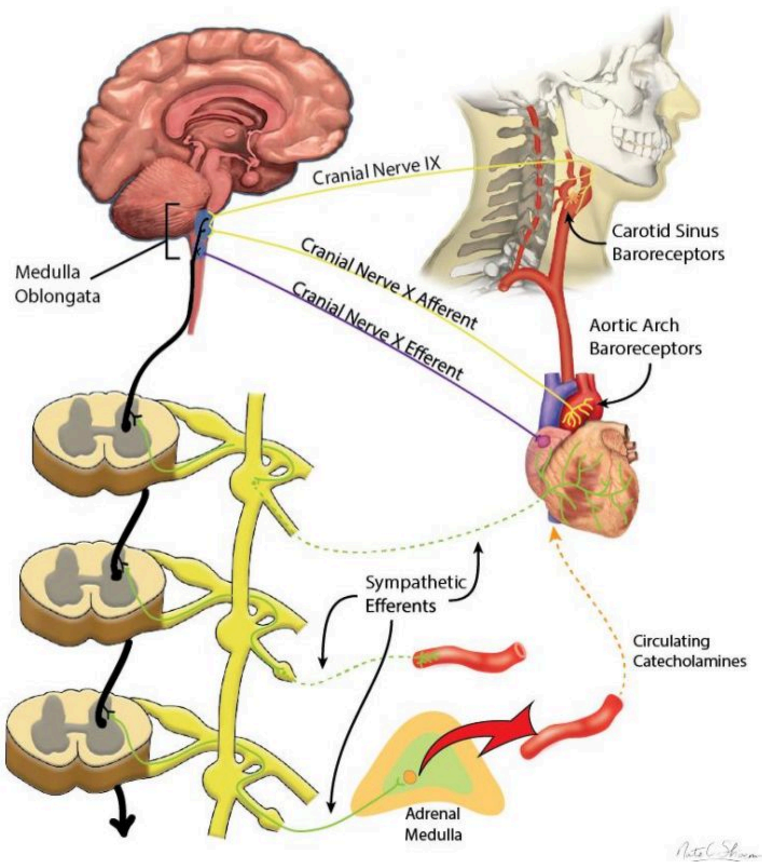
1.5.4

Baroreceptor and Chemoreceptor Reflexes

The Baroreceptor Reflex: The ultimate role of the heart is to create sufficient pressure (MAP) to ensure that blood flow to the body's tissues is maintained. Some tissues, like the cells of the brain and the cardiac muscle cells themselves, cannot survive for very long without a constant supply of blood. For example, brain cells die after only 4 or 5 minutes without oxygen. The baroreceptor reflex plays a key role in the short-term regulation of blood pressure. Like all reflexes, there are five components to this mechanism. We will describe the components and then explain what happens when there is a sudden change in blood pressure.



Baroreceptor Reflex.*Image modified by Nate Shoemaker (Spring 2016) using the following Wikimedia images: Title: Brain Anatomy (Sagittal) Author: BruceBlaus Site URL: https://commons. wikimedia.org/wiki/File:Brain _Anatomy_(Sagittal).png License: Public domain Title: Cervical vertebrae lateral2 Author: Was a bee Site URL: https://commons. wikimedia.org/wiki/File:Cervical _vertebrae_lateral2.png License: Public domain Title: Cervical vertebrae lateral2 Author: Was a bee Site URL: https://commons. wikimedia.org/wiki/File:Cervical _vertebrae_lateral2.png License: Public domain*

1. **The receptors:** For this reflex the receptors are **baroreceptors** (pressure receptors) that reside in the arch of the aorta and in the carotid sinuses. The carotid sinuses are located in the internal carotid arteries immediately distal to the bifurcation of the common carotid arteries. These receptors are stretch receptors whose rate for generating action potentials is proportional to blood pressure, increased blood pressure results in increased stretch and an increased frequency of action potentials. Conversely, a drop in blood pressure decreases the frequency of action potentials generated by the receptors.

2. **Afferent pathway:** Action potentials from the carotid sinus receptors are transmitted to the brainstem via cranial nerve IX (glossopharyngeal) while action potentials from the aortic arch receptors are transmitted via cranial nerve X (Vagus)

3. **Integrating center:** Located in the medulla of the brain stem are the **cardiovascular centers** that regulate the rate and strength of contraction of the heart, as well as the diameter of the systemic blood vessels (primarily the arterioles).

