

Chapter 19

Immune System - Part I (Lymphatic System)

Our body contains several ways to protect us from internal and external threats to our health. Historically, these methods have been categorized into a single organ system known as:

The Immune System

Over the years, however, our knowledge of the body has increased and the "immune system" cannot stand by itself as a single system. The immune system actually consists of several **immune responses** carried out by systems within the body as we have already discussed. For example, the integumentary system is part of the immune system as it provides a line of defense for our bodies against infections within the skin. Immune responses exist within the respiratory system as well. Every breath we take places unwanted pathogens on the surfaces of our cells and our organ systems have developed many different ways to protect us from infection. To put it simply, the physiology of our immune system is to provide some form of immune response towards all potentially damaging invaders to our body. Its anatomy, however, is spread out throughout the body.

This chapter will deal with the anatomy and physiology of a particular subsection of the immune system known as the...

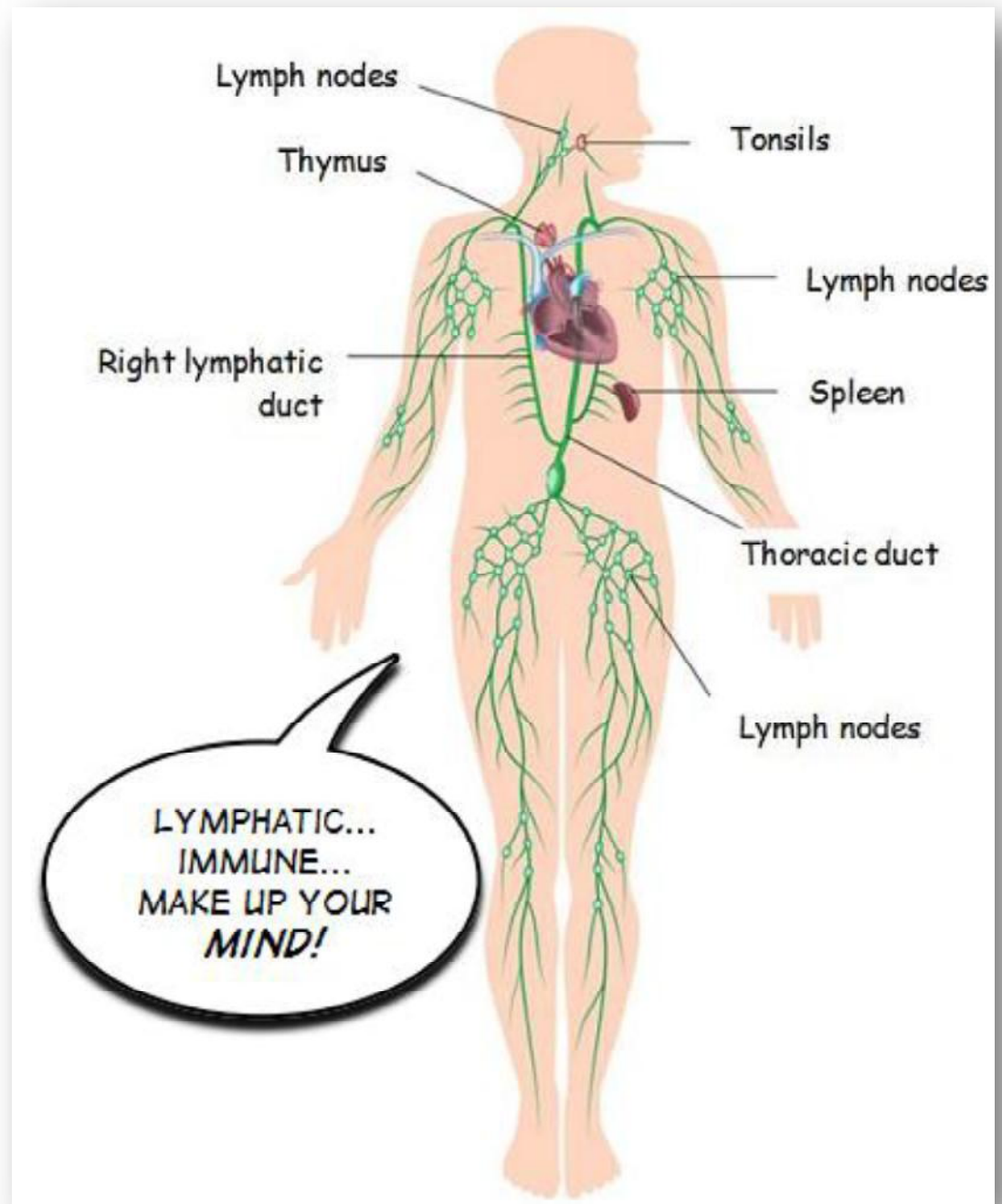
Lymphatic System

...and the next chapter will deal more specifically with the actions at the battle sites of infections, otherwise known as the immune response.

The lymphatic system has two main functions within the human body:

Immunity and **Regulation of Blood Volume**

