Lab 9: Circulatory System of the Cat

Lab Objectives
1. To learn how blood flows through a dual circuit circulation with lungs.
2. To learn which vessels supply and drain different organs and areas of the body.
3. To understand how blood flows through the heart of the cat and compare this to what is seen in the shark.
4. To appreciate the differences between the circulatory system of the shark and the cat.

Material to Learn
Cat circulation
- Figures 7.51, 7.52, 7.53, 7.54, 7.55, 7.56, 7.58, 7.59, 7.60, 7.61, 7.63.
- Use Figures 7.64-7.67 to help, but delete vessels from omitted figures.
- OMIT: Figures 7.57 (you only need to know common carotid a. on this figure), 7.62.
- OMIT: All hepatic portal vessels.

Term list
Adrenolumbar a.  Coronal a.  Papillary muscle
Anterior mesenteric a.  External iliac a.  Posterior
Anterior rectal a.  External jugular v.  Posterior vena cava
Anterior splenic a.  Gastric a.  Pulmonary a.
Anterior vena cava  Gastroduodenal a.  Pulmonary v.
Aorta  Gastroplenic a.  Pulmonary semilunar valve
Aortic arch  Hepatic a.  Pulmonary trunk
Aortic semilunar valve  Hepatic v.  Renal a.
Atrioventricular valves  Internal iliac a.  Renal v.
Axillary a.  Internal iliac v.  Right atrium
Axillary v.  Internal jugular v. Left atrium  Right auricle
Bicuspid valve  Left auricle  Right gastric a.
Brachiocephalic v.  Left subclavian a.  Right ventricle
Caudal a.  Left vena cava  Splenic a.
Caudal v.  Middle colic a.  Subclavian v.
Celiac a.  Ovarian a.  Trabeculae carnae
Chordae tendinae  Ovarian v.  Tricuspid valve

Background & Instructions
During this week’s lab, you will be dissecting and studying the cat’s circulatory system. A bear heart and sheep heart are available as demo, so use these to study internal heart anatomy. The cat’s arterial and venous systems are injected as they were in the shark.
Again, try to gain an appreciation for the 3-D arrangement of the circulatory vessels. Unlike the shark, the cat has a dual circuit circulatory system, which means that the blood passes through the heart twice per cycle through the body. The heart takes the blood to the lungs, then the blood returns to the heart, where it is pumped to the rest of the body. Such a system is very efficient, but requires higher blood pressure. Circulation is divided into a pulmonary circuit and a systemic circuit. As with the shark, arteries take blood away from the heart and veins return it, but now, each circuit has its own set of arteries and veins. In this lab, we will be focusing mainly on how blood enters and leaves the heart, large blood vessels anterior to the heart, and vessels of the abdominal cavity. We will consider only the most major vessels supplying blood to and draining blood from the limbs and head.

Even more so than with the shark, blood vessels can be highly variable between individuals: although all individuals typically have the same vessels, the junctions between vessels vary. The best way to learn the vessels is to learn what each vessel supplies blood to or drains, and to learn the order in which vessels branch off one another. A good way to proceed is to start centrally with big vessels and to work peripherally.

Continue to think about the direction that blood is flowing in vessels as you learn them. In your cat, arteries are colored red, and veins are colored blue.

For the cat, think about the following for each vessel:
• Is the vessel an artery or vein?
• Is the vessel part of the pulmonary or systemic circuit?
• Is the vessel taking blood to the heart or away from the heart?
• Is blood inside the vessel oxygenated or deoxygenated?
• Is blood inside the vessel nutrient rich or nutrient poor?

1. Dissecting instructions
   Step 1: The heart may still be in its pericardium. If so, use small scissors to cut through its fibrous connective tissue and examine the external morphology of the heart. Do not cut the heart open. Instead, study the internal anatomy of the heart using the bear heart.
   Step 2: Blood vessels can be very delicate, and although the latex makes them much more resilient and easier to dissect, there may be fragile areas where not enough latex penetrated. Use the curved forceps and small scissors as needed to expose the blood vessels. You can cut through muscles as needed. Leaving things as intact as possible is a good idea so that you see what the various vessels supply or drain. Work anteriorly from the heart, tracing the anterior vena cava and the branches of the aorta towards the neck and the front limb. Note that there are many vessels that you do not need to know - concentrate on the major ones (see term list).
   Step 3: Once you have identified all of the vessels in the anterior region of the cat, turn your attention to the abdominal cavity. Start by following the dorsal aorta anterior to posterior and finding all of the branches that come off it. Here we are going into considerable detail so that you gain an understanding of how the circulatory system is integrated with the organs of the gastrointestinal tract and urogenital system. Study and learn them, keeping the tips discussed above in mind as you do so.

