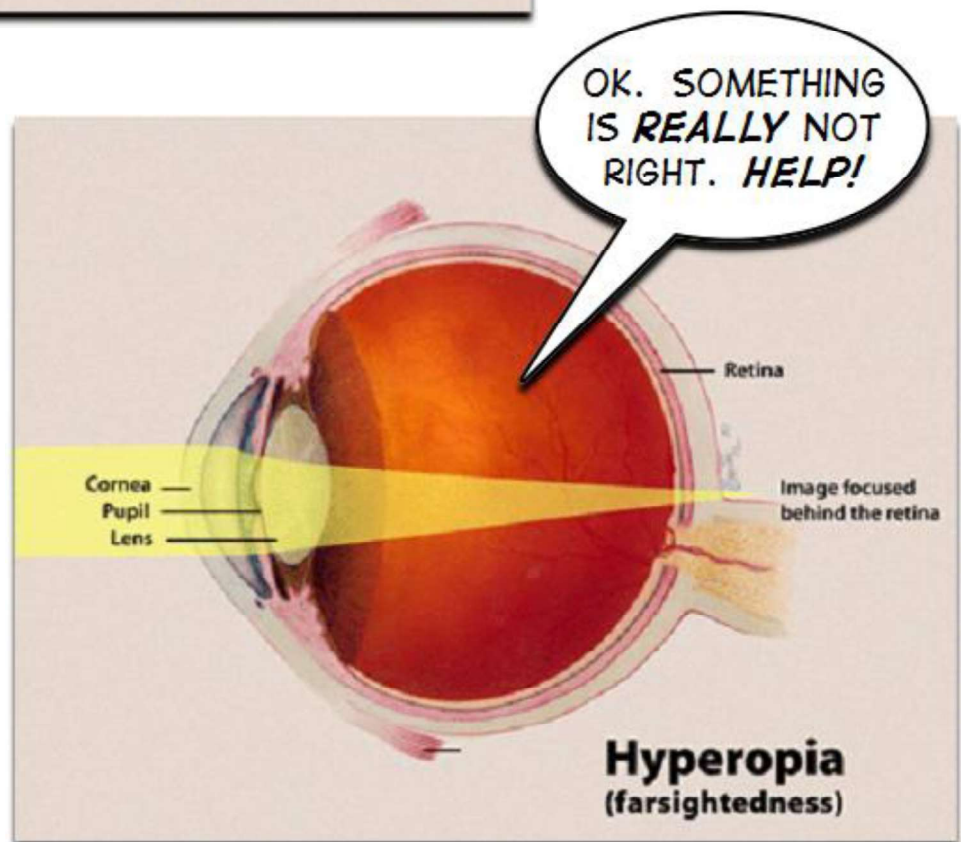
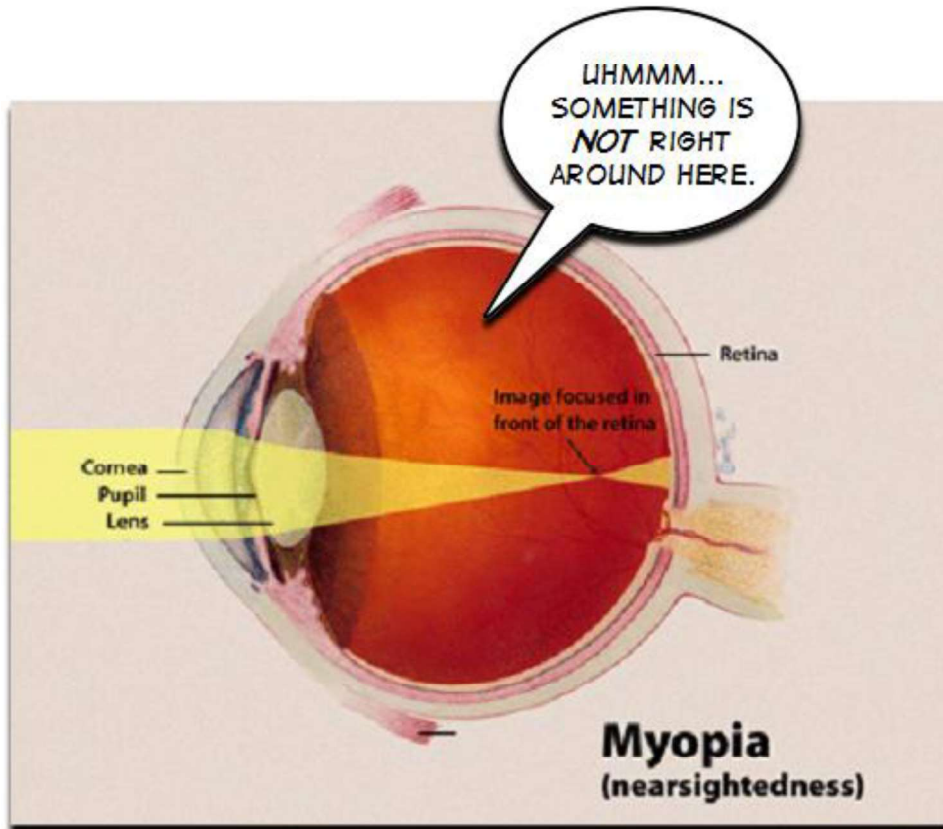
Two other issues pertaining to vision need to be mentioned:

Myopia (Nearsightedness)
and
Hyperopia (Farsightedness)

Nearsightedness is the ability to see objects near you, but not far away. As you can probably guess, **farsightedness** is the ability to see objects far away, but not near to you.

