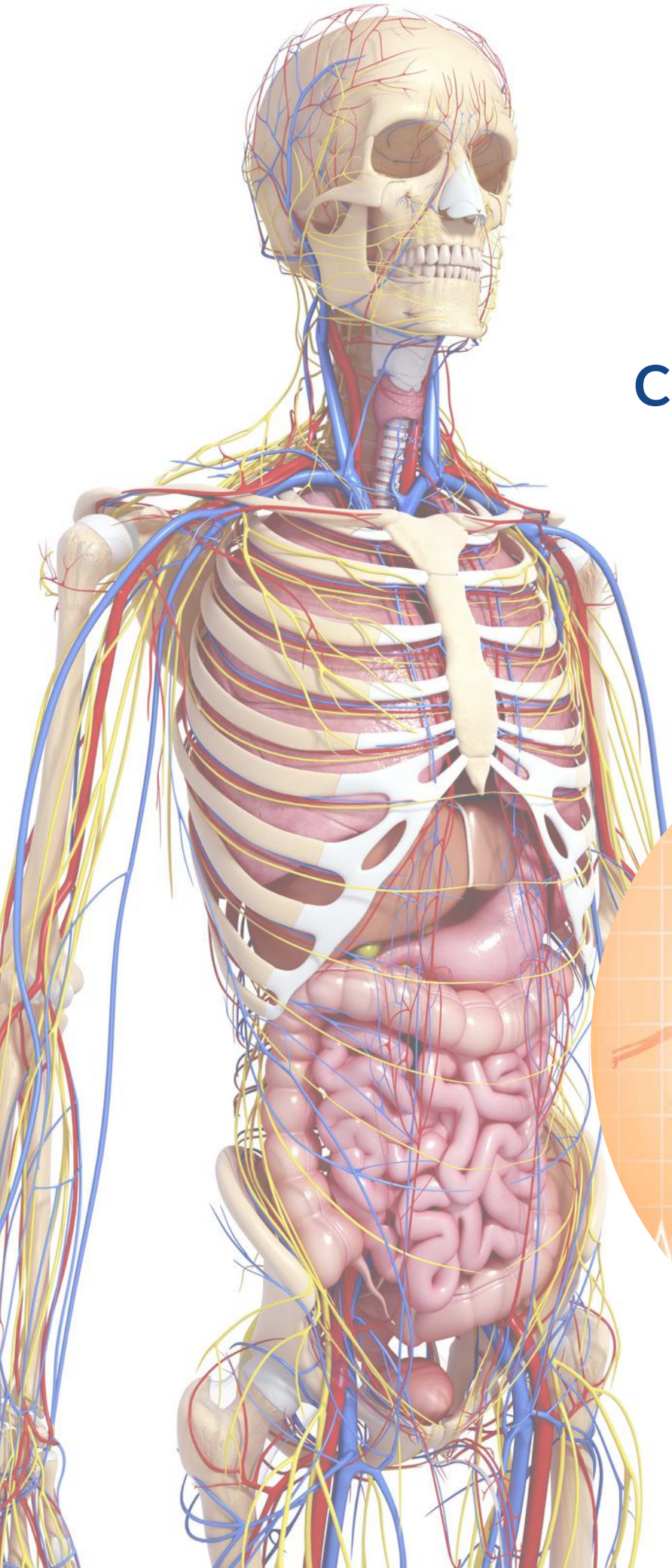
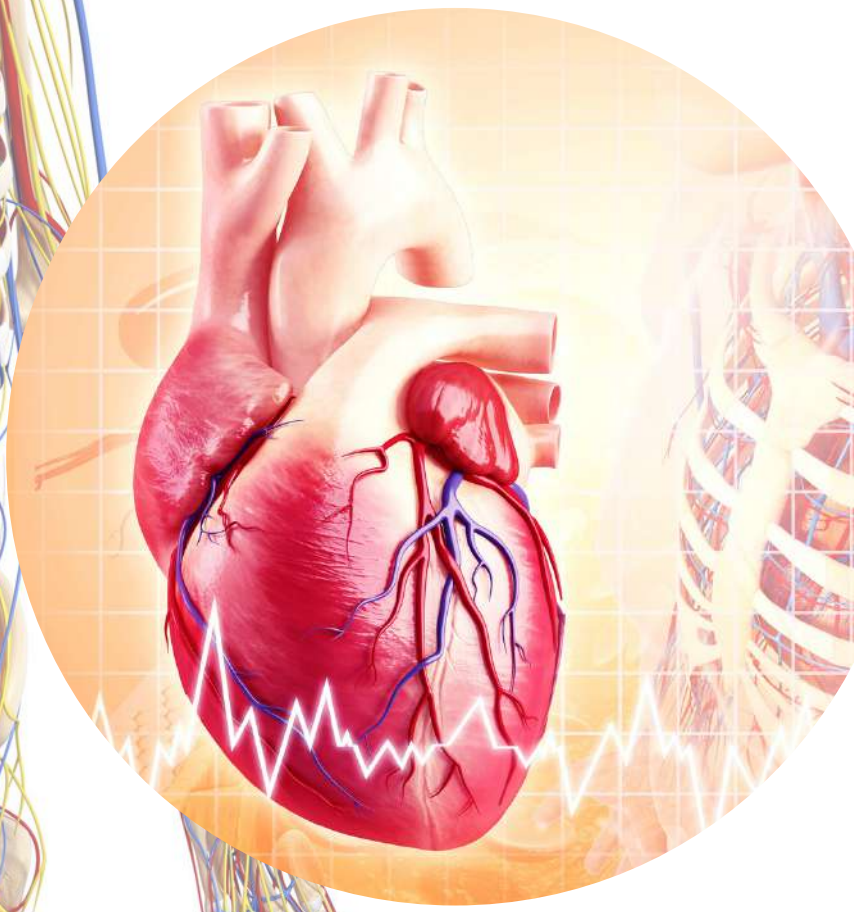
Cardiovascular System Lesson Plan

Grade 12





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The following unit plan was created in accordance with the Canadian Council on Animal Care's recommendations to replace any present procedures involving the use of animals in teaching, testing and research.

The Three Rs principle of Replacement states, if you can meet your scientific or educational goals without the use of animals, it is your ethical obligation to use non-animal methods. Grade 12 anatomy content is often taught using fetal pigs - here we offer an effective and humane alternative.

This is in alignment with the public's concern for animal welfare and a cultural respect for animals passed down from the Aboriginal perspectives of the First Peoples.

Elisabeth Ormandy created this unit plan and series of lesson plans for your use in teaching life science content to Grades 12 based on the BC Science Curriculum.

These Humane Science Education materials were developed to provide equivalent or greater standards in education for Canadian youth, without the use of animals.

Curriculum Alignment

This lesson plan can be used to create classes for Grades 12 based on the BC Science Curriculum. Specific **Big Ideas** covered in this lesson plan include:

Grade 12 - Organ systems have complex interrelationships to maintain homeostasis.

ORGAN SYSTEMS:

- Structure and function
- Structural and functional interdependence
- Maintenance of homeostasis

We have recommended specific virtual anatomy tools to use to get the most out of the unit plan. You'll find links to those on pages 5 & 6.

Lesson Plan Overview

Subject: Science

Unit Overview: Anatomy and Physiology

Unit Duration: ~90 minutes

Grade: 12

Big Idea: Organ systems have complex interrelationships to maintain homeostasis

Curricular Competencies

- *Analyze cause-and-effect relationships*
- *Construct, analyze, and interpret graphs, models, and/or diagrams*
- *Consider the changes in knowledge over time as tools and technologies have developed*

Content

- By the end of this lesson, students are expected to demonstrate understanding of the following:
  - *Cardiovascular system:*
    - *Structure and function*
    - *Structural and functional interdependence*
    - *Maintenance of homeostasis*

Recommended Education Tools

Hardware & Workbooks:

This inventory is for a regular in-person class - use x1 iPad/tablet per student for responsible physical distancing. If teaching online, teachers can screen share their iPad/tablet or desktop.

- 6 (or more) iPads or other tablets
- 6 (or more) 3D Anatomica workbooks

Recommended Software:

- 3D Anatomica: https://3danatomica.com
- 3D4Medical Complete Anatomy: https://3d4medical.com

Lesson Plan Overview

Topic: Organ systems have complex interrelationships to maintain homeostasis. Homeostasis is maintained through physiological processes.

