

## **CHAPTER 3**

### Basic Cardiac and Vascular Anatomy

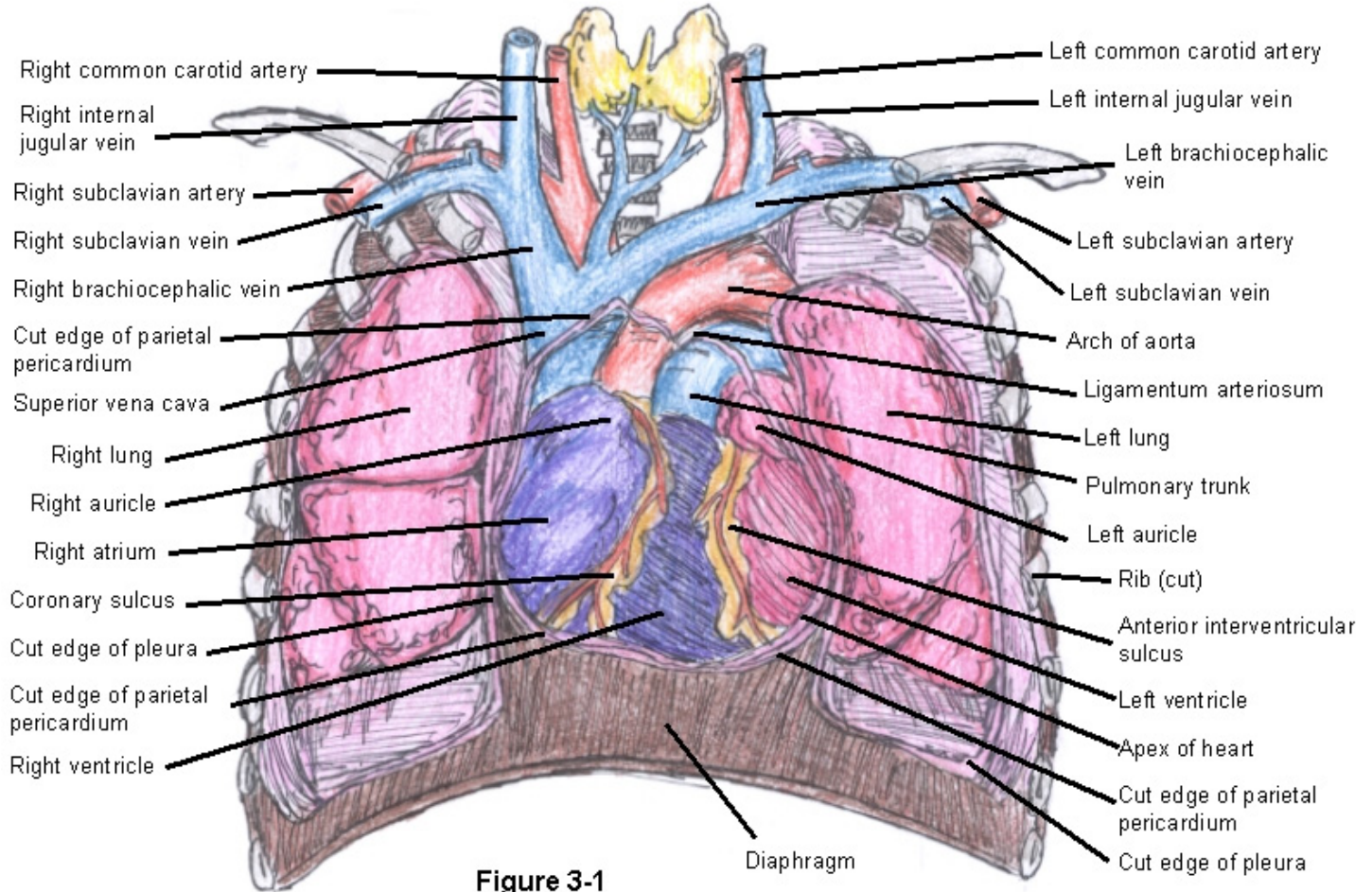
In order to understand the function of the cardiovascular system we must first understand its structure to give us a common knowledge base. Please be able to identify the following cardiac and vascular anatomical structures and know the basics behind its function.

#### 3.1 Cardiac Anatomy Checklists

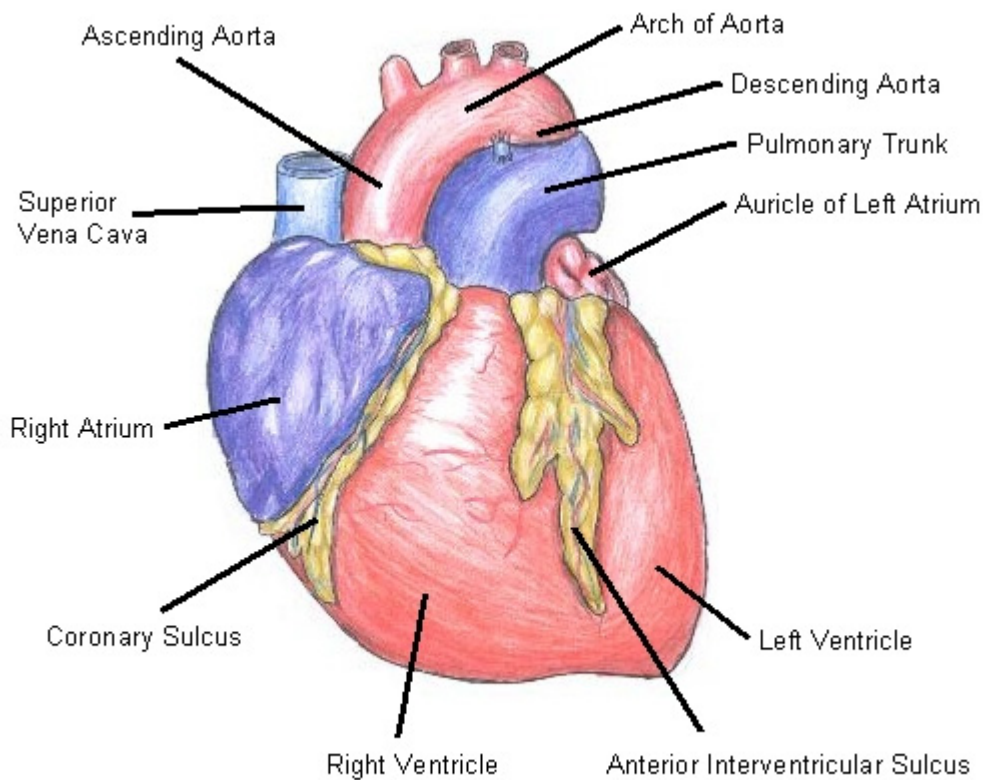
1. **Left and Right Ventricles**
2. **Left and Right Atria**
3. **Aorta**
4. **Pulmonary Arteries**
5. **Pulmonary Veins**
6. **Superior and Inferior Vena Cavae**
7. **Aortic valve (semi-lunar)**
8. **Pulmonary valve (semi-lunar)**
9. **Mitral (Bicuspid, left A/V valve)**
10. **Tricuspid (right A/V valve)**
11. **Cellular structure**
  - A. **Epicardium**
  - B. **Endocardium**
  - C. **Myocardium**
  - D. **Pericardium**
  - E. **Synctium**
  - F. **Intercalated disks**
12. **Coronary Circulation Anatomy**
  - A. **Right Coronary Artery**
  - B. **Left Coronary Artery**
    - left main
    - left circumflex
    - left anterior descending
  - C. **Great cardiac vein**
  - D. **Middle cardiac vein**
  - E. **Coronary sinus**
13. **Interventricular Septum**
14. **Papillary muscle**
15. **Chordae Tendineae**