We will explore how the lymphatic system maintains a constant volume of blood shortly. First, let's look at the topic of **immunity** - the ability of the body to resist infection and disease. Our immunity can be broken down into two independent types which are known as **innate (nonspecific) immunity** and **adaptive (specific) immunity**.



All bodily actions which prevent the spread of infection or disease, regardless of the damaging agent, are carried out by our *innate immunity*. This type of immunity does not identify the specific threat that is invading the body. Our *adaptive immunity*, on the other hand, involves defenders who identify each invading pathogen (such as bacteria or viruses), unhealthy body cells (such as cancer cells), and other foreign particles before they begin their attack.

Several different structures play an important role within the lymphatic system as it maintains our immunity and regulates the volume of blood:

Lymph, Lymphatic vessels, Lymphocytes, and Lymphatic tissues/organs

Lymph

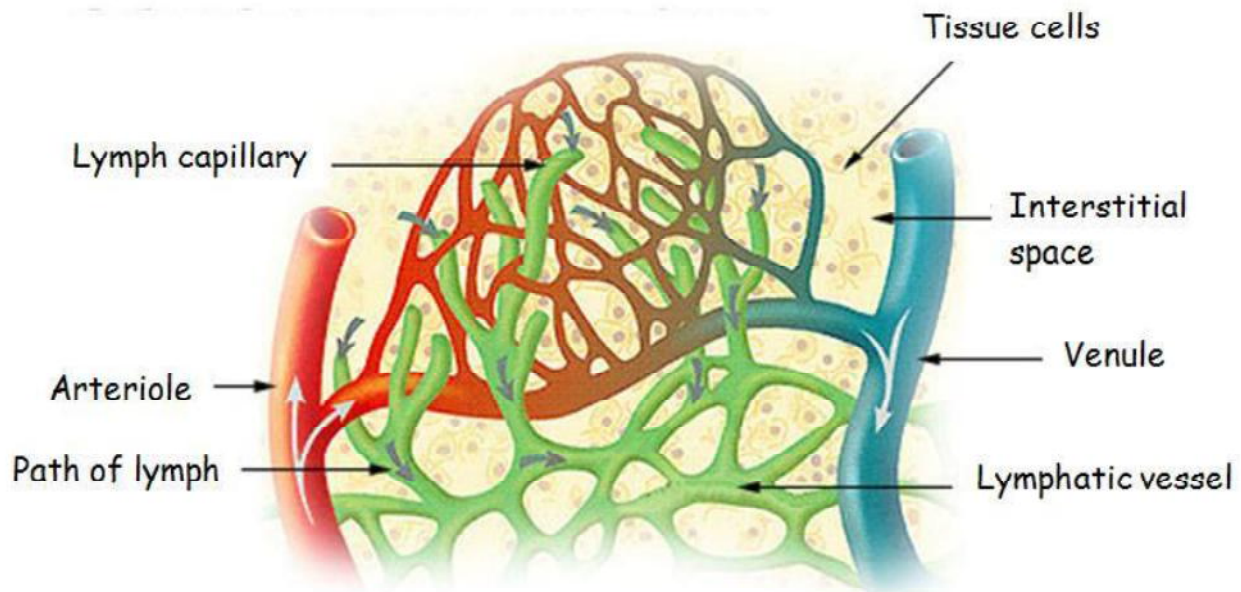
Up to three quarts (three liters) of **lymph** exists within our bodies and is primarily made up of recycled plasma from the blood. This fluid passes through the lymphatic system and carries with it white blood cells, water, and other dissolved substances. Movement of this fluid is partially caused by the contractions of surrounding muscles which push the lymph along its pathways much like the venous blood of the cardiovascular system. Red blood cells and most proteins are typically not found in the lymph as their large size prevents them from moving into the "pathways" of the lymphatic system, also known as...