Content: The human cardiovascular system: organs, structure and function

Goals	Students will be able to: • Describe the function of the cardiovascular system and its major organs. • Describe the relationships between the different components of the cardiovascular system. • Explain how the cardiovascular system is interdependent with other organ systems. • Explain how the cardiovascular system maintains homeostasis in the body
Objectives	After this lesson students will state the structure and function of each organ/tissue in the cardiovascular system and explain how the cardiovascular system is functionally interdependent with other body systems.
Materials	• 3DAnatomica • 3D4Medical • Cardiovascular System Workbook
Introduction	Using the 3DAnatomica and/or 3D4Medical app(s), the teacher will introduce the topic of cardiovascular organ structure and function.
Development	Questions to support inquiry-based learning: • What is the advantage of having specialized tissues in the cardiovascular system? • How does the cardiovascular system help the body maintain internal balance during exercise? • What are the impacts of external stimulants (e.g. alcohol, caffeine) on the cardiovascular system? • What lifestyle decisions would you make to improve your cardiovascular health? • How does the cardiovascular system respond to infection by a pathogen?
Practice	Students will work independently or in pairs to navigate 3DAnatomica and/or 3D4Medical to learn about the structure and function of the cardiovascular organs.

Lesson Plan Approach

If teaching regular in-person classes:

- Split students into **6 groups**.
- Give each group a **3D Anatomica workbook** to refer to, and one (or more) iPad(s) or tablet(s) with the **3D Anatomica app**, and **3D4Medical Complete Anatomy app** loaded and ready to use.
- Your **introduction** should include discussion of the function of the cardiovascular system, identifying its major components, and the vocabulary you would like students to learn (~ 15 mins). **Define homeostasis**. Have the students follow along using the 3D4Medical Complete Anatomy app.
- **Discuss sequence** of organs and structures that blood moves through within the cardiovascular system. Have students use the 3D Anatomica and 3D4Medical Complete Anatomy app to explore the flow of blood in their groups, filling their 3D Anatomica workbook and/or handouts provided. This can be student or teacher led. (40-45 mins)
- Explore the "**Structures in Detail**" pages using the 3D4 Medical App. The students can cut away at the structures in the app to locate structures that need to be labeled.
- Ask students to brainstorm **ways the cardiovascular system interacts with other systems,** and go over the specific examples provided
- Discuss different ways the cardiovascular system helps maintain homeostasis using examples provided, then ask students to provide their own examples using what they've learned.
- **Close the class with a 20-minute recap** of what the students have learned, discuss how the parts of the cardiovascular system work together, and check for understanding. Begin a **conversation on ethics** of animals in science using the questions provided

If teaching a physically-distanced class:

- Use x1 iPad for each student and proceed as per the directions above.

If teaching online:

- Lead the students through the cardiovascular system by screen sharing your own iPad/tablet or desktop with the 3D4Medical Complete Anatomy app installed, filling out the tables, and labeling the models as you go
- Proceed as per the directions above

Detailed Lesson Content & Teaching Notes

Introduction to the Lesson

Include a First Nations land acknowledgement and ask students to reflect on what respect for animals means to them. Provide an introduction to the apps and models that will be used in class. Provide an overview of how to access the Cardiovascular System workbook if teaching remotely.

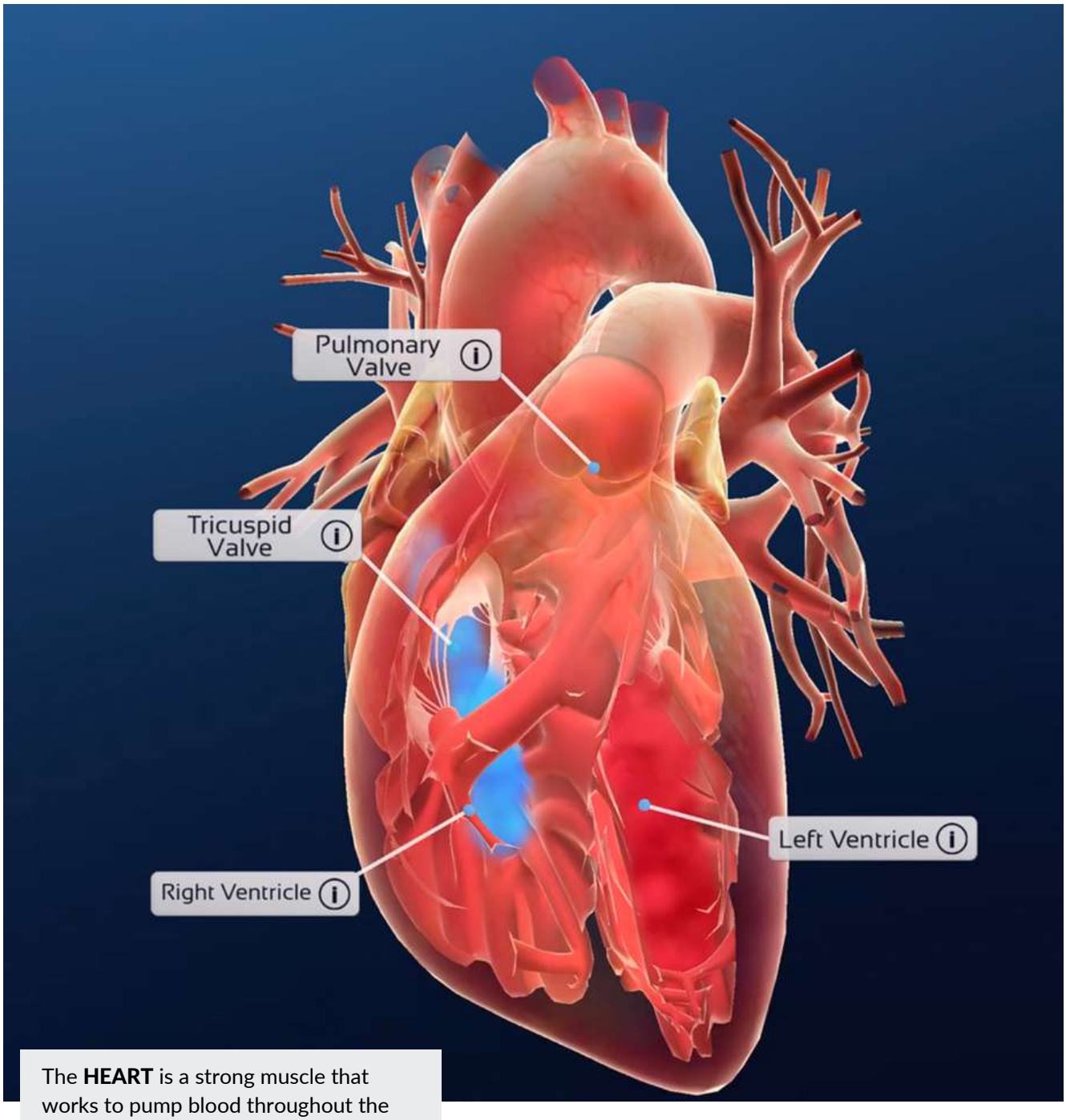
Introduction to the Topic

Students will use **3DAnatomica** and **3D4Medical Complete Anatomy** app to explore the circulatory system at large. We recommend covering the function of the circulatory system, identifying the major components of the system, and discussing the vocabulary you would like the students to learn (such as the names of major blood vessels, heart sections, and valves) early in the lesson.