#### 3.2 Cardiac Anatomy

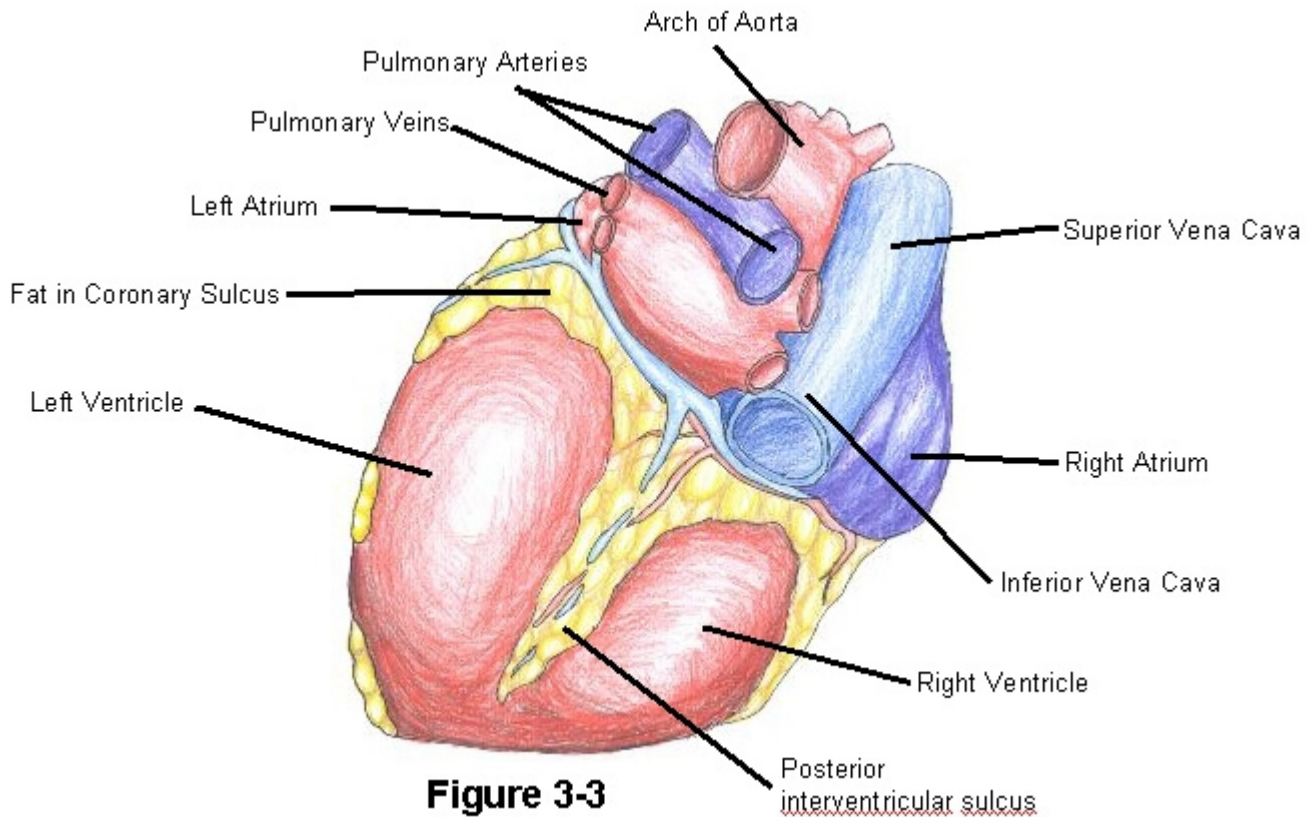
The heart is a four-chambered pump. In Figure 3.1 the relationship of the heart to the thoracic anatomy can be examined.