Lymphatic vessels

Lymphatic vessels act very much like the blood vessels of the cardiovascular system. Although somewhat different in appearance, a network of these thin-walled vessels surrounds the same general areas as the capillaries throughout all of the vascular tissues of the body. As gases, nutrients, and wastes are being exchanged by the capillaries and the various tissues, it is normal for excess fluid to "pool" in the spaces between tissues and capillaries. This **interstitial fluid** is collected and drained back into the blood by the lymphatic vessels which act much like rain gutters on homes. Once this fluid enters the lymphatic vessels, it is collectively known as lymph.

These last statements are very important! The lymphatic system regulates the volume of blood by returning excess fluids back into the blood stream and towards the heart.

Lymph capillaries among interstitial space



Excess fluids (approximately three liters per day) are picked up by the lymphatic "capillaries" and are carried through a series of larger vessels which end in two large tubes known as the **right lymphatic duct** and the **thoracic duct**. Both of these ducts drain their fluids into the **right and left subclavian veins**, respectively, which flow quickly into the heart.

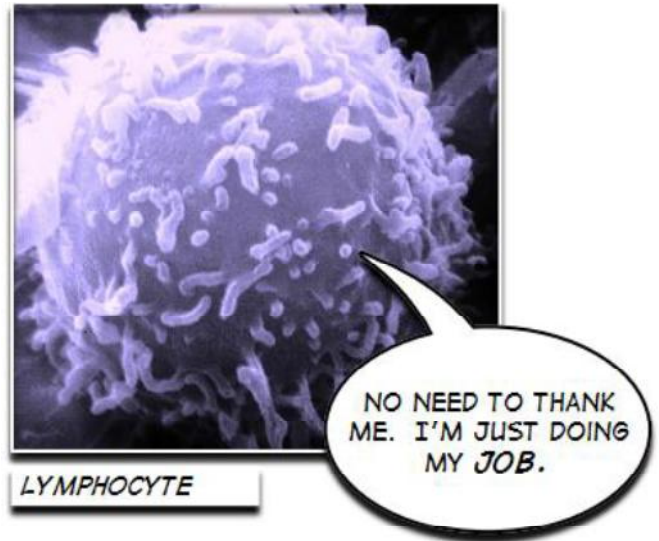
The right lymphatic duct is the smaller of the two vessels and contains lymph from the right side of the head, right upper limb, shoulder and lung, and the right side of the heart.

The thoracic duct receives lymph from 75% of the body including the left side of the head, neck, chest, the left upper limb, and the entire body below the ribs.

Both the lymph and the lymphatic vessels are responsible for the regulation of blood volume within the body. However, it is the lymphocytes and lymphatic tissues/organs within the lymphatic system that provide us with our immunity!

Lymphocytes

The primary cells involved with our immunity are known as **lymphocytes**. Lymphocytes are a specific type of white blood cells (leukocytes) whose function is to identify and/or eliminate all potentially damaging substances from our body. Much like the red blood cells, lymphocytes are produced primarily within the red bone marrow.



A couple of facts about these tiny protectors...

There are close to 10 trillion lymphocytes in your body right now and have a collective weight of over 2.2 pounds (1 kilogram). Their life span is equally impressive as most lymphocytes can remain floating throughout the lymphatic system and blood for up to 20 years!

There are three types of lymphocytes:

T cells, B cells, and NK (natural killer) cells

T cells make up over three quarters of all lymphocytes and mature within the thymus of the endocrine system after being created by the red bone marrow. The T cells are the primary agent of cellular defense within our body and are part of our adaptive immune system.