THE CARDIOVASCULAR SYSTEM AT-A-GLANCE

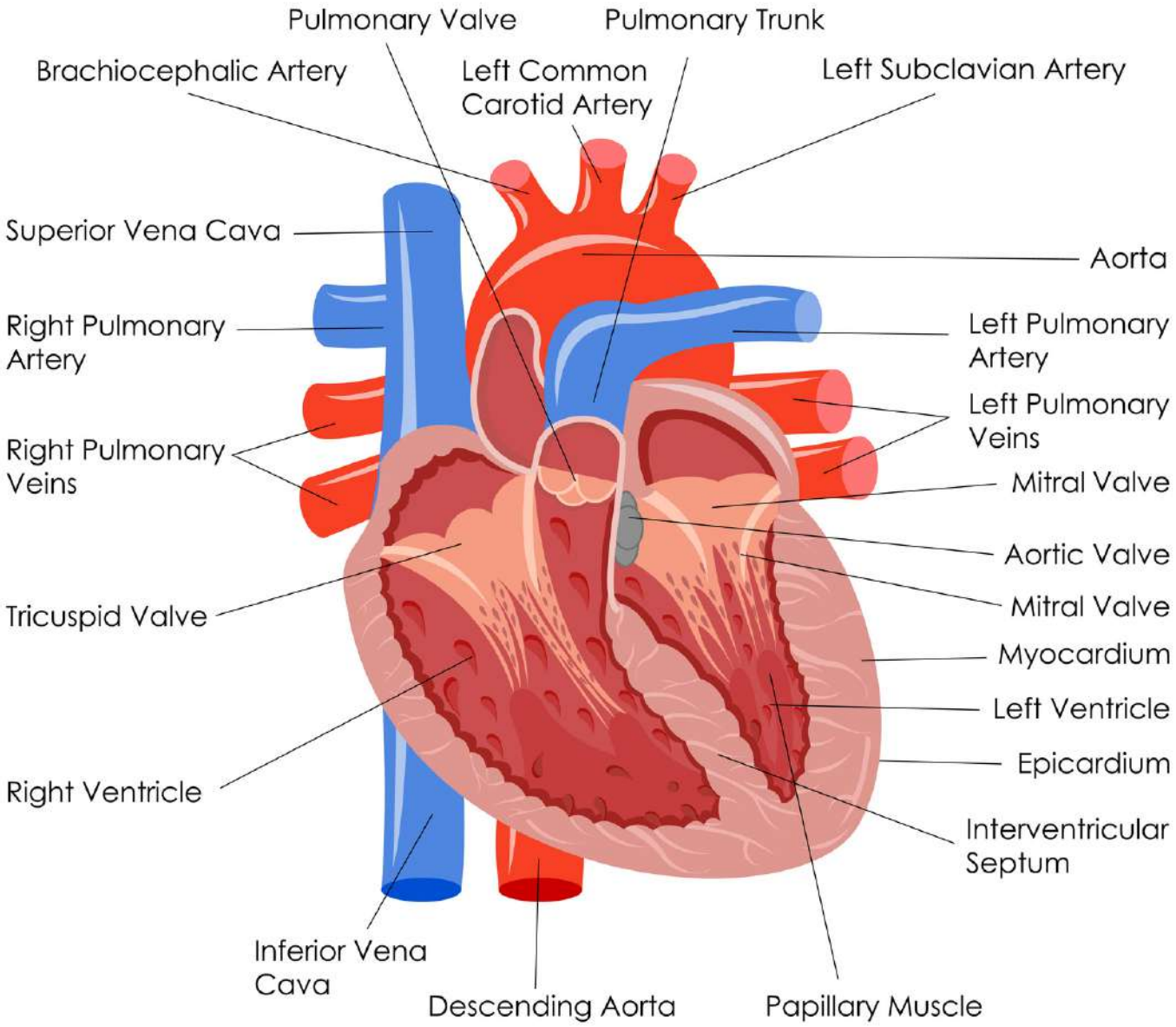
Function	Composed of blood vessels, the circulatory system is responsible for transporting blood towards and away from the heart, and throughout the body. The blood carries oxygen, nutrients, and hormones to cells while simultaneously removing waste products, such as carbon dioxide.
Components	Heart, blood, veins, arteries, capillaries.
Important vocabulary	Heart, blood, blood vessels, arteries, veins, capillaries, atrium, ventricle, contraction, pulmonary circulatory system, pulmonary circulation, systemic circulatory system, systemic circulation, vena cava, valve, tricuspid valve, pulmonary valve, pulmonary artery, gaseous exchange, pulmonary vein, mitral valve, aortic valve, aorta, tunica externa, tunica adventitia, tunica media, tunica intima, venous valves, basal lamina, plasma, red blood cells, erythrocytes, white blood cells, leukocytes, neutrophils, monocytes, lymphocytes, basophils, eosinophils, platelets, thrombocytes.

Components in Detail:
Heart Anatomy

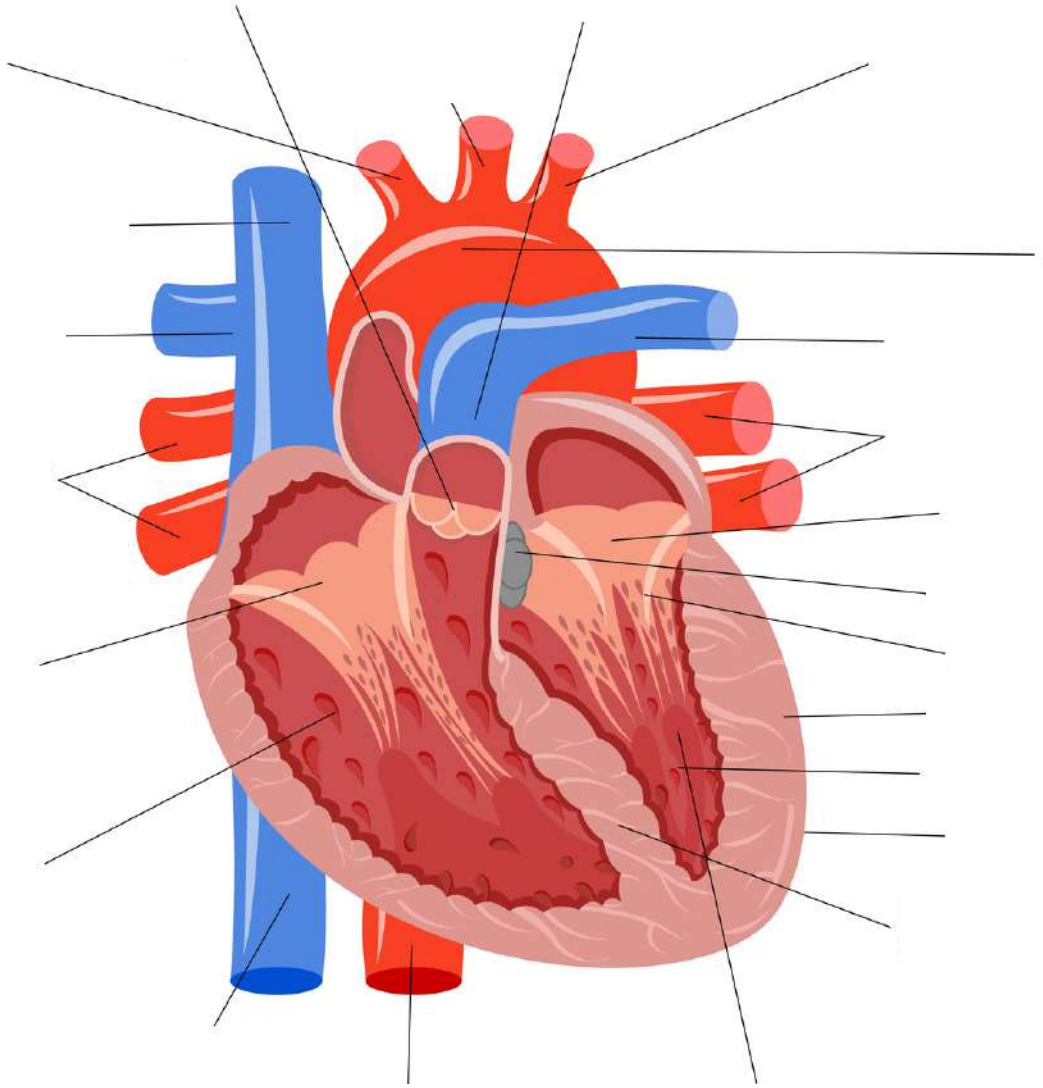


The **HEART** is a strong muscle that works to pump blood throughout the entire body by contracting rhythmically. The human heart has four chambers - the two at the top are called atria (atrium singular), and the bottom two are the ventricles.

Human Heart Anatomy (teacher copy)



Human Heart Anatomy (student activity)

