Chapter 15

Blood – Part 1

During the next few weeks, we will be exploring the primary method of how our body transports nutrients, wastes, and other various chemicals. And since we are talking about transportation, we are going to need some form of vehicle to get us from point A to point B. Therefore, our next two chapters will be dealing with this amazing vehicle commonly known as...

Blood

Way back in Chapter 2 we explored the following question:

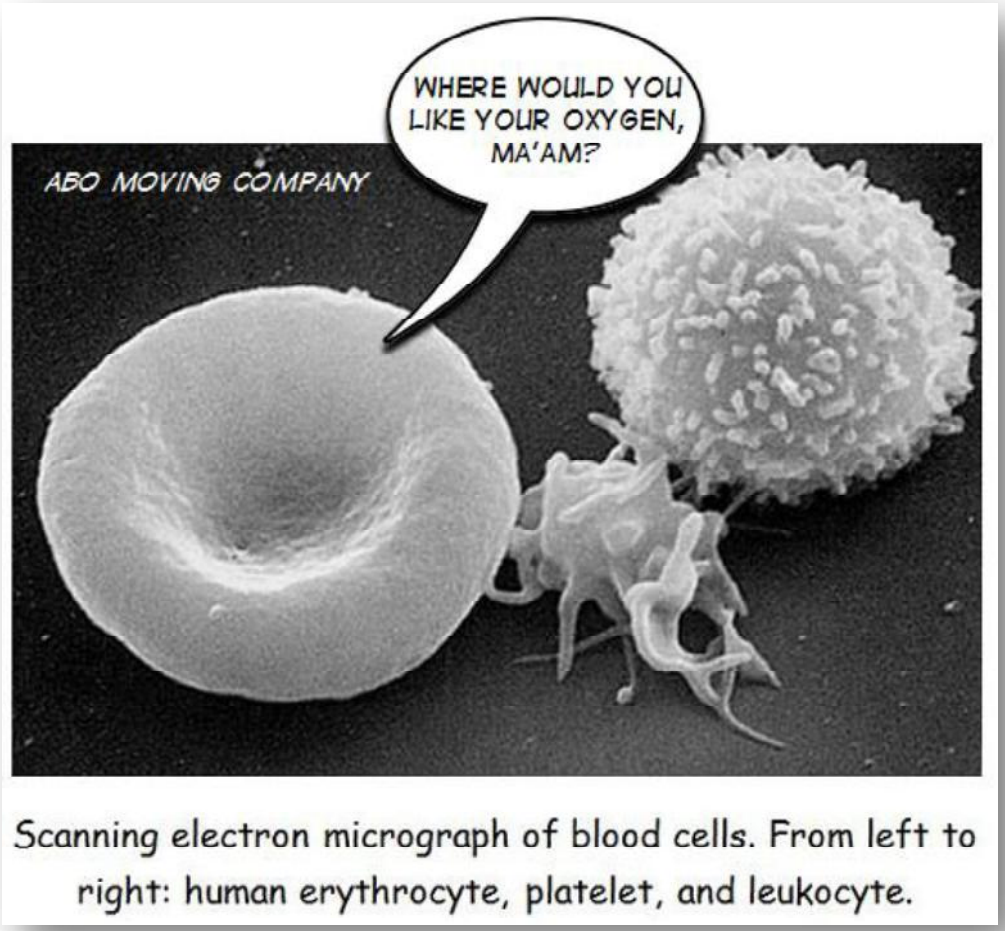
How can blood be considered a tissue?

Our blood is a form of connective tissue as it is a combination of various types of cells, cell parts, and a fluid called plasma which contains several dissolved substances as well. Although there are many different things floating around in our blood, we will be spending most of our time on the following four substances:

Red blood cells (erythrocytes),
White blood cells (leukocytes),
Platelets,
and **Plasma**

The function of all these items help to move things throughout our bodies, regulate homeostasis by maintaining a constant body temperature, pH, and blood pressure, and protect us from various forms of infection. As you learned in Chapter 4, all of the solid particles within our blood (red blood cells, white blood cells, and platelets) are formed through a process called hematopoiesis that occurs within the red bone marrow of our bones.

Let's take a closer look at each of the solid particles in more detail...



Scanning electron micrograph of blood cells. From left to right: human erythrocyte, platelet, and leukocyte.