**Figure 3-1**  
**FIGURE 3.1 Heart Position in Thorax**



**Figure 3-2**  
**FIGURE 3.2 Anterior (sternocostal) surface**

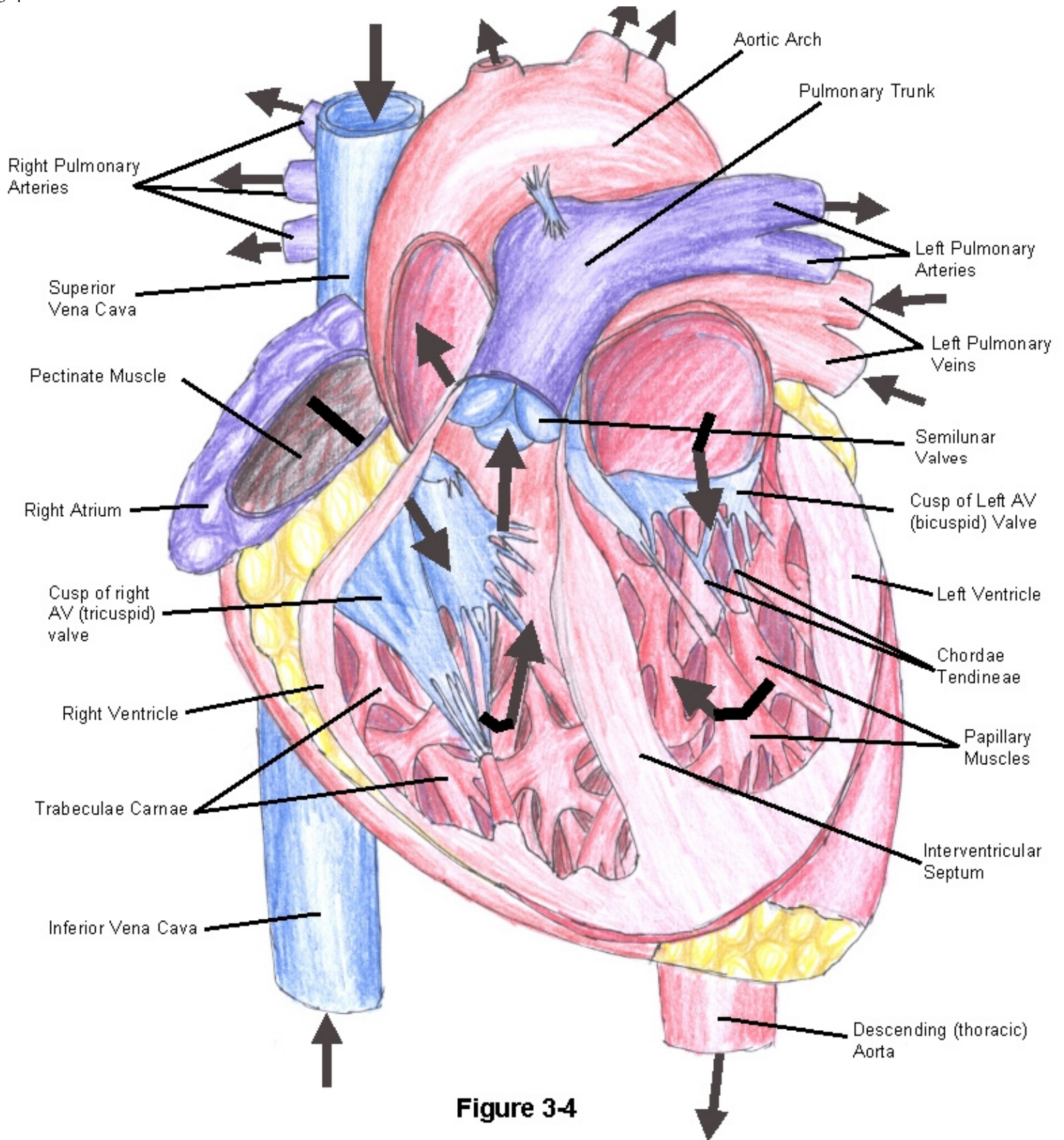


**Figure 3-3**

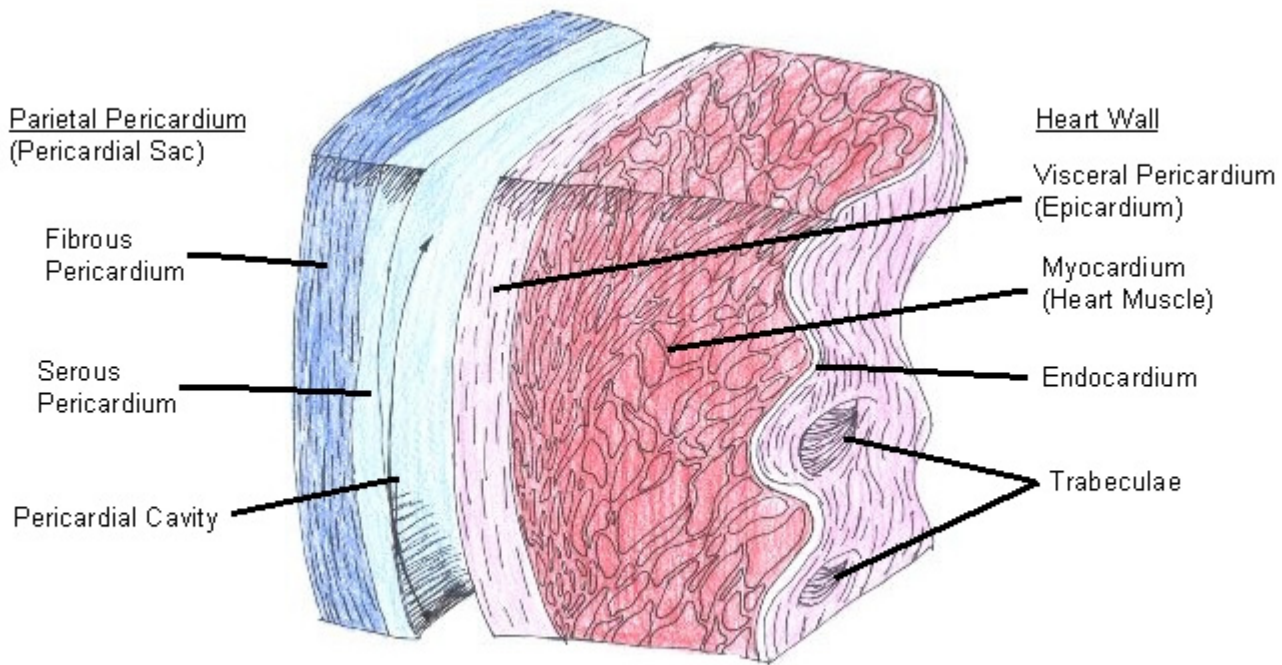
**FIGURE 3.3 Posterior (Diaphragmatic) surface**

In Figure 3.2 and 3.3, the blood flows to the body tissue via the **aorta (ascending, arch, descending)** where it gives up oxygen and nutrients to the tissue. The blood returns from the body tissue via the **superior and inferior vena cava**. The heart then pumps the deoxygenated blood to the lungs via the **pulmonary artery**. The re-oxygenated blood returns from the lungs to the heart through the **pulmonary veins**. Figure 3.4 depicts a cut-away view of the heart as viewed from the anterior surface.

Here one can see the direction of blood flow within the heart. Blood within the **left ventricle** is expelled through the **aortic valve (semi-lunar)** into the **ascending aorta**. This blood is distributed to the systemic circulation and returned to the heart through the **superior and inferior vena cava**. Next, the blood fills the **right atrium** and then travels through the **tricuspid valve (A/V valve)** into the **right ventricle**. The blood is then expelled through the **pulmonary valve (semi-lunar)** into the **pulmonary artery**, where it is distributed to the lungs. After passing through the lungs the blood is returned to the **left atrium** via the **pulmonary veins**. At last the blood passes through the **mitral valve (A/V valve)** and into the **left ventricle** and the process repeats itself. Also shown here are the **chordae tendinae** and **papillary muscles** that help open the A/V valves. Note also the **interventricular septum** that separates the **right and left ventricles**.



**Figure 3.4 Anterior Cut-Away View**



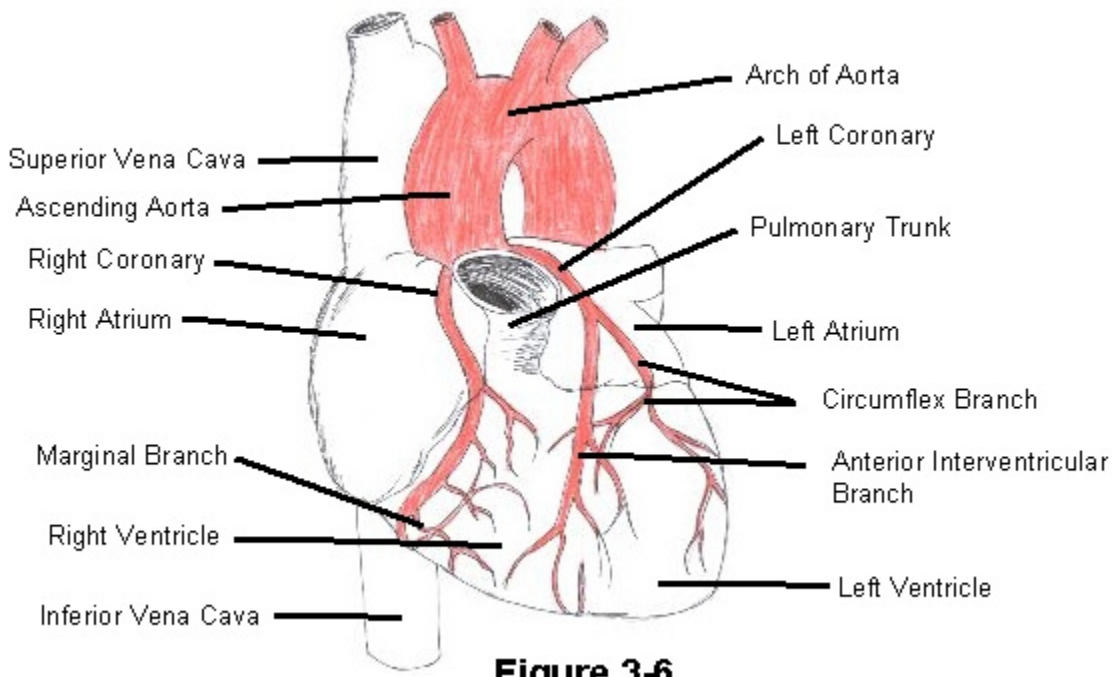
**Figure 3-5**

**Figure 3.5 Structure of the Parietal Pericardium and Heart Wall**

If one sections a bit of heart muscle, the structure of the **myocardium** may be revealed (Figure 3.5). On the ventricle surface is the **endocardium**. Next, is the actual heart muscle, the **myocardium**, and then an outer layer called the **epicardium**. A pericardial cavity separates the **epicardium** from the tough fibrous outer layer called the **pericardium**.

