Before we start exploring the liquid part of blood...

Plasma

...let's take a quick look at some information about the general properties of our blood:

Volume

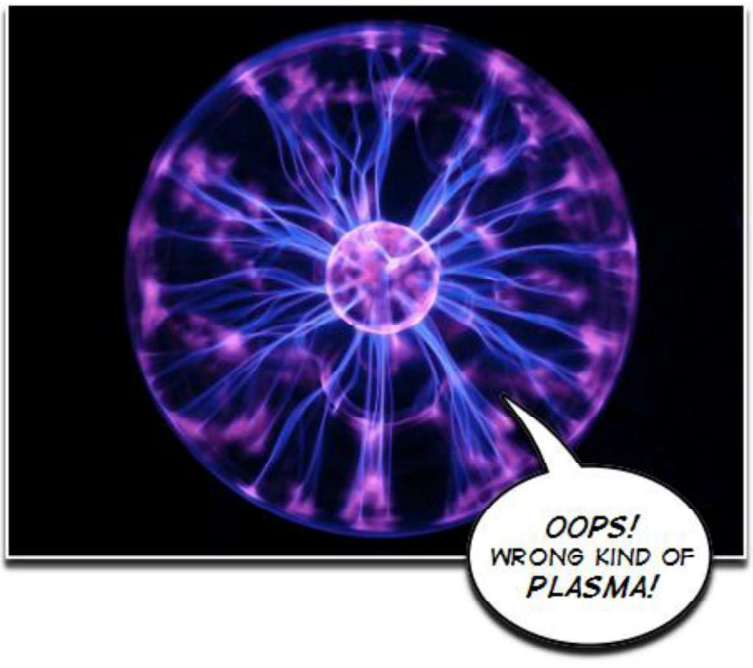
An adult male contains 5–6 liters (5.3–6.4 quarts) of whole blood while an adult female contains 4–5 liters (4.2–5.3 quarts).This difference in blood volume is due to the larger average body size of males.

Temperature

Blood temperature is about 38˚C (100.4˚F). This temperature is slightly above the normal body temperature of 37˚C (98.6˚F). The extra heat within the internal blood is spread throughout the body before it reaches the epidermal layers of our skin.

Thickness

The **viscosity** of blood is roughly five times that of water. Viscosity refers to the relative thickness of a fluid. The high volume of solid particles, dissolved proteins and other molecules within the plasma give blood the consistency of a sticky and thickened fluid.



pH

Blood is slightly alkaline (non-acidic), with an average pH of 7.4.

In the last chapter, you explored the solid particles which make up blood:

Red blood cells, White blood cells, and Platelets

All of these solid particles float within a fluid known as plasma which takes up nearly half (46-63%) of the total volume of blood. Within this fluid, three main proteins can be found which are all produced by the *liver* (an organ of the digestive system you will learn about in Chapter 25):