Red blood cells (erythrocytes)

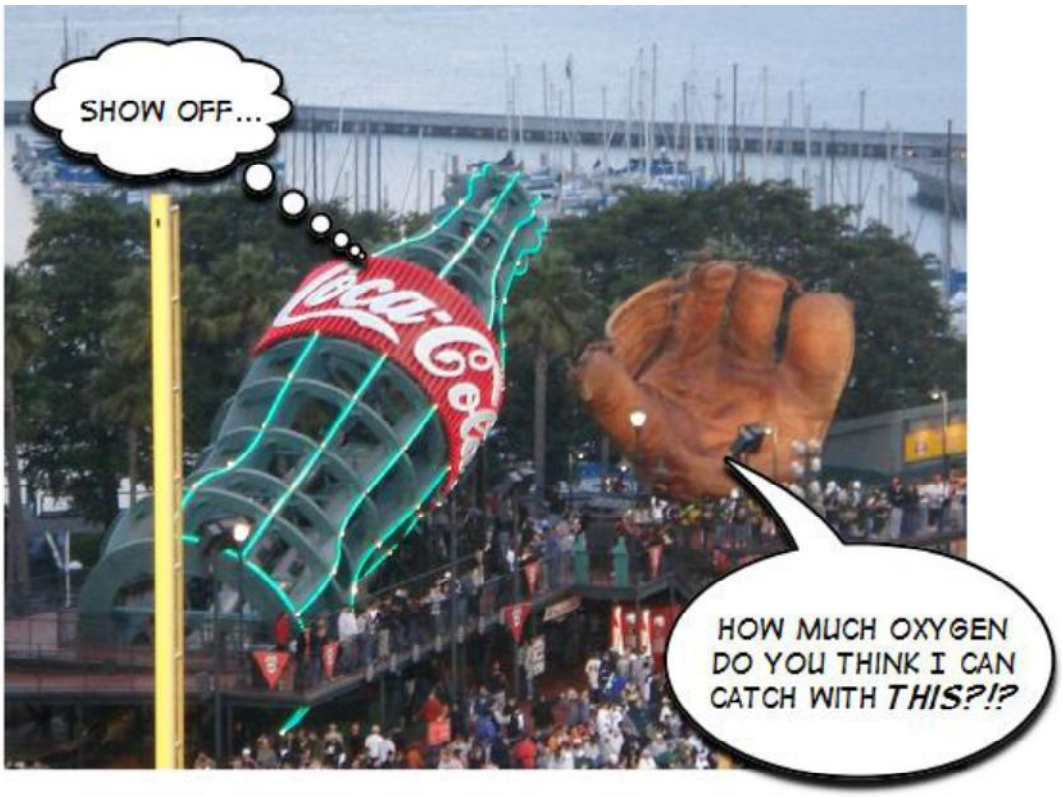
The shape of **red blood cells (RBC)** has been compared to that of a flattened hamburger bun or donut. This shape allows the cells to stack on top of each other easily and to squeeze through very narrow blood vessels. In addition, this shape also allows for the maximum amount of gases to pass through its membrane as we will explore very shortly.

The red blood cells make up nearly one-third of all the cells in the body and almost all of the solid material found in the blood. In fact, if you were to stack all of the red blood cells in your body like crackers in a tube, you could stretch that tube around the Earth 1.25 times. That is about 31,000 miles (49,890 kilometers) in length!

One of the main functions of the red blood cells is the transport of oxygen and carbon dioxide gases. This is accomplished through a protein within each cell called **hemoglobin**. Think of hemoglobin as four baseball gloves stitched together.

Why baseball gloves?

Because each glove has the ability to "catch" or "bind to" a single molecule of oxygen gas



Within each of these "gloves" is another smaller molecule known as **heme** which contains an atom of iron in its center. Iron has a tendency to bind with oxygen very easily. In fact, when iron binds with oxygen a new molecule is formed which is known as iron oxide. I am certain you have seen iron oxide in your life because it has a very distinctive brown color, and a very familiar name...

Rust

That's right! Those scabs which form over cuts on the surface of your skin that eventually turns brown are actually molecules of rust! And since each red blood cell contains approximately 280 million hemoglobin molecules, a single red blood cell has the ability to carry more than one billion oxygen molecules!

Homeostasis plays an important role in the production of red blood cells as it is directly linked to the amount of oxygen within our body.

When the hormone **erythropoietin** is released into the blood, it signals the skeletal system to increase the rate of red blood cell production. How does the body determine when this is needed? The release of erythropoietin is triggered when the body detects a low level of oxygen within the blood.

There are times when the blood does not contain a safe amount of oxygen gas.

For example, a dangerous condition known as **anemia** occurs when a person has a low level of red blood cells or hemoglobin. Without plenty of these tiny oxygen transporters, the body will not contain enough of this important gas. Another example of how low oxygen levels in the blood can occur is when an individual is placed in high altitudes. Locations in higher altitudes contain lower amounts of atmospheric gases, including oxygen.

If you live in an area that is close to sea level and vacation to a location that is much higher in elevation, you likely felt the effects of a decreased amount of oxygen – headaches, muscle cramps, and exhaustion are normal if you decide to physically exert yourself immediately upon arrival. Typically, a couple of restful days within a higher elevation will help your body acclimate to the low oxygen levels. Then you can consider that early morning jog!