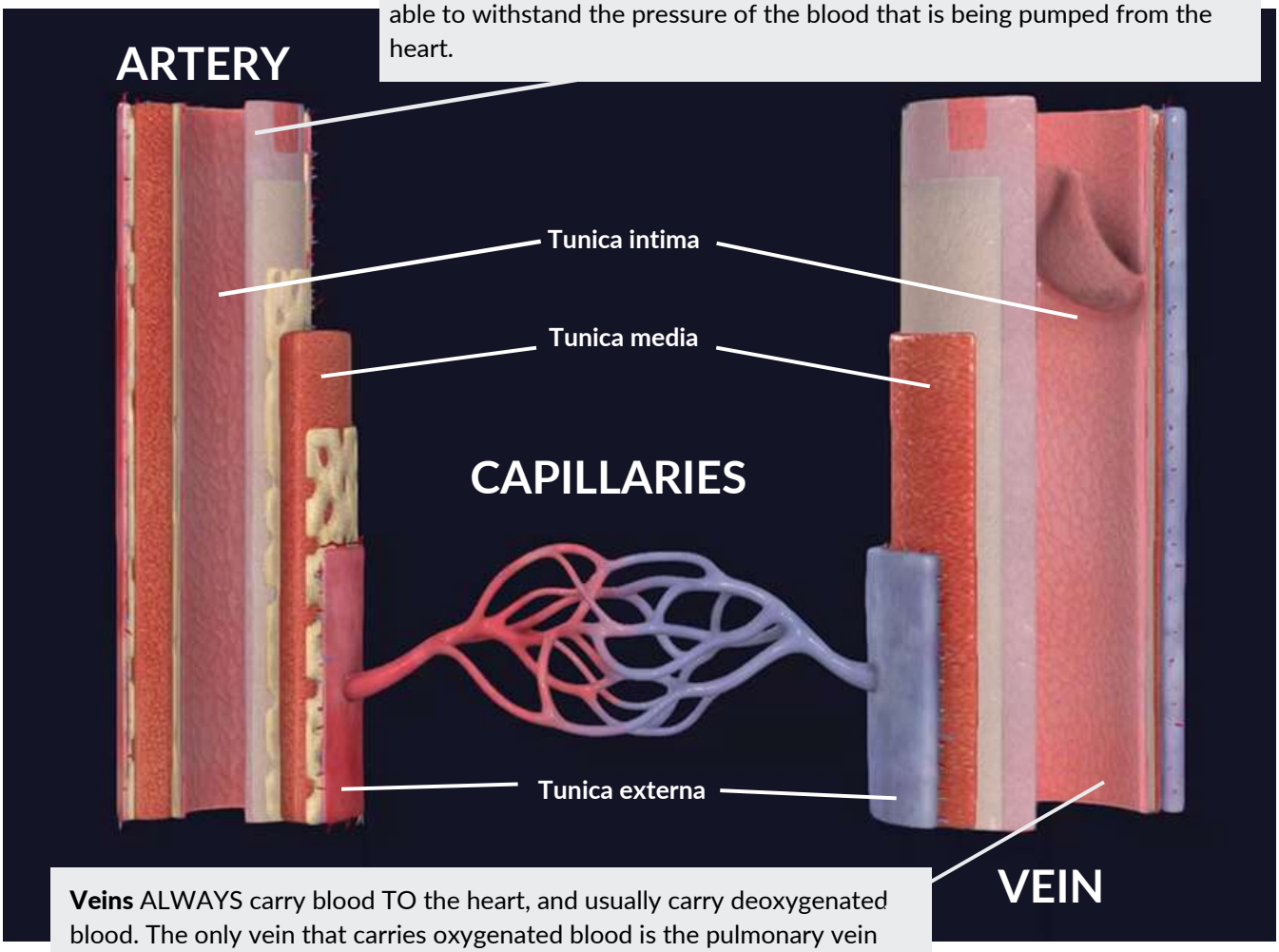


Components in Detail:
Blood Flow Through The Body

Blood flow through the circulatory system	The circulatory system can be divided into two systems that work together: a short system circulating blood between the heart and lungs called the pulmonary circulatory system, and a longer system circulating blood between the heart and the rest of the body called the systemic circulatory system.
Blood flow through the pulmonary circulatory system (pulmonary circulation)	The first part of the blood's journey through the heart begins with two large veins known as the superior vena cava, and the inferior vena cava. • The superior vena cava delivers deoxygenated blood to the heart from the thoracic cavity, head, neck, and upper limbs; • The inferior vena cava collects deoxygenated blood to the heart from the lumbar, gondal, renal, hepatic, and inferior phrenic veins. The blood that passes through the superior and inferior vena cavae are emptied into the right side of the heart. • The right atrium receives the deoxygenated blood from the vena cavae. • As the atrium contracts, blood flows from the right atrium to the right ventricle through the tricuspid valve. • The tricuspid valve is important because it prevents blood from flowing back into the right atrium. • As the ventricle contracts, blood flows from the right ventricle through the pulmonary valve into the pulmonary artery. • The pulmonary artery is the only artery that carries deoxygenated blood, splitting into two to supply blood to two sides of the lungs. The lungs oxygenate the blood in a process known as a gaseous exchange, which is then carried back to the left side of the heart through the only vein that carries oxygenated blood: the pulmonary vein. • The pulmonary vein empties this newly-oxygenated blood into the left atrium. • As the atrium contracts, blood flows from the left atrium to the left ventricle through the mitral valve. • The mitral valve functions similarly to the tricuspid valve, and prevents blood from flowing back into the left atrium. • As the ventricle contracts, the blood flows from the left ventricle through the aortic valve into an artery called the aorta. • The aorta carries oxygenated blood out of the heart, where it is then circulated to meet the needs of the rest of the body.
Blood flow through the systemic circulatory system (systemic circulation)	Once the blood leaves the heart, it is circulated throughout the body to deliver oxygen and nutrients to all of the cells, before returning to the heart. • At the same time the blood delivers the oxygen and nutrients, it collects carbon dioxide and other waste products from the cells. • The waste products are excreted from the blood when it is returned and oxygenated at the lungs.

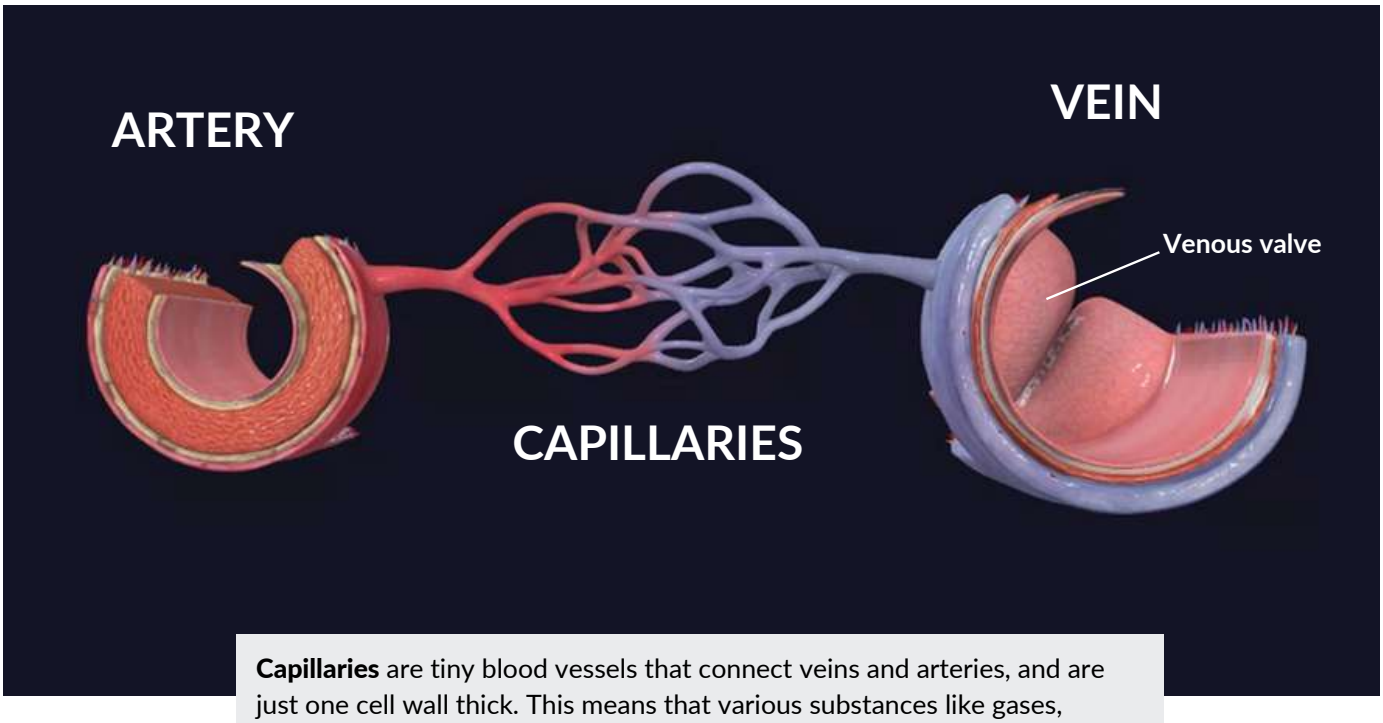
Components in Detail:
Blood Vessel Anatomy

Arteries ALWAYS carry blood AWAY from the heart, and usually carry oxygenated blood. The only vein that carries deoxygenated blood is the pulmonary artery that carries deoxygenated blood away from the heart to the lungs. Like veins, the anatomy of arteries consist of three main layers: An outer layer of connective tissue called the tunica externa or tunica adventitia; a middle layer of smooth muscle called the tunica media; and an inner layer of endothelial cells called the tunica intima. The layers of the arteries are thicker than the layers of veins, making them more rigid and able to withstand greater pressure. This is important because arteries need to be able to withstand the pressure of the blood that is being pumped from the heart.



Veins ALWAYS carry blood TO the heart, and usually carry deoxygenated blood. The only vein that carries oxygenated blood is the pulmonary vein which carries blood from the lungs towards the heart. The anatomy of a vein consists of three main layers:
An outer layer of connective tissue called the tunica externa or tunica adventitia; a middle layer of smooth muscle called the tunica media; and an inner layer of endothelial cells called the tunica intima. Medium to large veins have venous valves, which ensure that blood keeps flowing in the correct direction (i.e. prevents backflow).

Components in Detail:
Blood Vessel Anatomy



Capillaries are tiny blood vessels that connect veins and arteries, and are just one cell wall thick. This means that various substances like gases, nutrients, waste products, hormones etc. can pass across the cell wall of capillaries. It is through the capillaries that oxygen, nutrients, and other substances are exchanged between the blood and tissues.
The majority of blood vessels found in the body are capillaries. The anatomy of a capillary consists of a thin layer of endothelial cells (tunica intima) and is surrounded by a protein matrix called the basal lamina.