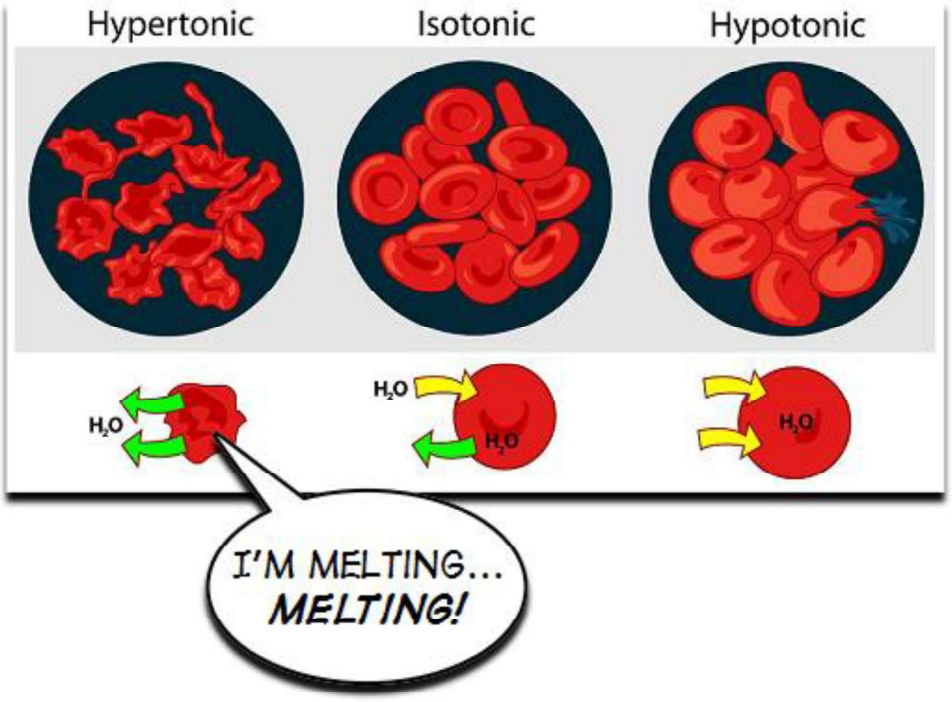
Albumins, Globulins, and Fibrinogen

Albumins

Albumins make up close to 60% of the plasma proteins. The relatively large numbers of these proteins help to keep water from leaking out of the blood vessels by "plugging up" the tiny holes which exist within its walls. It can be said, therefore, that albumins regulate the **osmotic pressure** of our blood. Osmotic pressure is defined as the pressure needed to prevent water from moving through a permeable substance (like our blood vessels). This movement of water across a permeable substance (osmosis) requires a couple of important definitions first:

*All substances (such as albumins, glucose, red and white blood cells, etc.) that are found floating within the fluid plasma are known as **solutes**. The liquid that holds these solutes together is known as the **solvent** and is primarily the water found within the plasma itself. When you have a mixture of a solute and a solution, scientists call this a **solution**. By this definition, blood is to be considered a solution.*

*Solutions containing fewer solutes as compared to another fluid which are separated by a permeable membrane are known as **hypotonic**; solutions with more solutes as compared to another fluid are known as **hypertonic**; and, solutions with equal concentrations of solutes are known as **isotonic**.*

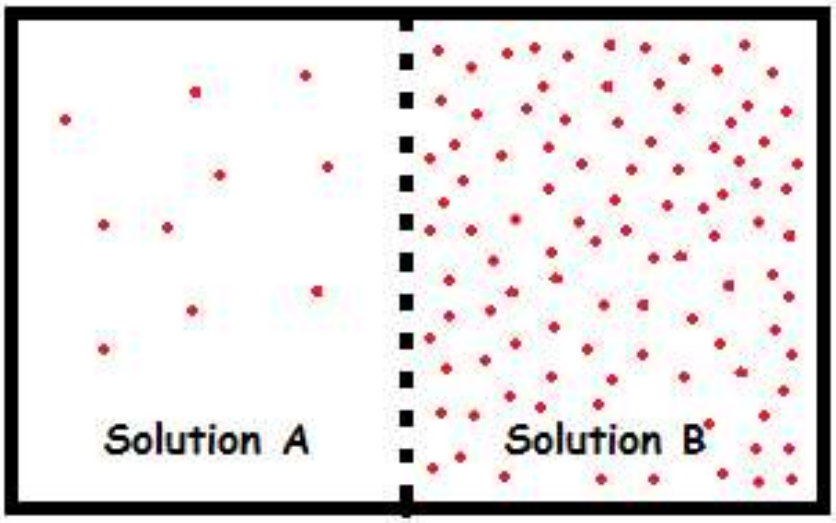


Now that you understand how a solute gets dissolved by a solvent to make a solution, let's take a look at how you can best remember the movement of water through the process of osmosis:

Water flows from the solution with the lower solute concentration into the solution with higher solute concentration. This flow will continue until the concentrations on both sides are equal and are considered isotonic.

Here's an example of how osmosis works:

Let's represent the porous walls of a blood vessel as the dotted line in the center of the drawing below. "Solution B" represents the inside environment of the blood vessel and is filled with albumins and other plasma proteins swimming in a sea of water. This solution would be considered hypertonic. "Solution A" is the outside environment of the blood vessel. It, too, is filled with water and represents any number of various tissues within the body; however, its concentration of solutes is not nearly as high as represented by the fewer red dots. This makes Solution A hypotonic as compared to Solution B. Given the uneven amounts of proteins inside the blood vessel and the presence of water on both sides of the blood vessel wall, which direction will the water flow?



If you said the water would flow from Solution A into Solution B you would be correct! Within Solution B, some of the pores within the wall get "plugged up" with plasma proteins; however, this does not happen in Solution A. Therefore, water is more likely to flow from Solution A into Solution B. The presence of more solutes in Solution B causes the osmotic pressure of this solution to be greater than in Solution A.

Globulins

Globulins are the second most abundant proteins within the plasma (35%). The functions of the globulins are twofold:

Protection and Transport

One specific type of globulins are known as **antibodies** (also known as **immunoglobulins**) and do a very good job at attacking foreign invaders that find their way into the bloodstream. If you are thinking this action is similar to the white blood cells' protective qualities, you would be correct as antibodies are created by white blood cells!

Transport globulins bind to important compounds that may otherwise be excreted out of the body. Thyroid hormones, testosterone, and the element iron utilize transport globulins as "taxis" to circulate throughout the body.