What is the lifespan of a red blood cell?

Red blood cells only exist for approximately four months within the human body before they become worn down and break apart. Each of these cells undergoes a huge amount of damage in their short life span. In fact, nearly 150 million red blood cells are being destroyed every minute.

White blood cells (leukocytes)

We could spend a full year studying the various types and functions of the **white blood cells**. As the key players within the immune system you would think their presence within the body would be amazing. This, however, is not entirely true. Less than one percent of our blood is made up of leukocytes whose function is to protect us from foreign invaders that find their way into our bodies. These tiny protectors utilize a wide array of mechanisms to identify and attack unwanted objects in the body. Some white blood cells, which we will discuss in future chapters, are known as **phagocytic cells** which literally mean "cells that eat." I'll let your imagination run wild with that one until our study of the immune system.

Until then...

When compared to red blood cells, leukocytes make up a very small amount of space within the blood. But don't let that fool you! Consider this fact, if you were to make a cube that is one millimeter in length, width, and height (one cubic millimeter) you would find a staggering ~10,000 of these hungry cells!

That is a fairly impressive number even though you would find nearly 5 million red blood cells in that same cubic millimeter.

Why aren't leukocytes found in greater numbers throughout the blood stream?

Well, as you learned in Chapter 7, pathogens such as bacteria begin to grow rapidly in damaged connective tissues such as when we cut our skin. This damage causes inflammation to take place and is a location where white blood cells are needed very quickly.

It is true that white blood cells are found within the bloodstream; however, these defenders typically use the blood for rapid transportation between organs and other tissues during an inflammatory response to our internal systems. Typically, white blood cells are found within the connective tissues of the body. And even though they are not found in the bloodstream for long periods of time, some types of leukocytes have life spans that can be measured in decades! You'll have to wait until our study of the immune system to learn more about these amazing cells. Until then, let's move to our last type of cell found within the blood...

Platelets

Much like red and white blood cells, **platelets** are formed within the marrow of our bones. However, the contents and functions of these unique cells are much different than its counterparts. One of these differences can be found in its lifecycle. The life expectancy of most platelets is around 7-12 days, which is considerably shorter than the 120 days of a typical red blood cell and the old-timers of the blood stream (aka – the leukocytes).

Despite their relatively short life spans, the structure and function of platelets separate them considerably from both red and white blood cells. Platelets are membrane-bound "packets" of cytoplasm – a gel-like substance that fills up a cell and holds all the cell's internal organelles. Many dissolved molecules along with the proteins actin and myosin (check back in Chapter 6 for a review) can be found within the cytoplasm, all of which play a role in the two main functions of platelets:

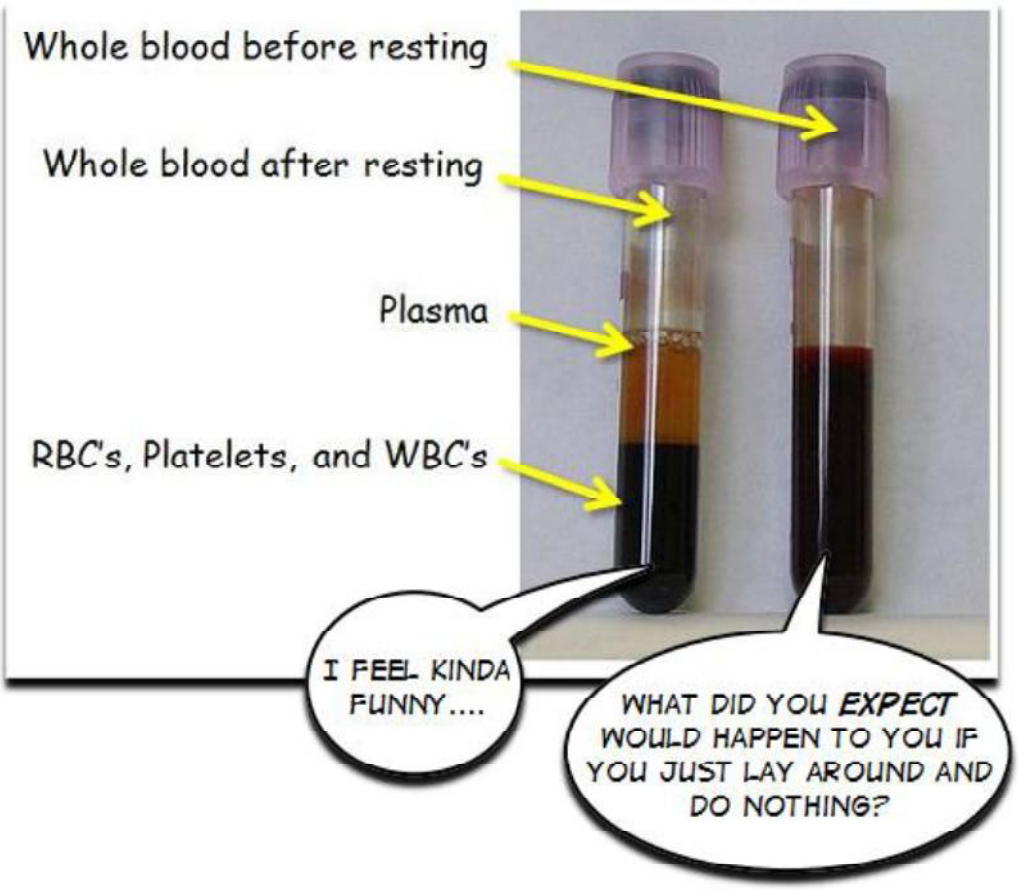
#1: Platelets temporary patch the walls of damaged blood vessels and control the **clotting** of blood.