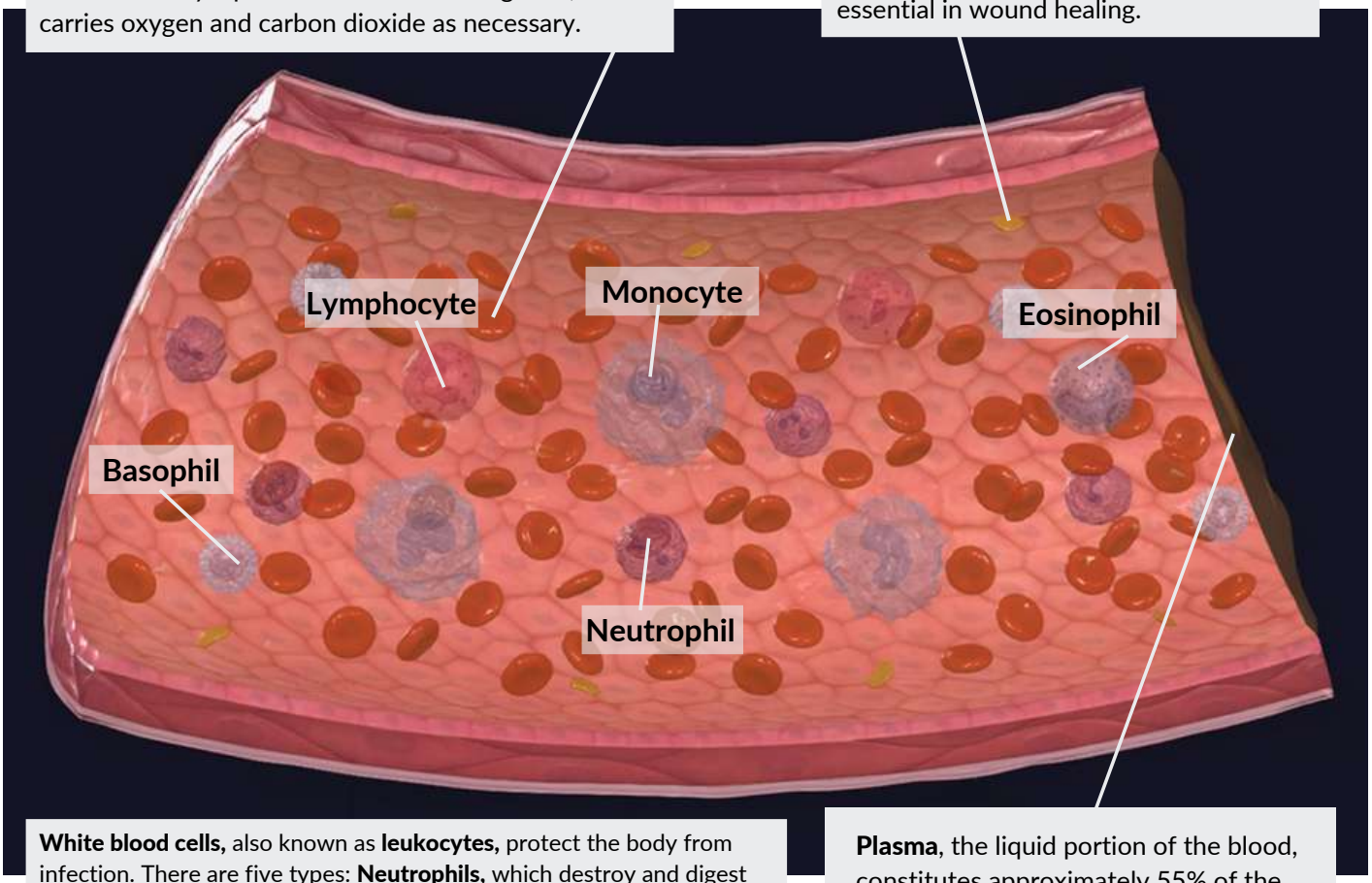
Components in Detail:

Blood Composition

Blood has many functions, including:
Transporting oxygen, nutrients, and hormones;
Transporting carbon dioxide and other waste products; and
Helping regulate body temperature by absorbing and distributing heat throughout the body.

Red blood cells, also known as **erythrocytes** and shaped like a disc with shallow indentations on both sides, are the most abundant type of cell in the blood. They have no nucleus and can change shape, which allows them to fit through the various types of blood vessels in the body. The primary function of red blood cells is to carry a protein known as hemoglobin, which carries oxygen and carbon dioxide as necessary.

Platelets, also known as thrombocytes, are cell fragments which assist in blood clotting and prevent bleeding. They are essential in wound healing.



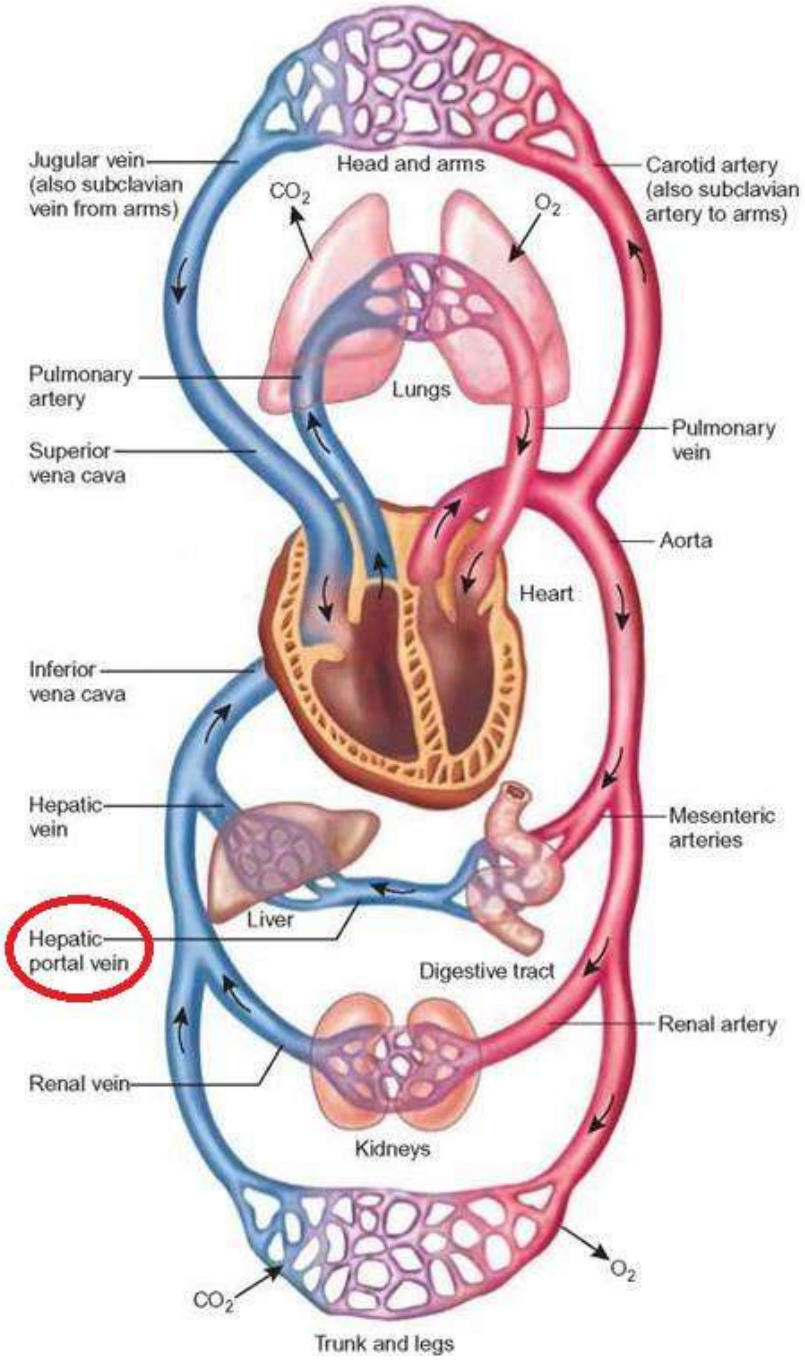
White blood cells, also known as **leukocytes,** protect the body from infection. There are five types: **Neutrophils,** which destroy and digest bacteria and fungi. They are considered the 'first line of defence'. **Monocytes**, which help break down bacteria and clean up dead cells. **Lymphocytes**, which create antibodies to fight against bacteria, viruses, and other harmful invaders. There are two main types of lymphocytes - T lymphocytes which regulate the functioning of other immune cells and assist in the destruction of invaders, and B lymphocytes which make antibodies. **Basophils**, which secrete chemicals like histamine to assist in controlling the body's immune response. **Eosinophils**, which attack and destroy parasites and cancer cells, and assist in allergic responses.

Plasma, the liquid portion of the blood, constitutes approximately 55% of the total blood volume; it is composed of mostly water with a mixture of lipids, proteins, and salts. The primary function of plasma is to transport blood cells and platelets throughout the body with nutrients, waste products, antibodies, hormones, and proteins.