Fibrinogen

Fibrinogen works with the platelets in our blood to help with the formation of a blood clot. Fibrinogen normally accounts for roughly 4% of plasma proteins. When blood vessels become damaged, as you learned last week, platelets act to plug up the holes.

However, platelets need some form of support in order to hold together. This is the function of fibrinogen. As more and more fibrinogen proteins assemble around the plug of platelets, they become intertwined and begin to form long strands which are called **fibrin**. It is fibrin which provides structural support to the platelets at the site of injury.

As fibrinogen goes through the process of becoming fibrin, it is removed from the plasma and attaches itself around the platelets. Thus, the plasma which exists downstream from the site of an injury contains no cells or molecules needed to form a blood clot and is known by another name - **serum**.

Basically, plasma is whole blood without any red blood cells, white blood cells and platelets...

...while serum is plasma without any fibrinogen.

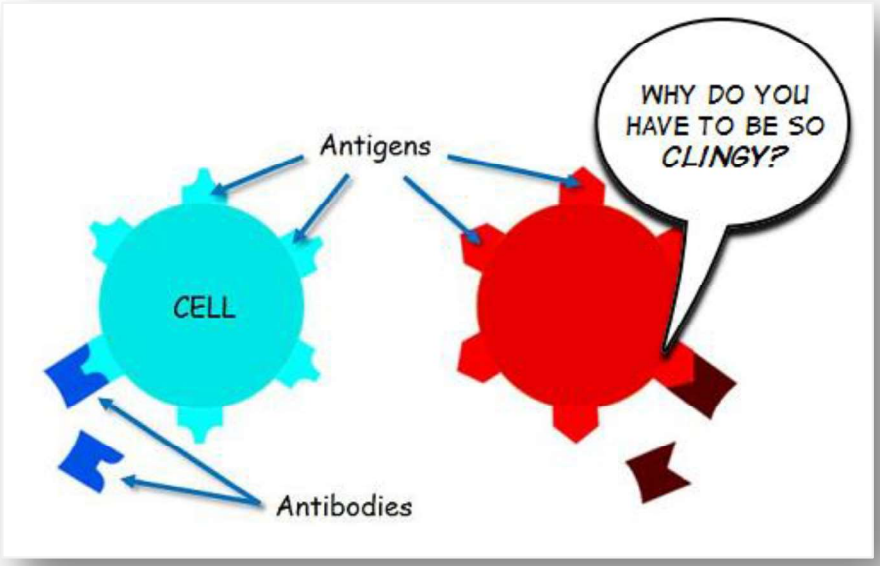
Why is this important?

That is a good question! Plasma and serum are used by doctors and researchers for entirely different purposes. Plasma is collected from whole blood that is donated by individuals and provided to patients who are in need of the vital plasma proteins. In addition, plasma can be tested for the presence of various diseases. Serum is typically used to test for an individual's **blood type** and will be explored throughout the remainder of this chapter.

Back in Chapters 11 and 12, you explored how target cells utilize a "lock and key" method of detecting specific hormones and/or other molecules. This is due to the fact that target cells have special receptors (locks) on their outer membranes that fit specific "keys" located on individual hormones/molecules. This is going to help you out as you explore the topic of...

Blood types

All red blood cells contain specific "locks" on their outer surface which are referred to as **antigens**. Your blood type is determined by the presence or absence of three different surface antigens which are labeled as A, B, and Rh.



Based upon the presence of the A and B surface antigens, every individual has only one of four possible blood types:

Type A blood has surface antigen A only,

Type B has surface antigen B only,

Type AB has both A and B,

and Type O has neither A nor B.

In regards to the Rh surface antigen, the term Rh positive (Rh+) indicates the presence of the Rh surface antigen, also known as the **Rh factor**. The absence of this antigen is indicated as Rh negative (Rh–). When an individual's blood type is recorded, the term Rh is usually omitted, and a positive or negative sign is used in its place. For example, a person with Type A blood and a positive Rh factor, their blood type is recorded as A positive (A+).

Bad things may happen if you receive blood with the wrong antigens!

If you recall, you have antibodies (globulins) that are floating around your plasma and attacking foreign invaders that enter your blood stream. If you have Type A blood, your plasma contains anti-B antibodies which will attach to and attack Type B surface antigens.

This occurs as the antibodies, acting as "keys", attach themselves to the specific "locks" found on the antigens.

And, if you have Type B blood, your plasma contains anti-A antibodies which will attack Type A surface antigens. Therefore, if you receive the wrong type of blood, your body's antibodies will destroy all of the red blood cells from the donated blood!