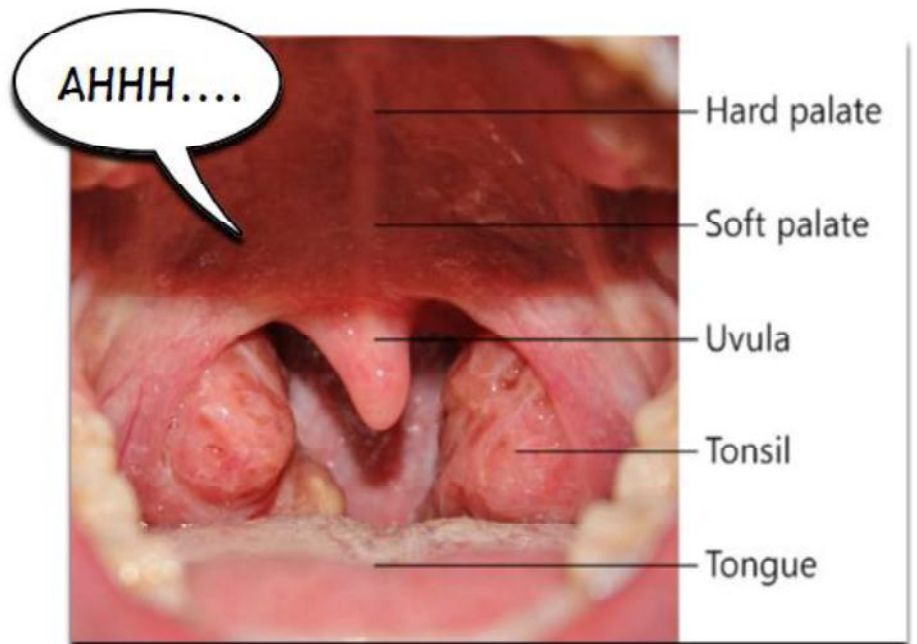
B cells are also created by the red bone marrow and are one of the primary agents within our adaptive immune system. These cells get their name from the location of their origin - the bone marrow. The immune response generated by the T and B cells will be a topic of discussion in the next chapter. Stay tuned...

Unlike the T and B cells, the **NK cells** are part of our innate immune system and provide an early line of defense against abnormal cells within the body. These cells are particularly good at removing cancerous cells from the body!

Lymphatic tissues and organs

Lymph nodules are specialized lymphatic tissues found beneath the epithelial layers of the digestive, respiratory, and urinary system. Areas such as these are typically exposed to high amounts of pathogens; and, as you will learn next week, the lymph nodules are important warehouses for the functioning of B cells during an immune response.

Another specialized tissue within the lymphatic system are the **tonsils**. The tonsils are a collection of lymph nodules found in the back of the throat and are responsible for the storage of large numbers of lymphocytes. These tissues are one of the first defenders against pathogens that enter the nose or throat.



Lymphatic tissues such as the lymph nodules and tonsils tend to be smaller than the lymphatic tissues

which we will be discussing now. In addition, they are typically not protected by a layer of connective tissue and are not attached to any vessels of the lymphatic system.

The three most important lymphatic organs includes:

Lymph nodes, the **Spleen**, and the **Thymus**

The **lymph nodes** are inch-long (2.5 cm) oval-shaped organs which are found throughout the body and are connected to the lymphatic vessels. Hundreds of these organs trap pathogens found within the lymph and are filled with protective lymphocytes and other white blood cells. As these organs are filled with disease-fighting lymphocytes, these areas act as filters of lymphatic fluid and are very active sites for the destruction of invading pathogens.

You already read about the second major organ of the lymphatic system - the *thymus*. This organ is anterior to the heart and posterior to the sternum within the chest. The function of this organ, as you read previously, is to help with the maturation of the T cells. Simply put, the thymus is an organ which "programs" the T cells to attack specific pathogens. How this programming takes place is well beyond the scope of this book; however, the preparation of T cells by the thymus is vital to the functioning of our adaptive immunity.

The **spleen** is the largest lymphatic organ located in the upper left portion of the abdomen. Measuring approximately 5 inches (12 centimeters) long and 5.6 ounces (160 grams), the spleen removes old red blood cells and recycles its iron for the bone marrow's generation of new blood cells. The spleen is one of the first organs to identify the presence of foreign particles in the blood as it acts as a filter for the blood. Furthermore, an immune response is typically generated within the spleen in response to the detection of these pathogens.