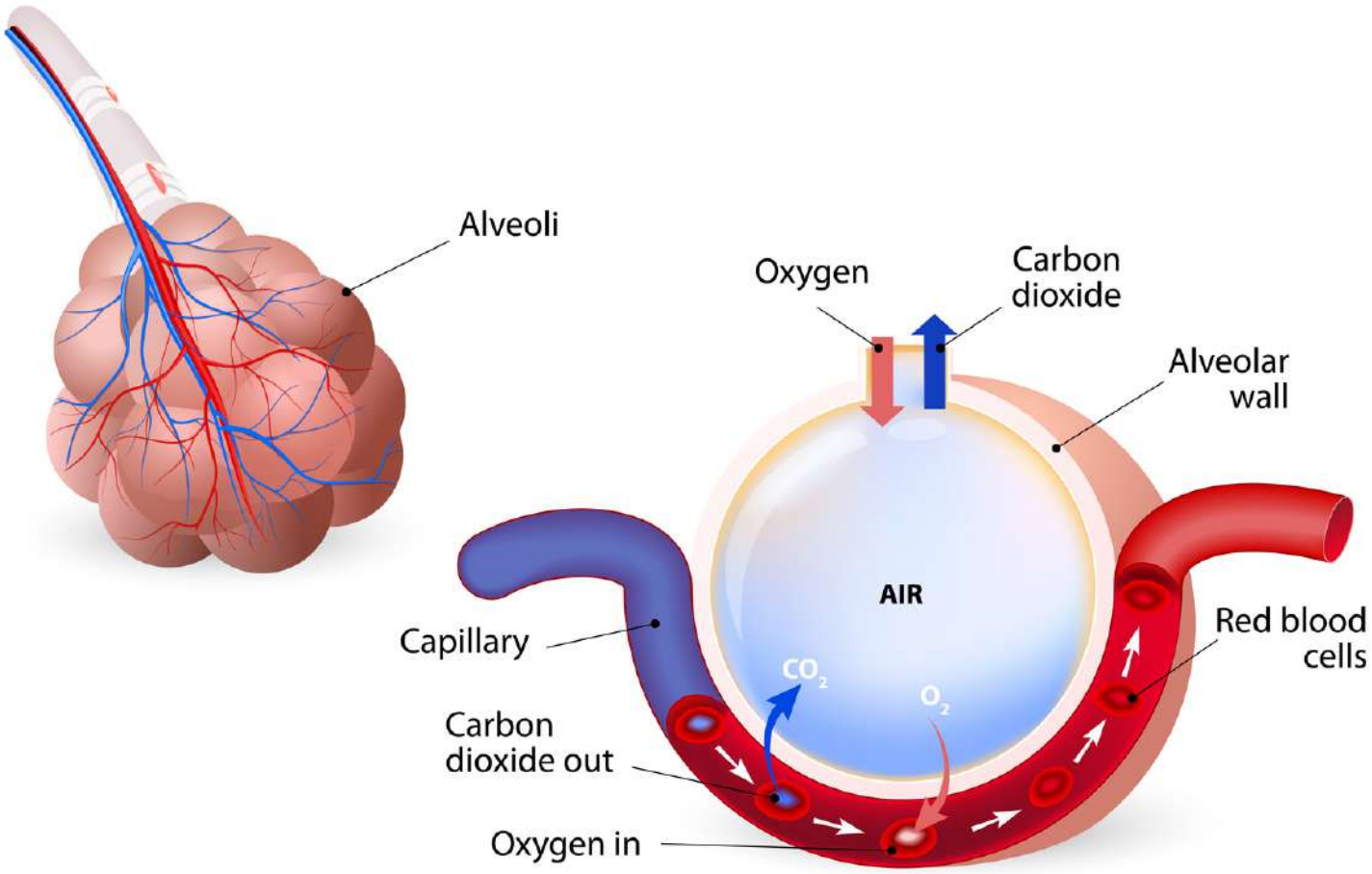
How Does the Cardiovascular System Work Together With Other Organ Systems?

Ask students how they think the different organ systems work together – specific questions can include:

1. How does oxygen get into the bloodstream?
2. How do the respiratory and cardiovascular systems connect with each other?
3. How do nutrients from our food get into the blood stream?
4. How do the digestive and cardiovascular systems connect with each other?



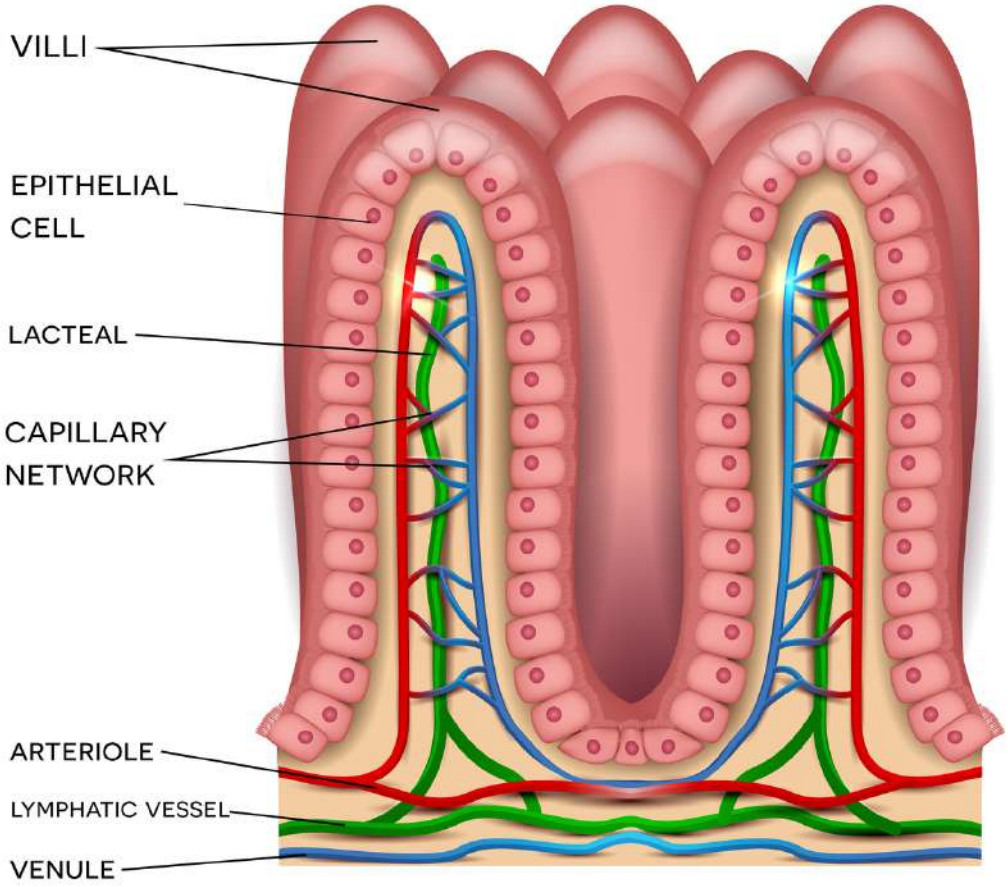
Gas Exchange in the Lungs:
Cardiovascular and Respiratory System Interdependence



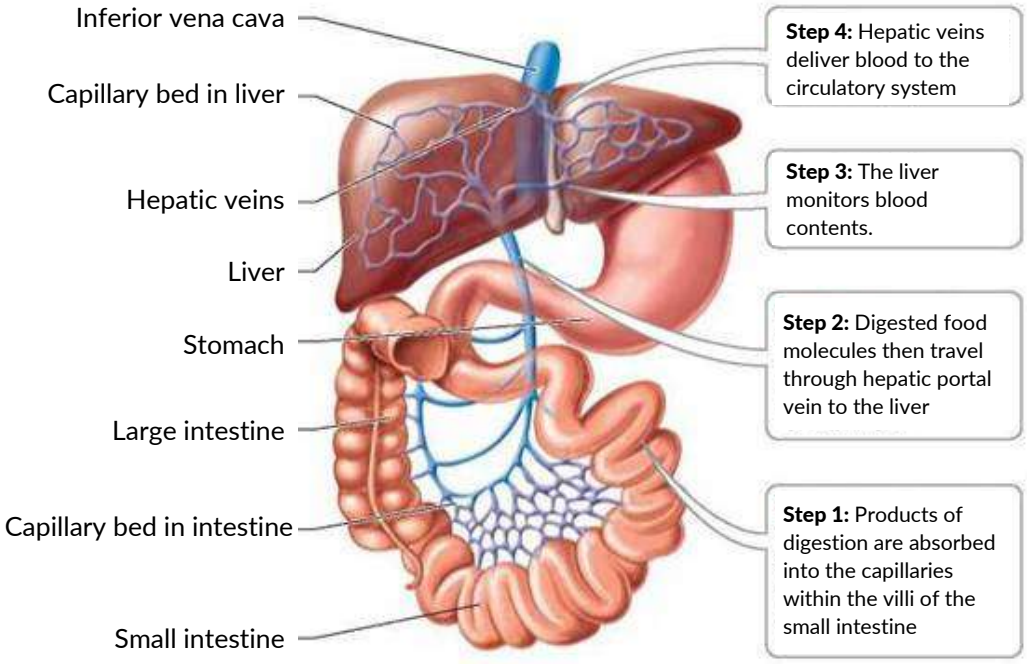
CAPILLARIES:
Tiny blood vessels that connect veins and arteries throughout the body, and are just one cell wall thick. This means that various substances like gases, nutrients, waste products, hormones etc. can pass across the cell wall of capillaries; it is through the capillaries that oxygen, nutrients, and other substances are exchanged between the blood and tissues. They cover alveoli to allow oxygen and carbon dioxide to move freely between the respiratory and circulatory systems. The majority of blood vessels found in the body are capillaries. The anatomy of a capillary consists of a thin layer of endothelial cells (tunica intima) and is surrounded by a protein matrix called the basal lamina.