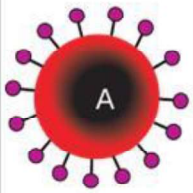
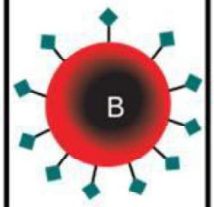
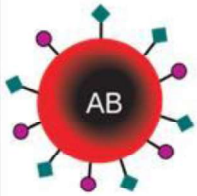
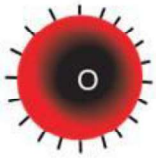
Tests can be performed to determine the blood type from an unknown sample by administering an **antiserum**. Antisera (plural form) is blood serum containing specific antibodies against specific antigens. For example, an antiserum that is "Anti-B" would contain B antigens. If Anti-B antisera comes into contact with B antigens within the unknown sample, the blood would begin to clump together as the antibody binds with the antigen.

What about a difference in Rh factors?

The plasma of an Rh-negative individual does not contain anti-Rh antibodies. However, if a pregnant woman is found to be Rh-negative, the father's blood type is also determined as parents with mismatched Rh factors can have babies with deadly blood problems.

Individuals who have Type O blood are known as **universal donors** because they are capable of donating their blood to any recipient.

If you look at the following table, you will see that Type O blood contains no surface antigens on their red blood cells. Without these antigens, the antibodies within the recipients of their blood cannot attack any of the newly introduced red blood cells. Therefore, Type O blood can be safely received by all patients.

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	A antigen	B antigen	 A and B antigens	None

All of this blood is worthless without a way to transport it throughout the body. In the next two chapters, we will be exploring how this life-giving fluid is transported through a study of...

The Cardiovascular System

Match the following vocabulary terms with their correct definition:

albumins	**globulins**	**solutes**
antibodies	**hypertonic**	**solution**
antigens	**hypotonic**	**solvent**
blood type	**osmotic pressure**	**transport globulins**
fibrin	**Rh factor**	**universal donors**
fibrinogen	**serum**	**viscosity**

1) _____ a mixture of solute(s) and solvent(s)

2) _____ a type of globulin which is responsible for attacking foreign invaders within the bloodstream

3) _____ blood plasma which contains no fibrinogen

4) _____ chemical "taxis" of the blood; bind to important compounds that may otherwise be flushed out of the body

5) _____ individuals who have type O blood

6) _____ long strands of fibrinogen proteins which assemble around the "plug" of platelets within a blood clot

7) _____ one of four different types of blood which is characterized by the absence or presence of three different surface antigens (A, B, and Rh)

8) _____ plasma protein; largest by volume; act to regulate the osmotic pressure of the blood

9) _____ plasma protein; works with the platelets in the blood to help with the formation of a blood clot

10)	_____	resistance of a fluid to flow
11)	_____	second most abundant type of plasma proteins; functions include protection and transport of molecules
12)	_____	solutions containing fewer solutes as compared to another fluid
13)	_____	solutions containing more solutes as compared to another fluid
14)	_____	specific molecular "locks" on the outer surface of cells that can only be opened by specific molecular "keys"
15)	_____	substances that are dissolved in a solution by solvents
16)	_____	substances which dissolve solutes to form a solution
17)	_____	surface antigen within blood that identifies an individual's blood type as either positive or negative
18)	_____	the pressure needed to keep water from moving through a porous substance (like the blood vessels)

.

Choose the correct answer from the following questions:

1) The AB blood type are based on the presence of:

A) A antigens
B) B antigens
C) O antigens
D) A, B, and O antigens
E) A and B antigens

2) The universal donor has blood type:

A) A
B) B
C) AB
D) ABO
E) O

3) Which blood type(s) can a person with blood type O receive?

A) blood type A
B) blood types A, B, AB, or O
C) blood type B
D) blood type O
E) blood type AB

4) Which of these blood types carries no antigens?

A) blood types A, B, and AB
B) blood type A
C) blood type O
D) blood type B
E) blood type AB

5) **Which antigen(s) does type AB blood contain?**
   A) sometimes A antigens, other times B antigens
   B) B antigen
   C) A antigen
   D) A and B antigens

6) **True or false:** Rh-related problems occur in pregnant Rh- women carrying a baby from an Rh- father.

7) **True or false:** Normal blood volume in healthy males is 5-6 liters.

Application Question:

A runner wanted to improve his performance in an upcoming marathon race. About 6 weeks before the race, 500 mL of blood was removed from his body, and its solid components were separated from the plasma. These components were frozen, and the plasma was placed back into his body. Just before the competition, the frozen components were thawed and injected into his body. Explain why this procedure, called blood doping, would help his performance in the marathon. Can you suggest any possible bad effects?