2. Internal heart anatomy
   The internal anatomy of the mammalian heart is a result of a high pressure, dual circuit circulatory system. It has two atria and two ventricles and can be divided into a right, pulmonary side and a left, systemic side. Atria are dorsal to the ventricles and are
thinner walled. Because the systemic circulation is under higher pressure, so that the blood gets to distant body parts, the left ventricle has a thicker wall than the right ventricle. **Atrioventricular valves** separate each atrium and ventricle with the **tricuspid valve** being on the right and **bicusp**id valve being on the left. Valves also control flow from each ventricle out of the heart: on the right is the **pulmonary semilunar valve**, and on the left is the **aortic semilunar valve**. The cords of connective tissue connect the valves with walls of the ventricles and prevent the valves from collapsing or inverting. The cords are called **chordae tendinae** and they connect to the ventricle via the **papillary muscles**, which are cone-shaped protrusions into the ventricular interior. Ridges of muscle inside the ventricles strengthen the walls and are called **trabeculae carnae**.

You will need to know how blood flows into, through, and out of the heart. Blood coming from various parts of the body is deoxygenated and enters the right atrium via the anterior and posterior vena cava. It then flows into the right ventricle, the **pulmonary trunk**, and the **pulmonary arteries**, which take blood to the lungs. Blood returns to the heart from the lungs (now oxygenated) via the **pulmonary veins**, flowing into the left atrium, the left ventricle, and the aorta. From the aorta, blood flows again to various parts of the body.

**What are the chambers of a cat’s heart?**

**Which ones store or pump blood going to the pulmonary circuit?**

**Which ones store or pump blood going to the systemic circuit?**

**Name two vessels that belong to the pulmonary circuit and four vessels that belong to the systemic circuit.**

3. Branching order and flow patterns
Blood vessels can be hard to learn because of the variability in where they branch - this differs between individuals. They also sometimes make loops, allowing for blood to flow in multiple ways to a place. The key to learning the vessels is to pay attention to the order in which they branch and the organs or tissues that they supply.

For example, if you follow the aorta as it arches dorsal to the heart and runs into the abdominal cavity, it has a number of branches. Some of these branches are bilateral (there is a left and right branch) and run to paired organs and structures, and some are unilateral, typically supplying the guts. If you follow the aorta anterior to posterior within the abdominal cavity, your first branch is unilateral and called the celiac a. Second is the anterior mesenteric a, then adrenolumbar aa, renal aa, internal spermatic aa or ovarian aa, posterior mesenteric a, deep circumflex iliac aa, external iliac aa, and finally the internal iliac aa. The dorsal aorta then continues as the median sacral a, continuous with the caudal a. This branching order is the first big step to learning abdominal circulation. Then concentrate on each of these branches to see what sub-branches there are. Some vessels, like the renal aa, simply run to a structure and do not subdivide further. Others, such as the celiac a, have branches that themselves subdivide.

Also remember that the name of many vessels either tells you what the vessel supplies (e.g., renal aa. go to the kidneys), or at least gives you a clue (e.g., anterior mesenteric aa. goes to the intestines via the mesentery).

Name the vessel that is supplying blood to and from the vessel that is draining each of the following structures.

<table>
<thead>
<tr>
<th>Supplying Blood</th>
<th>Structure</th>
<th>Draining Blood</th>
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<tbody>
<tr>
<td>Kidney</td>
<td>Liver</td>
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<td></td>
<td>Hind limb</td>
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<td>Pectoral muscles</td>
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<td>Head</td>
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<td></td>
<td>Front limb</td>
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<tr>
<td>Ileum</td>
<td>Hepatic Portal System</td>
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<tr>
<td>Stomach</td>
<td>Hepatic Portal System</td>
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Make a flow chart of the cat’s circulation, both arterial and venous. Although you have probably noticed that such a flow chart already exists in the lab manual, making one on your own without referring to the one in the book (instead, use the other figures and the actual cat specimens) is among the best ways to study circulation.