Nutrient Absorption in the Small Intestine: Cardiovascular and Digestive System Interdependence

Villi are specialized for absorption in the small intestine as they have a thin wall, one cell thick, which enables a shorter diffusion path. They have a large surface area so there will be more efficient absorption of fatty acids and glycerol into the blood stream.



Hepatic Portal System:
Cardiovascular and Digestive System Interdependence



The hepatic portal system is a series of veins that carry blood from the capillaries of the stomach, intestine, spleen, and pancreas to capillaries in the liver. It is part of the body's filtration system. Its main function is to deliver de-oxygenated blood to the liver to be detoxified further before it returns to the heart.

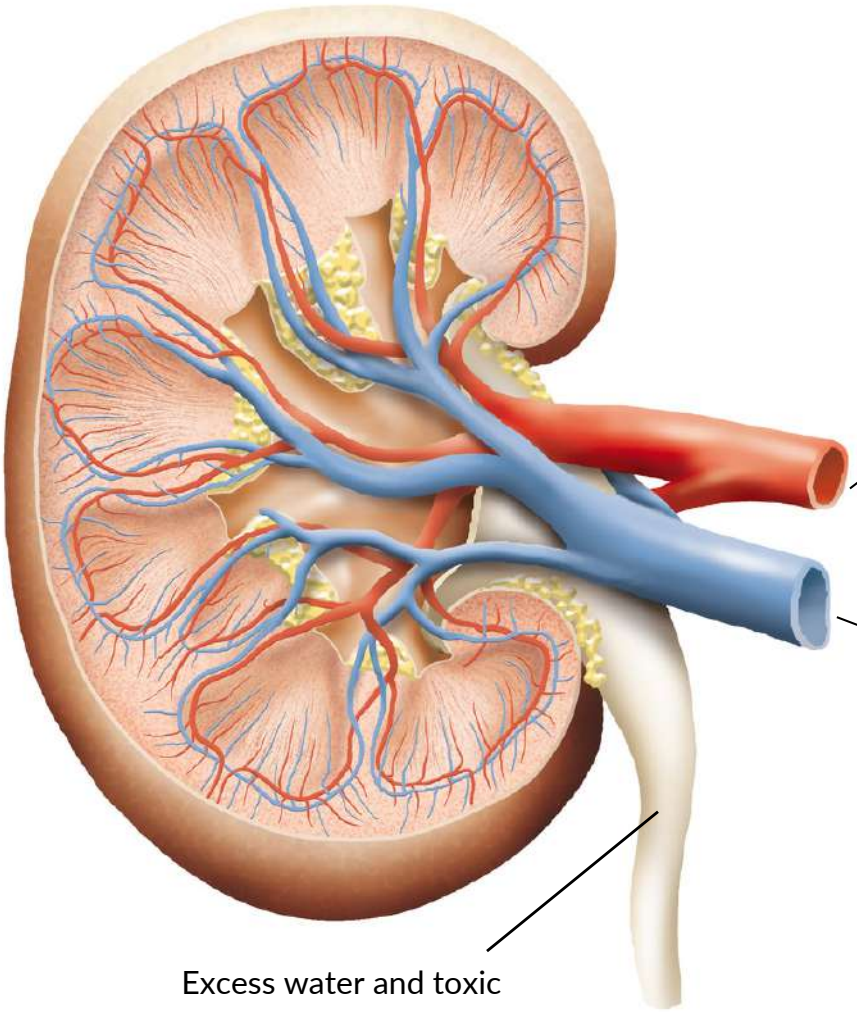
The hepatic portal system consists of:

- **Hepatic portal vein:** This is the main vein connected to the liver. It forms at the connection of the inferior and superior mesenteric veins.
- **Inferior mesenteric vein:** This vein takes blood from the colon and rectum and connects with the portal vein.Superior mesenteric vein: This drains blood from the small intestine and connects with the hepatic portal vein.
- **Gastrosplenic vein:** This tributary is formed by the union of the splenic vein from the spleen and the gastric vein from the stomach. It joins with the mesenteric vein inside the pancreas.

The hepatic portal system is designed to rid the body of toxins, and it cannot detect those that are designed to help it. Some drugs must be taken under the tongue, through the skin, or via suppository to avoid entering the hepatic portal system and being prematurely metabolized in the liver before reaching general circulation.

Kidney Filtration and Absorption: Cardiovascular and Urinary System Interdependence

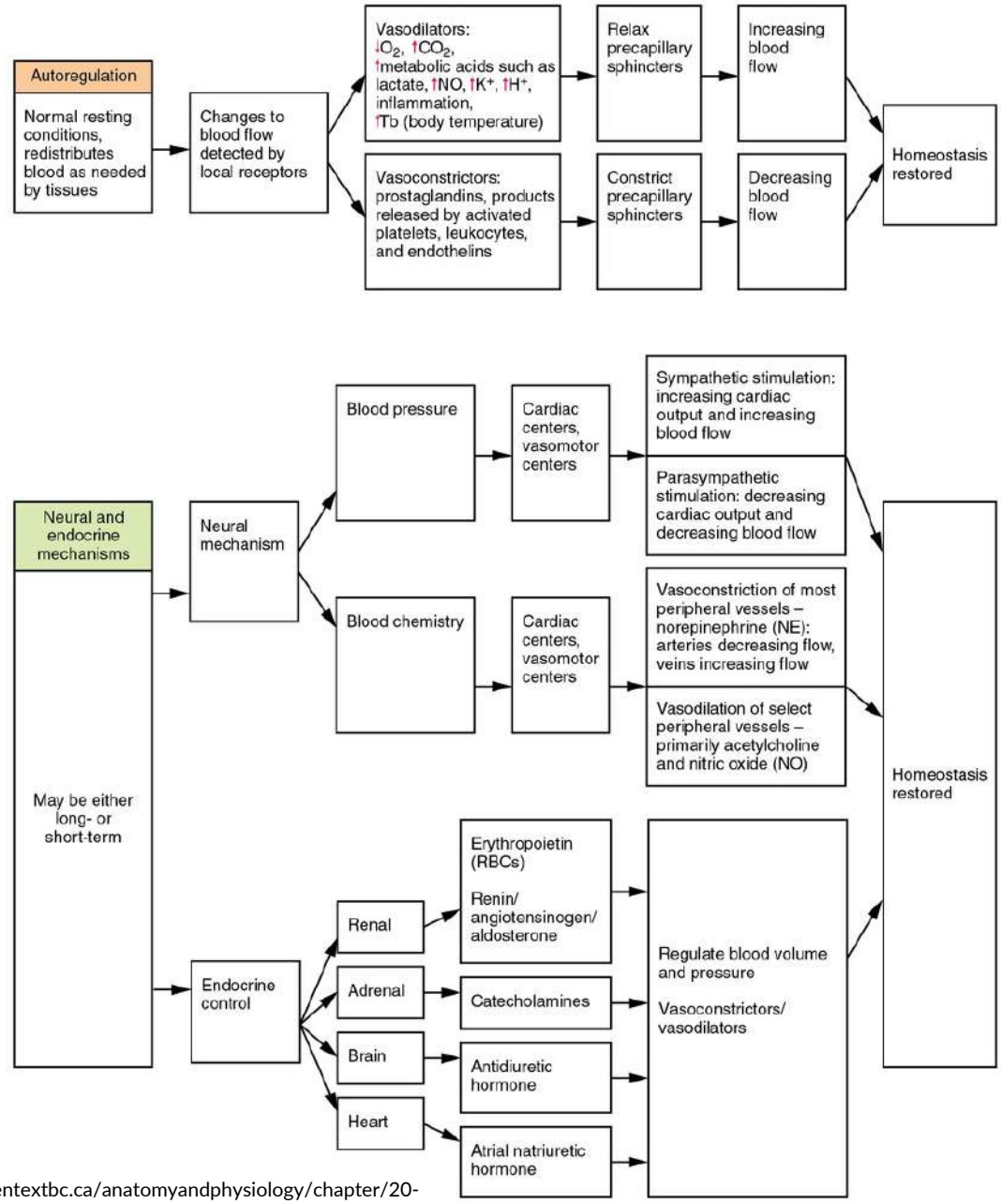
The urinary and cardiovascular systems work together: the urinary system cleans the blood in the circulatory system. Blood traveling back to the heart passes through the kidneys in the urinary system. The kidneys clean the blood and control the amount of salt, water, and other substances in the blood.