Both of these issues involve a defect in the eye which causes the images we see to be focused either too close or too far away from the lens. To help understand this situation, imagine using a magnifying glass over an object. In order to have an image focus through the magnifying glass, you likely have to move the glass up and down until the image becomes clearly visible.

This is similar to what happens within person with myopia or hyperopia. If your eyes cannot place the focused image onto each of the retinas, the image will remain blurry to the observer.

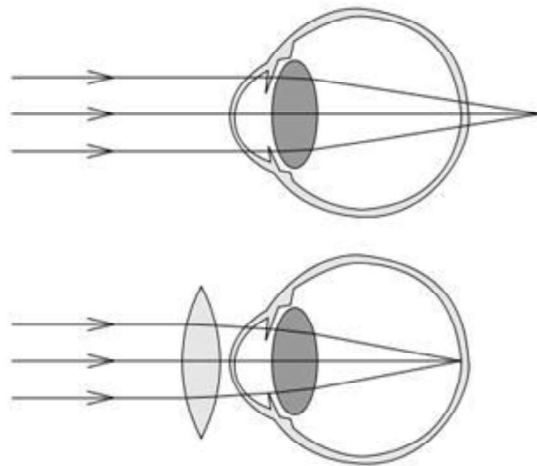


Corrective lenses such as glasses or contact lenses can be used to fix this problem. The different types of lenses which can be used to help these conditions include:

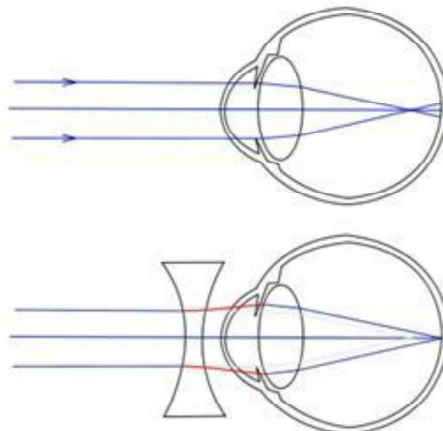
Concave lenses and Convex lenses

Concave lenses bend light outwards and is thinner in its center. If you look at something through a concave lens it appears smaller than it really is. On the other hand, **convex lenses** bend light inwards as they are thickest in the center. This type of lens makes objects appear much larger than they actually are. The lens of a magnifying glass is a convex lens. Convex lens are prescribed to lessen the effects of hyperopia.

Hyperopia and the restoring of vision with a convex lens



Myopia and the restoring of vision with a concave lens



Out of the massive amounts of problems which may exist within the endocrine system, we are only going to look at a few of the big issues.

Our first stop will be to look at how the process of aging affects the endocrine system.

Of all the processes of the endocrine system, it is the hormones associated with our reproductive system that are affected the most as we age. For example, the female ovaries decrease in size as a woman ages and no longer responds to the hormones FSH and LH, thereby causing a reduction in the secretion of estrogen in the body. Without the presence of estrogen, a woman's body cannot prepare physiologically for the act of pregnancy. On a different note, some tissues become less sensitive to being stimulated by hormones as we age.

Two separate disorders may exist within people who have abnormal levels of the human growth hormone (GH).

As you learned back in Chapter 12, human growth hormone targets nearly all muscle and bone tissues within the body to stimulate their growth. A child with a lower than average amount of growth hormone can expect to grow at a much slower rate and will likely result with a short physique in his/her life. On the opposite side, a child can expect to grow very tall (over 7 feet/2.1 meters) if an abnormally large amount of growth hormone is produced during and beyond adolescence. This is known as **gigantism** and can result in excessive thickening of the head, hands, and feet as well.

Let's take a look at disorders which affect the thyroid gland.

An individual producing excessive amounts of the hormones thyroxine (T_3) and triiodothyronine (T_4) from an overactive thyroid is said to have **hyperthyroidism**. As you learned in Chapter 13, these two hormones act to increase the rate in which cells use oxygen and nutrients to produce energy. Therefore, an increase in these hormones can produce symptoms such as sudden weight loss, rapid heartbeats, nervousness, irritability, and increased sweating.

You also learned that our thyroid gland is similar to a car which takes in fuel and turns it into T_3 and T_4 hormones which influence how much energy gets transmitted throughout the body. Therefore, during hyperthyroidism, the "car" gets revved up but it doesn't go anywhere. There's lots of energy being released, but it's not doing anything practical.