Whenever a blood vessel is damaged by cuts or other forms of injury, platelets act to plug up the broken vessels, reducing the amount of blood loss. This "plug" of platelets is known as a **blood clot**. Blood clots must form if we are to stop bleeding after an injury; however, harmful blood clots can also form which can cause serious damage. For example, if a blood clot dislodges and travels to the brain, it can cause a stroke which you explored in the last chapter.

**There is another player in the formation of a blood clot, but you are going to have to wait until next chapter to find out who this is. Stay tuned!*

#2: Platelets help to seal breaks in the walls of our blood vessels.

Platelets contain actin and myosin, the proteins found within the sarcomeres of muscle cells which contract to allow muscular movement (check back in Chapter 6 for a review.) As platelets plug up the damaged blood vessels, they begin to contract due to their high concentration of actin and myosin. This contraction pulls the platelets, and the blood vessels they are attached to, closer together. Thus, the contractive properties of platelets help to seal up blood vessels that have been injured.



The amount of platelets in the blood is considerably higher than those of the white blood cells; however, they only make up a small fraction of the total blood volume. In any sample of blood, the number of platelets makes up about 10% of the number of red blood cells in that volume. For example, if 5 million red blood cells are found within one microliter of blood, the same volume of blood would contain ~500,000 platelets.

That finishes our study of the solid particles found within our blood. In the next chapter we take a closer look at the fluid component of blood and how various types of this tissue are shared by people throughout the world.

Match the following vocabulary terms with their correct definition:

anemia	**heme**	**platelets**
blood clot	**hemoglobin**	**red blood cells**
erythropoietin	**phagocytic cells**	**white blood cells**

1)	_____	"cells that eat"
2)	_____	a "plug" of platelets within a damaged blood vessel
3)	_____	a dangerous condition occurring when a person has a low level of red blood cells or hemoglobin
4)	_____	hormone which is released into the blood and signals the skeletal system to increase the rate of red blood cell production
5)	_____	iron-containing molecule found within hemoglobin
6)	_____	major component of blood; responsible for transport of oxygen and carbon dioxide gases throughout the body
7)	_____	phagocytic cells within the blood ; major component of the immune system
8)	_____	protein within red blood cells consisting of heme which binds to a single oxygen gas molecule
9)	_____	short-lived packets of cytoplasm and dissolved molecules within the blood; assist in the immune response to the vessels of the cardiovascular system

Choose the correct answer from the following questions:

1) The hormone that regulates the rate of erythrocyte production is called:

A) renin
B) vasopressin
C) erythropoietin
D) leukopoietin

2) Which one of the following formed elements is the most abundant:

A) platelets
B) leukocytes
C) erythrocytes
D) white blood cells

3) Blood cell formation is called _____ and occurs within the bone marrow.

A) hemolysis
B) heme
C) hematopoiesis
D) hemoglobin
E) hemostasis

4) The average functional lifespan of a red blood cell is:

A) the body's lifetime
B) 50-75 days
C) 100-120 days
D) one year
E) 20-30 days

5) **There are an average of _____ white blood cells per cubic millimeter of whole blood.**
   A) 100-1000
   B) 4000-11,000
   C) 11,000-20,000
   D) 50,000-100,000
   E) 1 million-3 million

6) **True or false:** Erythropoietin is released to stimulate white blood cell production in response low levels of oxygen within the blood.

7) **True or false:** Leukocytes are more numerous in blood than erythrocytes.

Application Question:

Some people use chemicals known as barbiturates to reduce feelings of anxiety. Barbiturates cause hypoventilation, which is a reduced rate of breathing, because they decrease the activity of the parts of the brain responsible for our breathing. What do you suppose happens to the red blood count of a habitual user of barbiturates? Defend your answer.