4. **Efferent pathway:** Parasympathetic fibers extend from the cardiovascular centers of the medulla to the heart via the Vagus nerve. Sympathetic fibers travel through the cardiac sympathetic nerves to the heart. In addition, sympathetic fibers also project to the adrenal medulla where they stimulate the release of epinephrine and norepinephrine into the blood.

5. **Effector organ:** The effector organ in this reflex is the heart which can respond by increasing or decreasing cardiac output through changes in heart rate and strength of contraction. It should be pointed out that another effector organ in this reflex are the systemic arterioles. Their role in regulating blood pressure will be explained in the unit on blood vessels.

Now we will describe what happens when there is a sudden change in blood pressure. All of you have probably had the experience of quickly standing up and suddenly feeling light headed. This feeling is due to a transient decrease in blood flow to the brain. Fortunately, this happens only occasionally in most people. The reason you normally don't get light headed when you stand is due to the baroreceptor reflex. When we stand, blood flow to the brain decreases due to gravity. Venous return decreases, cardiac output decreases and blood pressure decreases. This is immediately sensed by the baroreceptors as they are stretched less. The reduced stretch results in a lower frequency of action potentials being transmitted to the cardiovascular centers, which is interpreted as a drop in blood pressure. The cardiovascular centers respond by decreasing parasympathetic activity and increasing sympathetic activity. These changes result in an increased rate of contraction as well as an increase in the strength of contraction, which increases cardiac output and restores blood flow to the brain. The reflex can respond within about two heartbeats of the time of the change. Take a moment and try a little experiment. While sitting quietly find the carotid pulse in your neck with your index finger. After you have an idea of how fast your heart is beating, quickly stand and see if you can detect a change. What happened when you stood up? Alternatively, you could try this experiment. Pick a Sunday when you are trying to catch up on sleep and after one of those 7-hour naps, suddenly jump up off the bed and see how far you can run before you slip into unconsciousness. You probably want to make sure your runway is clear of hard and sharp objects. One more assignment: see if you can explain the series of events that would take place if there were a sudden increase in blood pressure.

Chemoreceptor Reflex: We have just described what happens when blood flow to the brain changes. However, there may be situations when blood flow doesn't change but the amount of oxygen delivered to the tissues decreases. This would happen if the oxygen content of the blood were to change and carbon dioxide levels increase, such as when there is respiratory distress due to illness or even in the normal adjusting to different altitudes of varying oxygen content. One way to maintain oxygen delivery even if the blood oxygen content is decreased would be to increase blood flow to the tissues. The chemoreceptor reflex works to ensure sufficient delivery of oxygen when blood gas levels change. Located near the baroreceptors in structures called the **carotid and aortic bodies,** are chemoreceptors that respond to changes in oxygen, carbon dioxide, and hydrogen ions (pH) in the blood. When there is a decrease in oxygen, an increase in carbon dioxide or an increase in hydrogen ions these receptors are stimulated (the reflex circuitry is the same as for the baroreceptor reflex). Stimulation of the chemoreceptors results in an increase in cardiac output which delivers more blood to the tissues providing sufficient oxygen while at the same time increasing blood flow to the lungs to provide for adequate gas exchange. Although this reflex does influence cardiac output, it plays a much greater role in regulating the respiratory system, which will be discussed in a later chapter.

Clinical Note

Another important factor in the regulation of cardiac activity is the level of ions in the extracellular fluids. The generation and conduction of action potentials as well as the movement of calcium ions is crucial to normal functioning of the heart. As we have seen previously, the concentrations of certain ions in the extracellular fluid can have a huge impact on the actions of excitable tissues. Of particular importance, is the concentration of potassium in the extracellular fluids. Normal extracellular potassium ion concentrations are 3.5 - 5.0mM. A Concentration of <3.5mM is considered hypokalemia while a concentration of >5mM is considered hyperkalemia. Both conditions can be life threatening.

Hyperkalemia results in depolarization of the membrane potential. This affects the electrical activity of the heart and early signs are changes in the EKG, such as tall, peaked T waves, increased duration of the PR interval and widening of the QRS complex. If left untreated, the hyperkalemia can eventually result in asystolic cardiac arrest.

Hypokalemia, on the other hand, results in hyperpolarization of membranes. The heart muscle cells are particularly sensitive to hypokalemia and severe conditions can result in ventricular arrhythmias and again asystole or cardiac arrest.