How Does the Cardiovascular System Help Maintain Homeostasis?

In order to maintain **homeostasis** in the cardiovascular system and provide adequate blood to the tissues, blood flow must be redirected continually to the tissues as they become more active. In a very real sense, the cardiovascular system engages in resource allocation, because there is not enough blood flow to distribute blood equally to all tissues simultaneously. For example, when an individual is exercising, more blood will be directed to skeletal muscles, the heart, and the lungs. Following a meal, more blood is directed to the digestive system. Only the brain receives a more or less constant supply of blood whether you are active, resting, thinking, or engaged in any other activity.

Summary of Factors Maintaining Vascular Homeostasis. Adequate blood flow, blood pressure, distribution, and perfusion involve autoregulatory, neural, and endocrine mechanisms.



Source: https://opentextbc.ca/anatomyandphysiology/chapter/20-4-homeostatic-regulation-of-the-vascular-system/

Cardiovascular Homeostasis: Student Activity

Homeostasis and Heart Rate

Athletes are often keenly aware of homeostasis, because as they exercise, the body finds ways to return itself to the appropriate internal conditions. For example, if they get too hot, they sweat. If their body isn't getting enough water, they feel thirsty. If their heart rate speeds up, it will eventually go back to its normal resting rate. In these activities, students will look at how their heart rate returns to a state of homeostasis.

Materials:

Stopwatch or timer

Directions:

Teach your students to take their own pulse. The easiest way to do it this is to have students count their pulse for fifteen seconds from their wrist or carotid artery in their neck, and multiply by four. You can set a class timer or have everyone count quietly for 15 seconds.

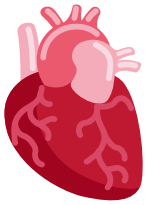
Homeostasis Exercise

Directions:

- Create a class data table, or place students into groups of 2-3 to record data together.
- Have each student in the group take their resting pulse, or their pulse while they are sitting in the chair doing nothing, and record it on their data table.
- Have students complete three minutes of physical activity. It can be as simple as walking around your classroom doing laps. You could even have your students get up and dance. Whichever physical activity you chose, it should be for at least three minutes.
- Have all students take their pulse again, using the same method they used previously.
- Have students sit quietly for another three minutes, then record their pulse again.You may even have them repeat it for a third time in another three minutes.
- Have students create a simple bar graph or line graph of their data.

Discuss homeostasis with your students:

Homeostasis is the body's way of maintaining a constant state in its internal environment, such as temperature or heart rate. So when we exercise, that disturbs our body's homeostasis. What evidence shows that homeostasis was disturbed in this activity? Students should give evidence from their graph or lab data. Discuss how long it took your heart rate to return to its state of homeostasis. What might cause differences in the time it took for different people? For instance, athletes typically have a quicker recovery time in their heart rate compared to the average person.



Common Cardiovascular Diseases

1. **Cardiovascular disease** is a term that refers to more than one disease of the circulatory system including the heart and blood vessels, whether the blood vessels are affecting the lungs, the brain, kidneys or other parts of the body. Cardiovascular diseases are the leading cause of death in adult Canadian men and women.The following six types of cardiovascular disease are highlighted below:Ischemic heart disease is the most common type of cardiovascular disease in Canada and other industrialized countries around the world. It refers to problems with the circulation of blood to the heart muscle. A partial blockage of one or more of the coronary arteries can result in a lack of enough oxygenated blood (ischemia) thus causing symptoms such as chest pain and shortness of breath. A complete blockage of an artery causes necrosis (damage to the tissues) or a myocardial infarction, commonly known as a heart attack.
2. **Cerebrovascular disease (stroke)** refers to a problem with the circulation of blood in the blood vessels of the brain. A blockage with effects lasting less than 24 hours is referred to as a transient ischemic attack. A complete blockage with long-term effects is referred to as a cerebrovascular thrombosis (clot) or accident or a stroke. Sometimes, a blood vessel in the brain can burst resulting in long term effects.
3. **Peripheral vascular disease** affects the circulation primarily in the legs. Patients with this disease typically complain of pain in their calves especially when walking.
4. **Heart failure** occurs when the pumping action of the heart cannot provide enough blood to the rest of the body as it is needed. This can happen as a result of damage to the heart muscle, for example from a heart attack, or from excessive consumption of alcohol, or because of a heart muscle disease also called a cardiomyopathy. Patients with heart failure usually suffer from shortness of breath and swelling of the legs.
5. **Rheumatic heart disease** once common in Canada is a major problem in many poor countries. This disease begins with a bacterial infection in childhood, affecting joints and heart valves. The heart problems appear many years later. Often the valves have to be replaced by an operation. Other infections can occur attacking the inner tissues of the heart including the valves (endocarditis) and the outer tissue overlying the heart (pericarditis).
6. **Congenital heart disease** is a problem with the structure of the heart arising because of a birth defect. These anatomical defects can be as simple as a small hole in one of the inside walls of the heart or they can be very complex, affecting the way blood flows through the heart and lungs. Some congenital heart problems result in death unless immediately corrected by surgical intervention. Others cause disability to varying degrees and are treated by surgery later in life with correction of the problem sometimes requiring more than a single operation.

Closing Check-In and Discussion

During the check closing in:

Recap with the students the path of blood flow through the cardiovascular system. Go over ways the cardiovascular system interacts with other body systems, as well as how it helps maintain homeostasis. Ask the following questions:

- **How might virtual dissections and models compare with using real specimens?**
- **Were you able to successfully learn the structure and function of individual parts of the respiratory system?**

Closing - Discussion on Ethics

The knowledge to create these accurate virtual models of the cardiovascular system had to initially come from real humans and or animals. However, now that we have such a plentiful resources for accurate models of these structures, as well as the ability to perform dissections virtually, do you think we need to continue using animals? Why or Why not?

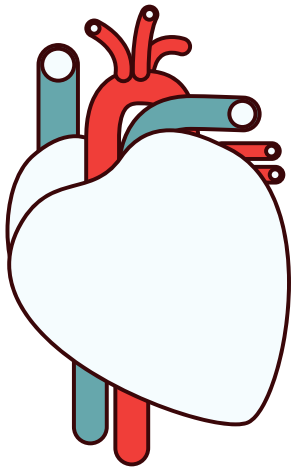
Think

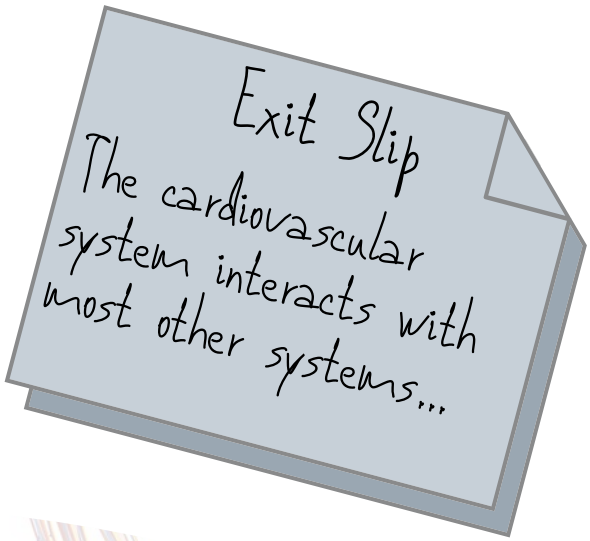
Ask the students to think about where they stand on the subject of animal dissections and the use of animals in science. They don't need to answer right away, rather, this is to get them to start forming their own ethical opinions.

Formative Assessment

The formative assessment can be in the form of an exit slip. This involves asking each student at the end of the class to answer 2-3 questions on a sheet of paper and hand it in, with their names on it, to ensure understanding of the main concepts covered. Examples of questions to include:

- **What is one way the cardiovascular system maintains homeostasis within the body?**
- **What is one way the cardiovascular system interacts with other body systems?**
- **What are the main structures blood moves through within the cardiovascular system?**





Thank you for choosing these materials to support your class adventures!

These Humane Science Education materials were developed by **Elisabeth Ormandy** for the Canadian Society for Humane Science (2015-2022) working to achieve better science without animals. By choosing these unit plans, you have joined a growing family of Humane Science Educators!

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