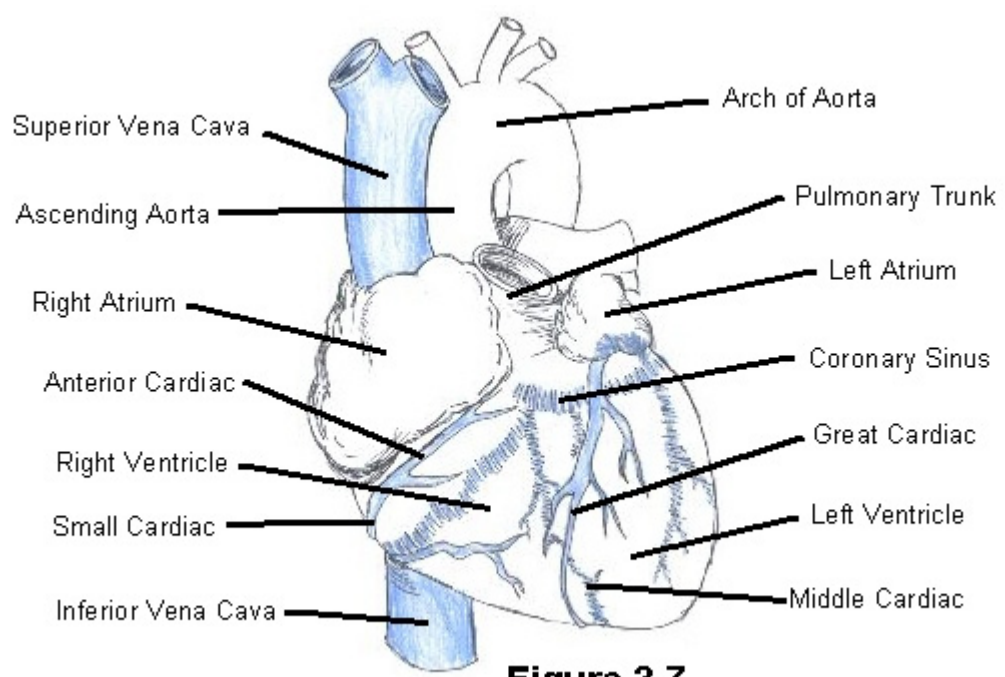
Figures 3.6 and 3.7 show some of the major coronary arteries and veins that will be important to our study of cardiac function. Significant coronary arteries include: 1) **left main**, 2) **left anterior descending (LAD)**, and 3) **left circumflex (LCX)**. These arteries perfuse most of the left side myocardium and the **interventricular septum**. Significant right side coronary arteries include the right **main** and **marginal branch**. Coronary veins of importance include **great cardiac** and the **coronary sinus**.

Finally the structure of the myocardium is such that **intercalated disks** connect the cells to each other. The intercalated disks allow all the myocardial cells to act as if it were one large cell as far as cell-to-cell communication goes. This “one big cell” concept is called a **syncytium**.



**Figure 3-6**

**Figure 3.6 Significant Coronary Arteries**



**Figure 3-7**

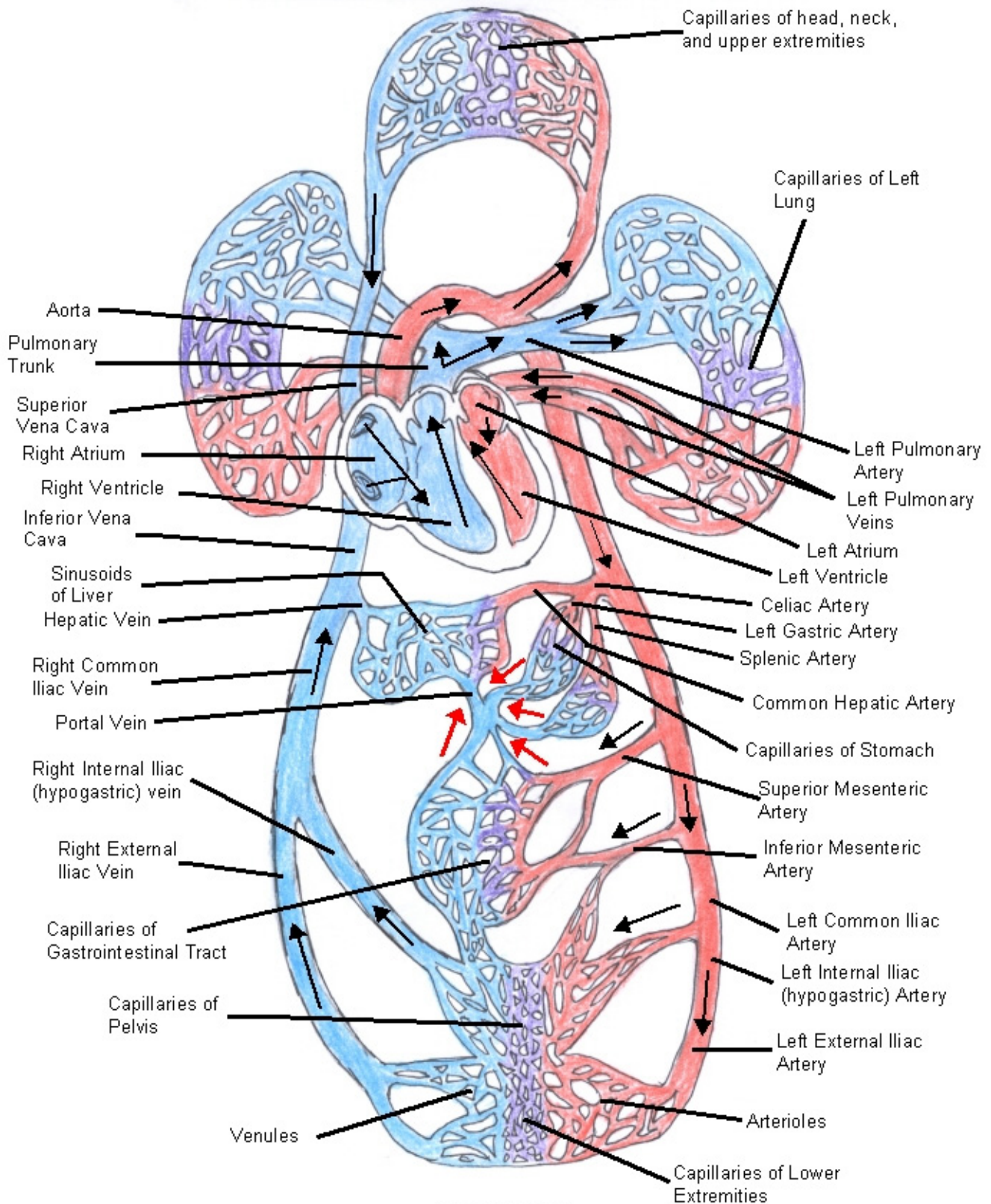
**Figure 3.7 Significant Coronary Veins**

### 3.3 Vascular Anatomy Checklist

1. Ascending, Descending, Thoracic Aorta
2. Aortic Arch
3. Pulmonary Arteries
4. Pulmonary Veins
5. Left internal and external carotid arteries
6. Femoral arteries and veins
7. Special Circulations (Know the function and uniqueness)
  - Renal
  - Hepatic/Portal
  - Cerebral
  - Coronary
8. Brachiocephalic
9. Right internal and external Carotid Arteries
10. Carotid sinus
11. Radial and brachial arteries
12. Ductus arteriosum (ligamentum arteriosum), foramen ovale and "blue babies"
13. Jugular veins
14. Median cubital vein
15. Inferior/superior vena cava
16. Venous valves
17. Arterioles, capillaries, venules

### 3.4 Vascular Anatomy

Figure 3.8 shows a simplified view of the circulatory system. Here one can trace the route of the blood from the left ventricle, through the aortic valve into the **aorta**, to the systemic circulations, back through the venous system to the right atrium, tricuspid valve, right ventricle, pulmonary valve, **pulmonary artery** and on to the lungs. The blood returns via the **pulmonary veins** to the left atrium, through the mitral valve and into the left ventricle where the process begins again. Note especially the **portal** and **hepatic** veins. The red colors of the circulation denote oxygenated blood and the blue color denotes de-oxygenated blood. The pulmonary artery contains deoxygenated blood and the pulmonary vein contains oxygenated blood.