But what if your "car" doesn't start or is sputters?

This would be an analogy to another thyroid disorder - **hypothyroidism**. An individual with hypothyroidism produces lower than average amounts of T_3 and T_4 hormones. This produces feelings of fatigue and coldness, dry skin and hair, weight gain, and muscle cramps.

The "car" is filled with fuel but is unable to convert it into the energy needed to make it move. Both hyperthyroidism and hypothyroidism may cause the thyroid to grow very large which is known as a **goiter**. While we are on the topic of energy, let's wrap up this chapter with one final disorder that was mentioned earlier....

Diabetes

Diabetes is a medical condition which is caused by the inability of the pancreas to produce or utilize the hormone insulin. As you learned in Chapter 13, insulin helps cells absorb excess sugar within the bloodstream. Without insulin, the amount of sugar within the blood increases significantly. This excess sugar is then forced out of the body through the urine and cannot be utilized as an energy source for the cells within our body. This can be a very serious problem for the body!

As was mentioned earlier, this is just a brief look into some common disorders which affects our nervous and endocrine systems. We could spend the rest of the year studying just these few conditions alone without mentioning the hundreds of other disorders that exists within these two systems.



I hope some of you will consider a more thorough study of these medical conditions in your future careers! We need scientists and doctors out there who are able to study these debilitating conditions.

Match the following vocabulary terms with their correct definition:

Alzheimer's disease
 amnesia
 autoimmune disease
 color blindness
 concave lenses
 concussion
 conduction deafness
 convex lenses

diabetes
 epilepsy
 gigantism
 goiter
 hyperopia
 hyperthyroidism
 hypothyroidism
 lidocaine

local anesthetics
 motion sickness
 mucus
 multiple sclerosis (MS)
 myopia
 novocain
 sensorineural deafness
 stroke

- 1) _____ a condition in which a vessel that supplies blood to the brain becomes blocked, inducing a series of potentially life-threatening symptoms
- 2) _____ a condition where the body attacks its own healthy cells
- 3) _____ a disease in which changes within neurons cause the death of a large number of cells within the brain
- 4) _____ a form of deafness in which an injury occurs within or beyond the inner ear; a nerve impulse may be generated, but the damage prevents the signal from reaching the central nervous system
- 5) _____ a form of deafness; caused by damage within the middle ear which prevents a nerve impulse from being created
- 6) _____ a general name given to any minor injury to the brain that is caused by a blow to the head
- 7) _____ a medical condition which is caused by the inability of the pancreas to produce or utilize the hormone insulin

- 8) _____ a thick, slippery solution that is produced in several areas of the body; its functions are varied and plays an important role in several body systems
- 9) _____ condition caused by an abnormally large amount of growth hormone being produced during and beyond adolescence
- 10) _____ condition caused by the overproduction of the hormones thyroxine (T_3) and triiodothyronine (T_4)
- 11) _____ condition caused by the underproduction of the hormones thyroxine (T_3) and triiodothyronine (T_4)
- 12) _____ condition in which the thyroid has grown very large; can be caused by hyper- or hypothyroidism
- 13) _____ disease in which a neuron's myelin is destroyed or lost; causes serious problems within the muscular system by slowing down or completely blocking the ability of muscles to function
- 14) _____ disorder of the brain; characterized by nerve impulses within the brain traveling much faster than normal
- 15) _____ lens which bends light inwards; its structure is thickest in its center
- 16) _____ lens which bends light outwards; its structure is thinnest in the center
- 17) _____ local anesthetic used for tooth pain
- 18) _____ local anesthetic used to numb the surface of the skin
- 19) _____ minor condition caused when the body undergoes rapid changes in speed and/or direction

- 20) _____ numbing agents which block the sensation of pain by keeping sodium ions from entering and leaving the cell membranes of neurons
- 21) _____ the ability to see objects far away, but not near to you
- 22) _____ the ability to see objects near you, but not far away
- 23) _____ the inability to perceive one or more colors
- 24) _____ the loss of memory that may be caused by a blow to the head

Choose the correct answer from the following questions:

- 1) Your friend Shelly suffers from myopia (nearsightedness). You remember from your physics class that concave lenses cause light waves to spread or diverge and that convex lenses cause light waves to converge. What type of corrective lenses would you suggest to your friend - concave or convex lenses?

- 2) Excess secretion of growth hormone after long bone growth has ended (as an adult) is called:
 - A) dwarfism
 - B) epilepsy
 - C) gigantism
 - D) hyperthyroidism

- 3) The inability to see distant objects is termed "nearsighted" or:
 - A) goiter
 - B) myopia
 - C) hyperopia
 - D) astigmatism

- 4) Sensorineural deafness occurs when there is damage within or beyond the:
 - A) inner ear
 - B) middle ear
 - C) outer ear

Application Question:

As a person ages, the speed of nerve impulses through action potentials and the transmission of neurotransmitters decreases. List at least two possible explanations for this occurrence.