You have begun to explore the anatomy and physiology of the lymphatic system - but you are not done yet! In the next chapter, you will be exploring the specifics of the lymphatic system as it provides us with the life-saving...

Immune response

Match the following vocabulary terms with their correct definition:

adaptive (specific) immunity
 B cells
 immune response
 immune system
 immunity
 innate (nonspecific) immunity
 interstitial fluid
 lymph
 lymph nodes
 lymph nodules

lymphatic vessels
 lymphocytes
 NK cells
 right and left subclavian veins
 right lymphatic duct
 spleen
 T cells
 thoracic duct
 tonsils

- 1) _____ a specific type of white blood cells (leukocytes) whose function is to eliminate all potentially damaging substances from our body
- 2) _____ all actions involved with the identification and removal of foreign invaders by the immune system
- 3) _____ all defensive actions our bodies undergo to prevent the spread of infection or disease, regardless of the damaging agent
- 4) _____ created by the red bone marrow and are one of the primary agents within our adaptive immune system
- 5) _____ directs lymphatic fluid from the right lymphatic duct and the thoracic duct towards the heart
- 6) _____ excess fluid which "pools" in areas where capillaries exchange nutrients and wastes
- 7) _____ inch-long (2.5 cm) oval-shaped organs connected to the lymphatic vessels and are filled with protective lymphocytes ;act as traps for pathogens

- 8) _____ larger of two ducts which carries lymph from the left side of the head, neck, chest, the left upper limb, and the entire body below the ribs
- 9) _____ largest lymphoid organ located in the upper left portion of the abdomen; removes old red blood cells and recycles iron for use by the bone marrow
- 10) _____ make up over three quarters of all lymphocytes; mature within the thymus of the lymphatic system after being created by the red bone marrow; primary agent of cellular defense within the adaptive immune system
- 11) _____ one of two different types of immunity; identifies each invading pathogen (such as bacteria or viruses), unhealthy body cells (such as cancer cells), and other foreign particles
- 12) _____ part of the innate immune system; indiscriminately attacks every foreign invader considered to be a threat
- 13) _____ recycled plasma from the blood
- 14) _____ smaller of two ducts which carries lymph from the right side of the head, right upper limb, shoulder and lung, and the right side of the heart
- 15) _____ specialized lymphatic tissues which are found between the epithelial and connective tissue layers of the digestive, respiratory, and urinary system
- 16) _____ specialized tissues within the lymphatic system responsible for the storage of large numbers of lymphocytes; found in the oral cavity
- 17) _____ the ability of the body to resist infection and disease

- 18) _____ the body's defense mechanism; a general term used to describe the collective anatomy/physiology of several systems within the body to remove foreign invaders
- 19) _____ thin-walled vessels surrounding vascular tissues which carries "pooled" interstitial fluid back into the cardiovascular system

Choose the correct answer from the following questions:

1) Which lymphatic organ acts to recycle old red blood cells?

- A) tonsils
- B) thymus gland
- C) lymph nodes
- D) spleen

2) Which lymph nodules trap and remove bacteria entering the throat?

- A) lymph nodes
- B) tonsils
- C) right lymphatic duct
- D) thymus gland

3) Excess fluid that pools in the spaces between capillaries and various tissues is known as:

- A) venous blood
- B) arterial blood
- C) plasma
- D) lymph
- E) interstitial fluid

4) Which one of the following is NOT true of lymph nodes:

- A) they are attached to lymphatic vessels
- B) they act as filters along the lymphatic vessels
- C) they remove foreign materials from the lymph fluid
- D) they are involved with the functioning of the B cells during an immune response
- E) they contain lymphocytes

5) The lymph organ that programs T cells and functions at peak levels only during youth is the:

- A) lymph nodes
- B) thymus
- C) spleen
- D) lymph nodules
- E) tonsils

6) Lymph flows:

- A) toward the heart only
- B) in a circular pattern within the tissues
- C) away from the heart only
- D) both toward and away from the heart

Application Question:

If the thymus of an animal is removed immediately after its birth, the animal tends to be more vulnerable to infections and has decreased numbers of lymphocytes in lymphatic tissue. How can you explain these observations?

Chapter 20

Immune System - Part II (Immune Response)