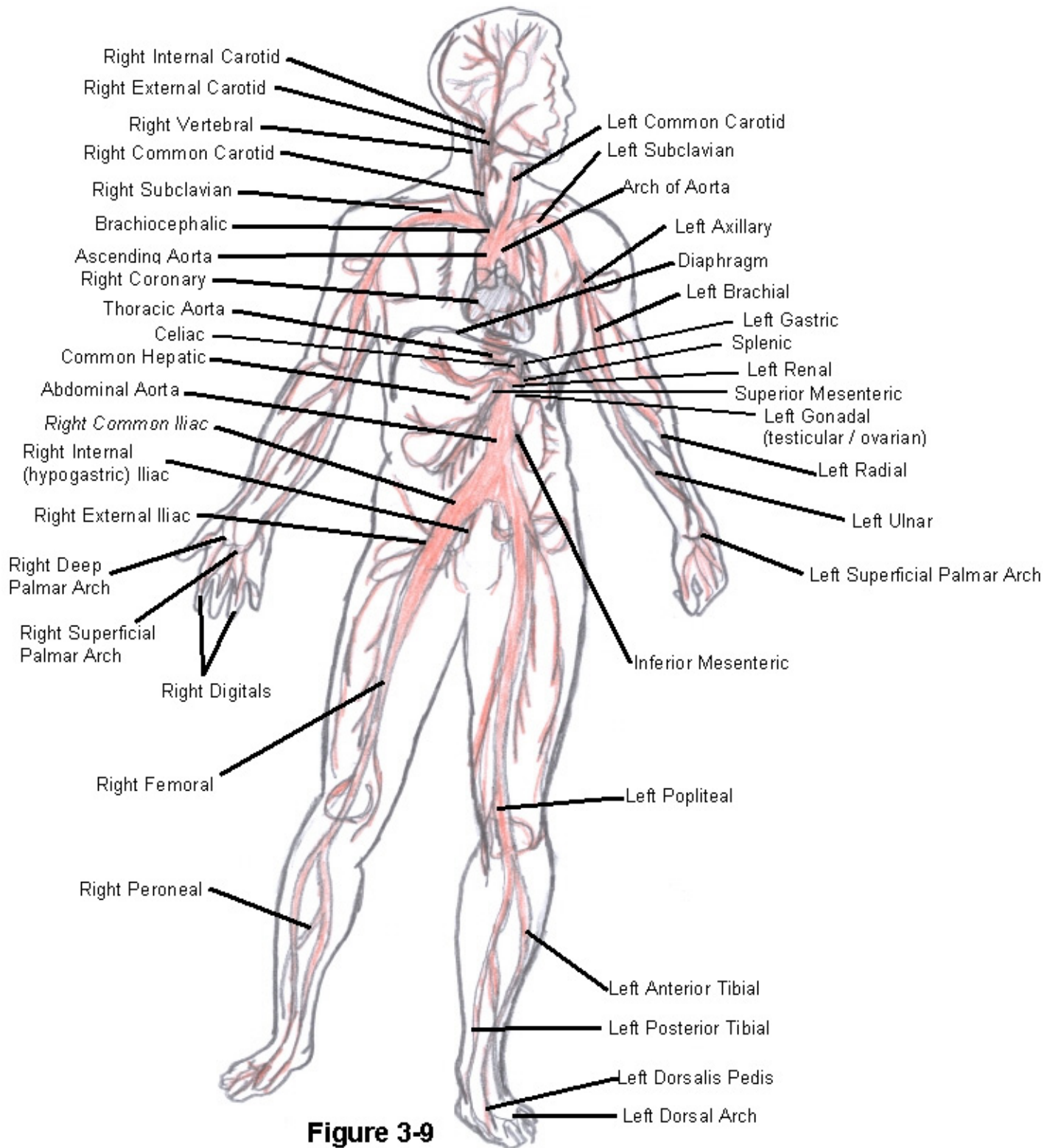


**Figure 3-8**

**Figure 3.8 Circulation Overview**

In Figure 3.9, a more anatomical correct and detailed illustration of the arterial system is shown. As the blood flows out of the left ventricle, some of the blood is delivered to the **left and right coronary** circulations. The next major branch, in humans, is **brachiocephalic**, which distributes blood to the head and right arm.

