Lab 8: Circulatory System of the Shark

1. To learn how the divisions of the circulatory system relate to one another.
2. To understand how blood flows through a single circuit circulation with gills.
3. To learn which vessels supply and drain different organs and areas of the body.
4. To understand how blood flows through the heart of the shark.

Material to Learn
Shark circulation

- Figures 3.27, 3.28, 3.29, 3.30, 3.31, 3.32
- Associated text: pp. 50-59
- KNOW BUT DO NOT DISSECT: any of the venous sinuses.

Term List
Afferent branchial a. Dorsal aorta Pancreaticomesenteric a.
Anterior cardinal sinus Efferent brancial a. Pancreaticomesenteric v.
Anterior intestinal a. External carotid a. Posterior cardinal sinus
Anterier intestinal v. Gastric a. Posterior cardinal v.
Anterior lienogastric v. Gastric v. Renal a.
Atrium Hepatic a. Sinus venosus
Brachial v. Hepatic sinus Subclavian v.
Celiac a. Hepatic v. Ventrail aorta
Common cardinal v. Internal carotid a Ventrail gastric a.
Conus arteriosus Lateral abdominal v. Ventricle
Coronary a. Lienomesenteric v.
Cross trunk Paired dorsal aortae

Background & Instructions
During this week's lab, you will be dissecting and studying the shark's circulatory system. The heart and anterior portion requires some dissection, while the posterior portion requires careful observation and working out the 3-D arrangement of the vessels. The shark is a great example of a single circuit circulatory system, where blood passes through the heart only once per cycle through the body. 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 (start at the heart, or with dorsal or ventral aorta) and to work peripherally.

Components of the Shark Circulatory System

Spleen: The spleen is an accessory circulatory organ that produces red blood cells and filters out old red blood cells. It also produces & releases white blood cells during infections.
**Heart:** Sharks have a 4-chambered heart. All chambers are formed of cardiac muscle tissue & are found within the pericardial cavity. Blood flows in a one-way path through the heart so they have a "single-circuit", low-pressure circulation. The heart pumps deoxygenated blood toward the gills:

\[
\text{low O2 blood} \rightarrow \text{sinus venosus} \rightarrow \text{atrium} \rightarrow \text{ventricle} \rightarrow \text{conus arteriosus} \rightarrow \text{low O2 blood}
\]

The **sinus venosus** is a very thin sac that tears easily when exposing the heart or the liver. The **atrium** is large, but very soft or spongy in texture. The **ventricle** will feel hard and muscular, but looks smaller than the atrium because of its contracted state. The ventricle generates most of the pressure that moves the blood forward. There are 1-way valves at the junction between the heart chambers to control the flow of blood. The **conus arteriosus** is a small, narrow tube that contains a series of **semilunar valves** to prevent back flow of blood. The conus contracts or recoils slowly, regulating pressure in the ventral aorta & keeps the flow of blood more uniform.

**Blood Vessels:** The heart is ventrally located. The first vessel that exits the heart is called the **ventral aorta**. The ventral aorta divides into a series of paired **afferent branchial arteries**. These arteries are ventral to the gills & take deoxygenated blood up into the gills for gas exchange, thus they "arrive" at the gills. Oxygenated blood leaves the gills dorsally via a series of paired **efferent branchial arteries** (blood "exits" the gills). One small branch forms the **commissural artery** that leads directly to the heart. When this vessel enters the pericardium it divides into a **pericardial artery** on the parietal pericardium wall & into the **coronary artery** that supplies cardiac muscle tissue with oxygen.

The efferent branchial arteries merge dorsally into the **dorsal aorta**. Branches off of the dorsal aorta may be divided into several categories: **Somatic** branches that are typically paired (R & L) will go to the body wall or limbs & include: R & L **subclavian arteries** that enter the pectoral fins, R & L iliac arteries that enter the pelvic fins and a caudal artery that is an unpaired somatic branch into the tail via the hemal canal. Unpaired, **visceral** branches go to digestive system organs & include: **celiac artery** with its branches, **anterior mesenteric artery, gastroplenic artery**, and a **posterior mesenteric artery**.

There are 3 major venous circuits that return deoxygenated blood via separate pathways to the sinus venosus. Paired, **lateral abdominal veins** takes blood from the fins & muscle tissue of the body wall. This vein empties into the **common cardinal sinus** just before blood enters the **sinus venosus**. Blood from the caudal vein is split into small, paired vessels, called **renal portal veins**, on the lateral sides of the kidney tissue. This blood flows through capillary beds in the kidney tissue & then enters paired, **posterior cardinal veins**. The posterior cardinal veins carry blood up into large, sac-like chambers called **posterior cardinal sinuses** & then into the **common cardinal sinuses**.