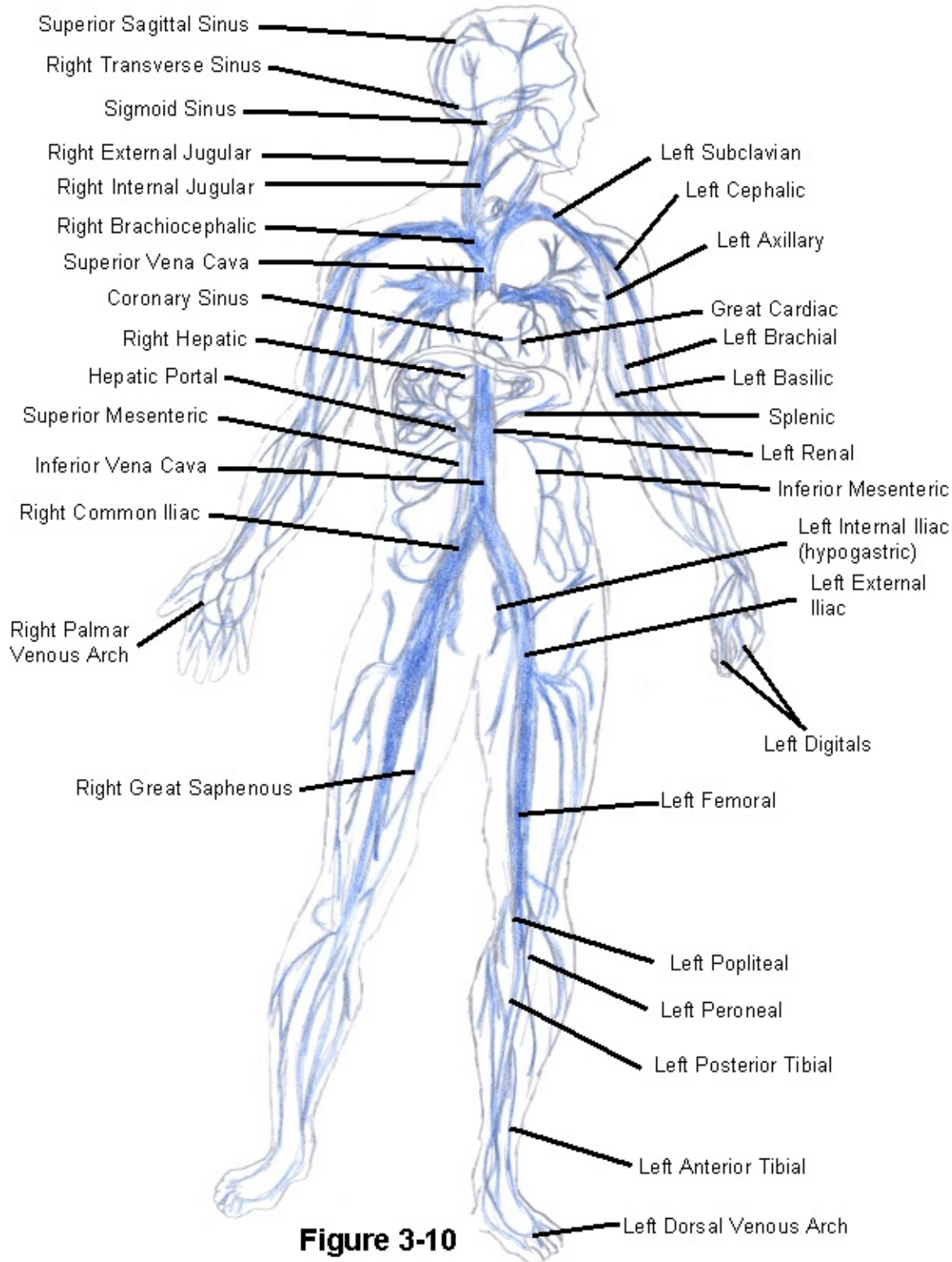




**Figure 3-9**

### Figure 3.9 Anterior View of Aorta and Principal Branches

The next major branch off the aorta is the **left common carotid**, which also perfuses the head. The next major branch is the **left subclavian**, which supplies blood primarily to the left arm. Important branches of the brachiocephalic are the **right subclavian** and the **right common carotid**. The **right common carotid** splits into the **right external and internal carotid arteries**. The point at which the split in the common carotid occurs is called the **carotid sinus**. The **femoral artery** near the groin is an important arterial system access point. The **radial and brachial arteries** provide access points to palpate the arterial pulse.

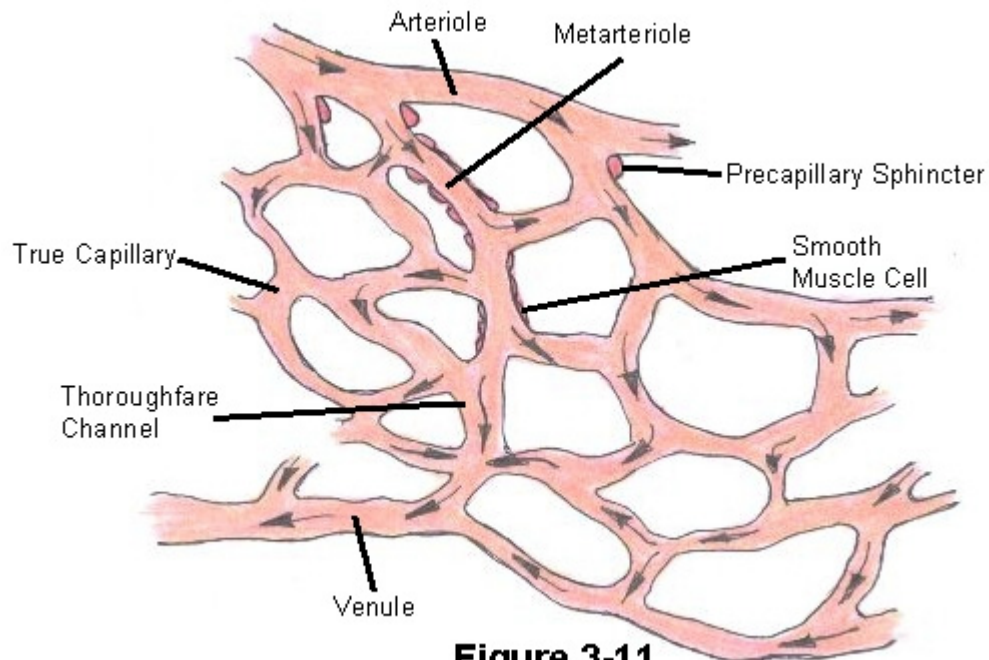


**Figure 3-10**

**Figure 3.10 Anterior View of Principal Veins**

Figure 3.10 shows the distribution of the veins. The **jugular** and **medial cubital** veins have special importance. The **jugular** offers an access point to catheterize the right side of the heart. The **medial cubital** vein, located in soft flesh on the opposite side from the elbow, is the preferred point to extract venous blood samples. Another access point often used to catheterize the right heart is the **femoral** vein.

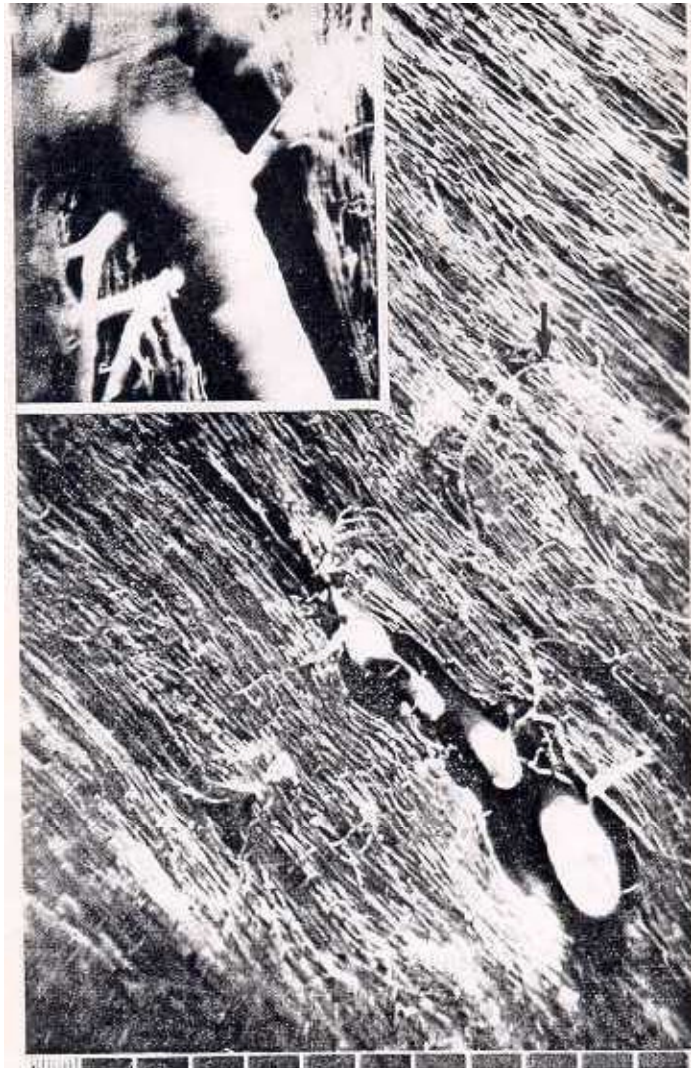
Figure 3.11 is an illustration of how arteries become smaller and smaller (**arterioles**) and distribute blood into the **capillary** network. Small veins, called **venules**, collect the blood from the capillary network.



**Figure 3-11**

### Figure 3.11 Arterioles and Venules

Figure 3.12 depicts the incredible **density** of **capillaries** located within the myocardium. Figures 3.13 and 3.14 show **terminal arterioles** splitting into two **daughter capillaries** and a typical **capillary network**. Typical terminal arteriole diameters are about  $10\ \mu\text{m}$  and are composed of sinuous smooth muscle which when contracted pinch off blood flow – thereby acting as minute flow controllers. It is thought that terminal arterioles alternately open and close over time. Of course, during maximum metabolic demands the terminal arterioles can all open delivering maximum flow through the capillary network. A current hypothesis is that adenosine, a metabolic waste product, relaxes the smooth muscle, thereby increasing flow and thus acting like an automatic control system to regulate the correct amount of blood in that tissue.



Subepicardial vasculature. Section parallel to epicardium, 1mm deep. Scale division 30 and 100um. A 60-um arteriole, accompanied by two venules, gives rise to three 10-um arterioles, two short and one long (at arrow). The insert (same scale) shows a 160-um vein giving rise to small venules and branching rapidly into the parallel capillaries.

**Figure 3-12**

**Figure 3.12 Subendocardial Vasculature**

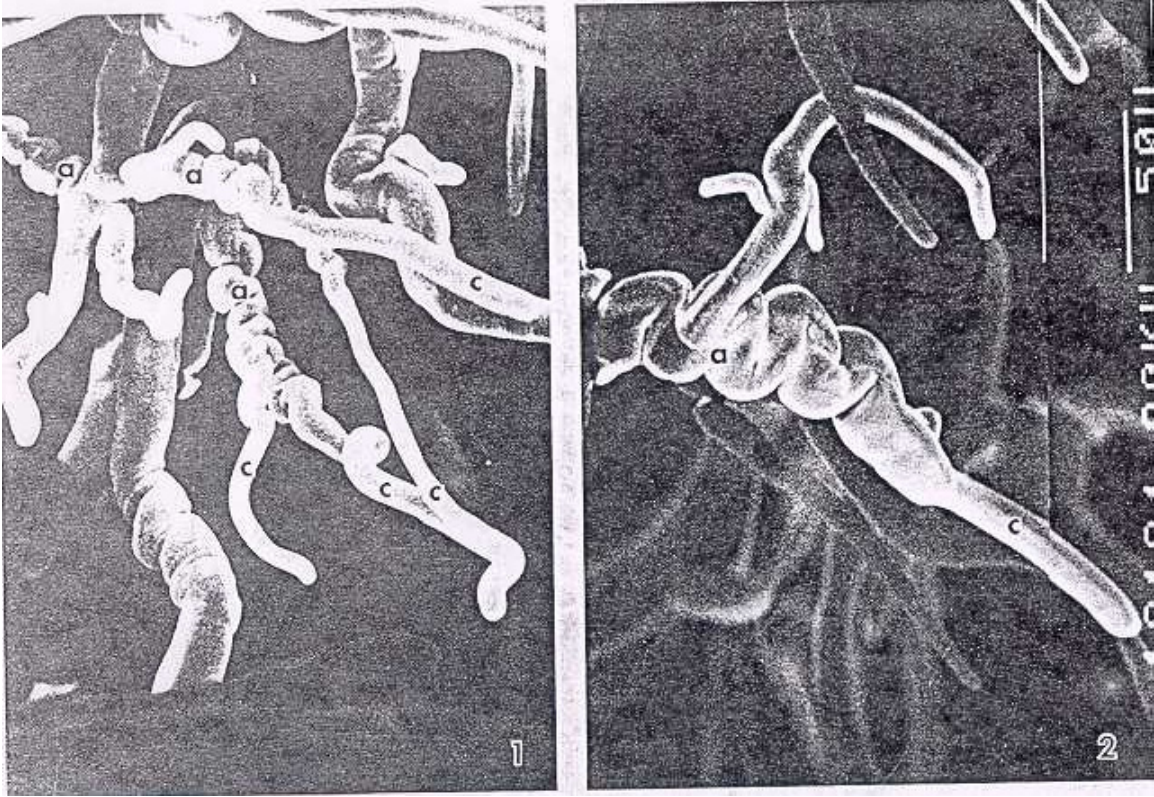


Figure 3.13 Terminal Arterioles (a) splitting into two daughter capillaries (c)

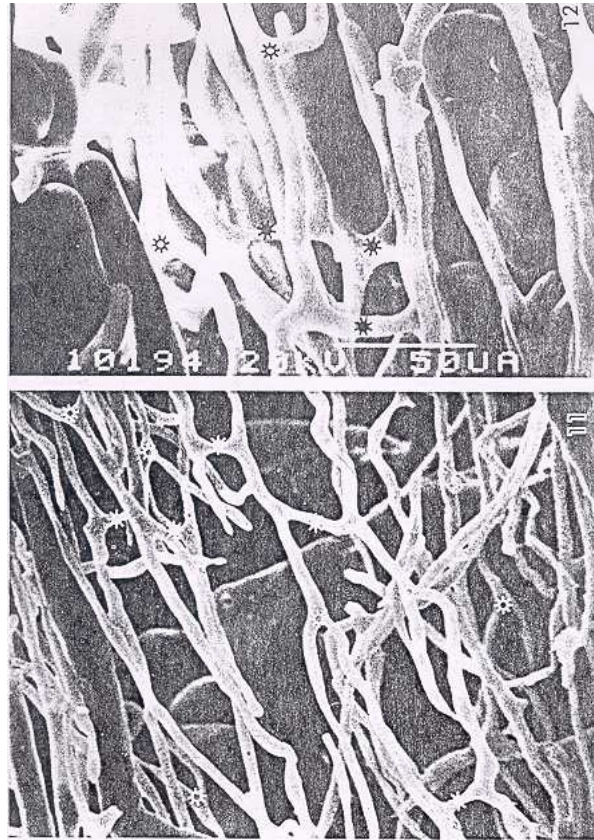
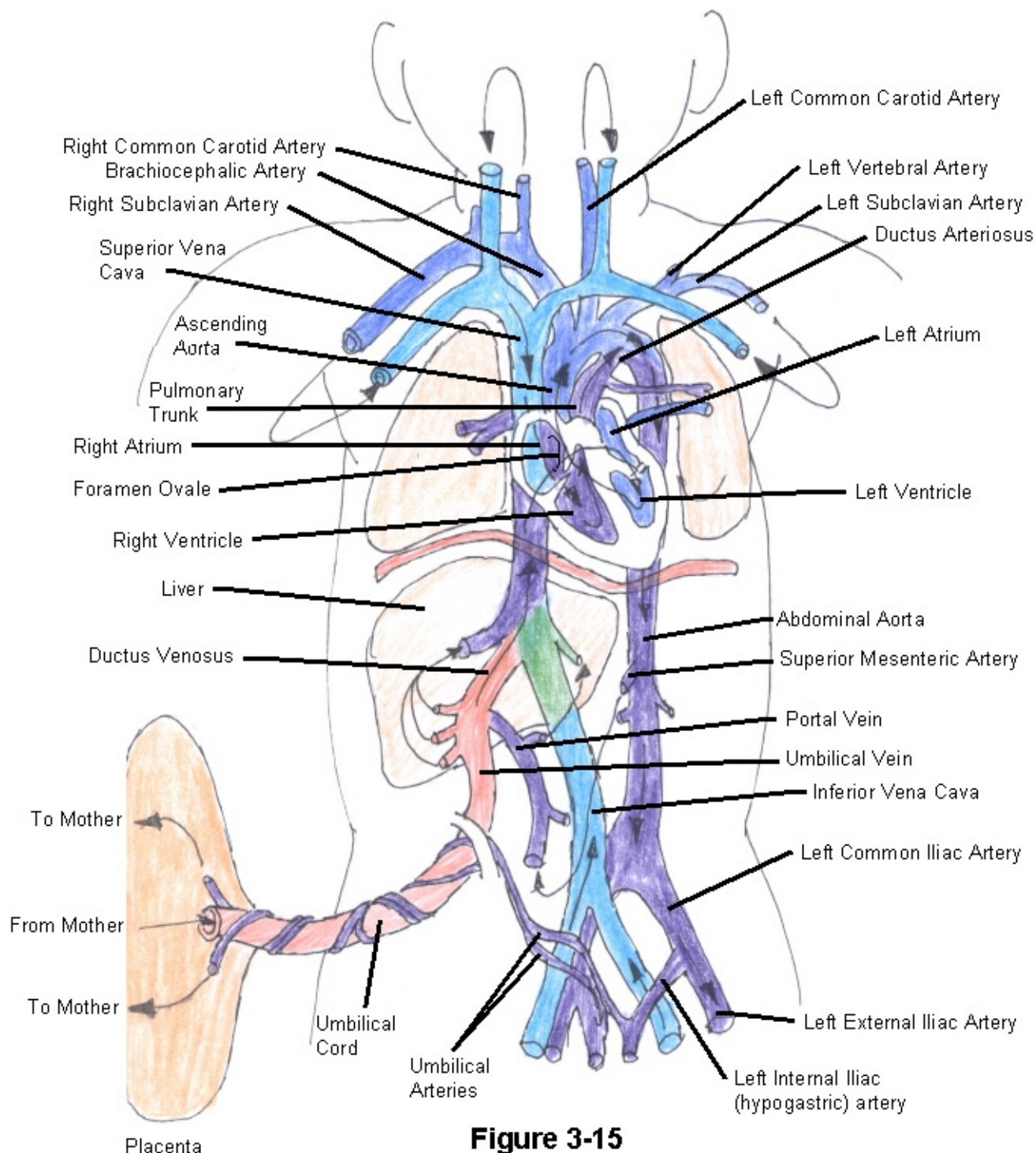