The **hepatic portal circulation** is a special subdivision of the venous blood flow. The venous blood from all of the digestive system organs & spleen goes into the liver before it goes back to the heart. The blood in the **hepatic portal vein** merges with blood from the **hepatic artery** to ensure that the liver receives some oxygenated blood. A portal circuit
takes blood from 1 capillary bed (e.g. stomach) carries blood in vein(s) to another capillary bed (e.g. liver). The processed blood exits the liver in paired hepatic sinuses that empty directly into the sinus venous through the transverse septum.

1. Dissecting instructions

1. Start with the branchial region and the heart. You will not be exposing the heart as shown in Figure 3.27. Instead, you will be accessing it from the dorsal/internal side. In a previous lab, you cut through the gills on one side. Reflect the lower jaw to open up the pharyngeal region and try to flatten it out. You may need to break some of the cartilage in the uncut gill arches to do this. Use blunt probes or pins to keep the pharyngeal region open. Do this by placing a probe/pin through the spiracle on the cut side, and another one through the thin tissue anterolateral to the tongue, also on the cut side. You should now be looking at the roof and floor of the buccal cavity, as shown in Figure 3.22.

2. Skin the roof and floor of the buccal cavity, and the gill arches to reveal the underlying vessels. On the dorsal side, you may need to clean some fascia beneath the skin to reveal the vessels. This should be fairly straightforward, but be careful not to rip through the vessels. Follow the efferent branchial aa. into the gill arches. Remove the ceratobranchial cartilages from the gill arches as needed to expose the collector loops with their pre- and posttrematic branches, as seen in Figure 3.30.

3. Now turn your attention to the floor of the buccal cavity. Note that there is a cartilaginous plate medially and slightly posterior to the gill arches. Use the curved forceps to break through this, slipping a blade underneath and pulling up toward you. Remove cartilage to expose the heart. Note that the heart, ventral aorta and afferent branchial aa. are NOT injected with latex. This means that they are very fragile and easily damaged. Uncover them by removing cartilage and muscle.

4. Once you have identified all of the vessels in the anterior region of the shark, turn your attention to the posterior – the abdominal cavity. Most of the other vessels require little or no dissection. Study and learn them. The best way to do this is to start with large vessels and follow the blow of blood to smaller ones (in the case of arteries, or against the flow of blood for veins). Start with the dorsal aorta and follow it posteriorly, noting all of its branches. Then follow each branch, identifying as you go. Use the tips given in other parts of this lab.

Always think about the direction that blood is flowing in vessels as you learn them. In your shark, the vessels are color-coded because they have been injected with colored latex. Arteries are colored red, and always take blood away from the heart and towards capillary beds of tissues. Veins are colored blue, and always take blood back to the heart. Arteries and veins are NOT defined by whether blood inside them is oxygenated or deoxygenated, but whether it is travelling toward or away from the heart.

When studying the vessels, think about the following for each vessel:

- Is the vessel an artery, vein or hepatic portal?
- 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?
• What is the vessel supplying blood to or draining blood from? This can help you remember vessel names.
You can use the answers to these questions to figure out a great deal about a vessel. For example, the anterior leinogastric v. drains blood from the spleen (leino~) and the stomach (gastr~), and so is a hepatic portal vein. This means that it is nutrient rich, oxygen poor, and is on its way to the heart via the liver.

**What are the four chambers of a shark’s heart, and in what sequence does blood flow through them?**

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

<table>
<thead>
<tr>
<th>Supplying Blood</th>
<th>Structure</th>
<th>Draining Blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chondrocranium</td>
<td>Gill lamellae</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pectoral fin</td>
<td></td>
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<tr>
<td></td>
<td>Kidney</td>
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<tr>
<td></td>
<td>Gonad</td>
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<td></td>
<td>Body of Stomach</td>
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<tr>
<td></td>
<td>Spleen</td>
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<tr>
<td></td>
<td>Liver</td>
<td></td>
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<tr>
<td></td>
<td>Posterior end of spiral valve</td>
<td></td>
</tr>
</tbody>
</table>

**Study exercise:** Make a flowchart with all of the blood vessels that you need to learn in the shark and drawing arrows between them. Learning this flowchart will teach you most of what you need to know about circulation in the shark.