Figure 3.14 Capillary Network

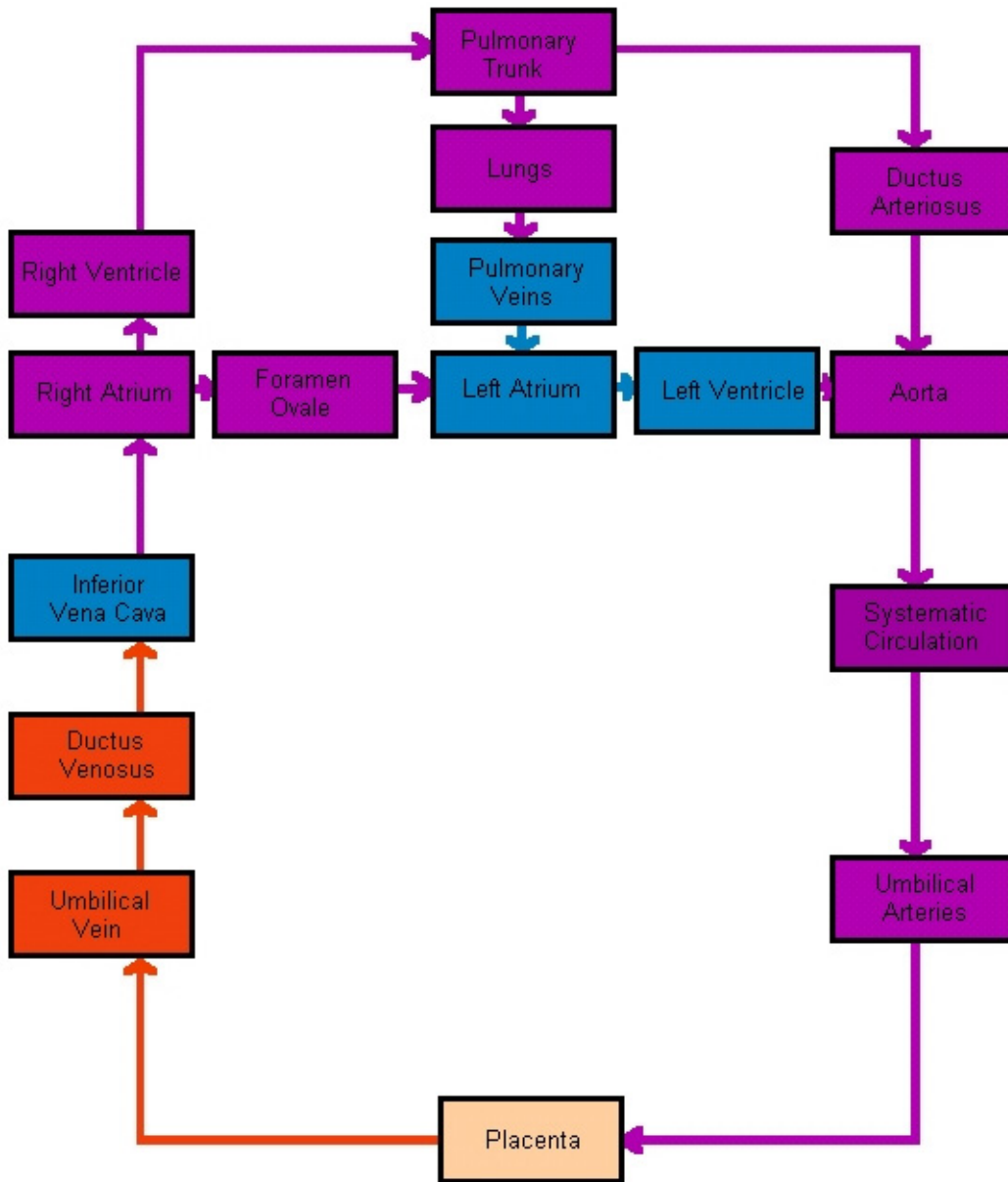
Figure 3.15 illustrates the intricacies of fetal circulation. Here the fetus is supplied with the mother's oxygenated arterial blood by the **placenta**, through the **umbilical vein and ductus arteriosus** (liver). The next notable circulation difference is the **foramen ovale**, which allows blood to pass from the right atrium into the left atrium. As the blood leaves the left and right heart, it can mix again due to the **ductus arteriosus**, a communication between the aorta and pulmonary artery. After traversing the body, the blood leaves via the **umbilical artery** and travels to the placenta where the process repeats itself.



**Figure 3-15**

**Figure 3.15 Fetal Circulation**

A block diagram of the fetal circulation is shown in Figure 3.16. Upon birth, the **foramen ovale (fossa ovalis)** closes and the **ductus arteriosus** begins to constrict (**ligamentum arteriosum**) and eventually close. With these occurrences, and the cutting of the umbilical cord, the normal human circulation is achieved. Failure of the **foramen ovale** to close results in the “**blue baby**” syndrome – as the mixing of venous and arterial blood in the atria give the baby a “blueish” hue.



**Figure 3-16**

**Figure 3.16 Fetal Circulation, Block Diagram**