Kidney Dissection
Teacher Guide

Purpose of the Investigation

This investigation teaches students about an important pair of organs for maintaining homeostasis in the body: the kidneys. In this investigation, students will explore the anatomy of the kidney and develop their dissection skills.

Safety Information

This investigation involves using scalpels. Ensure the students are informed how to safely handle these instruments.

It is also important that students wear eye protection to protect them from fluids.

Risk Management

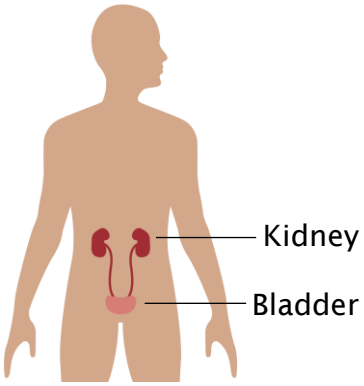
All schools must have their own risk management procedures and each laboratory will have the required proformas as it is a legal requirement, but it is incumbent upon the teacher and the lab technician to know and understand all risks associated with the practical.

Aim

To learn about how the kidney functions and identify its key features.

Background Information

The Role of the Kidney in Homeostasis



The body controls its internal environment through a process called **homeostasis.** Organs in the body work together to keep the body at the same temperature, keep the blood at the correct pressure and make sure that all the substances in the body are kept at the right concentrations.

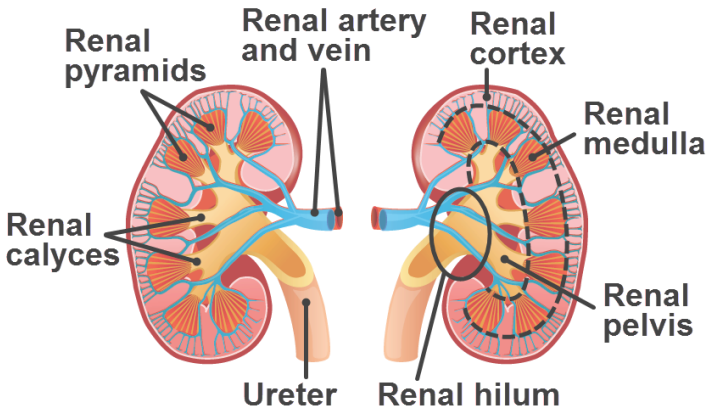
An important organ in homeostasis is the **kidney.** The kidney is a red, bean-shaped organ. Each person has two kidneys, although a person can survive with only one. They are located inside the bottom of the ribcage, on either side of the spine. In humans, each kidney is about the size of a computer mouse.
The kidneys act like a **filter** for the blood. As blood flows through the kidneys, toxic wastes are removed, such as urea and ammonia. Many of these toxins are metabolic by-products produce by the body's own cells. If a person did not have a kidney, these toxins would build up in their system and they would die.

The kidneys don't just remove toxic substances from the blood. They also regulate the **concentrations** of many other substances, such as salts and water. If there is too much water or salt in the blood, the kidneys will remove some, bringing the blood back to normal concentrations. If there is too little water or salt, the kidneys will leave these substances in the blood, keeping the blood as close to the normal concentration as it can. This regulation of salts and water is very important, since having too much or too little of these substances can cause serious health problems.

The substances removed from the blood are excreted from the kidney in a solution called **urine.** Urine is transported from the kidney to the **bladder** via a tube. It is stored in the bladder until the individual goes to the bathroom, at which point the urine is expelled out the urethra.

The amount of work the kidneys do is amazing. Over the course of one minute, the kidneys filter approximately 125 mL of blood. This amounts to 180 litres of blood per day. Since the average person has around 7 to 8 litres of blood in their body, this means all of their blood is filtered around 20 to 25 times over the course of a day.

Anatomy of the Kidney

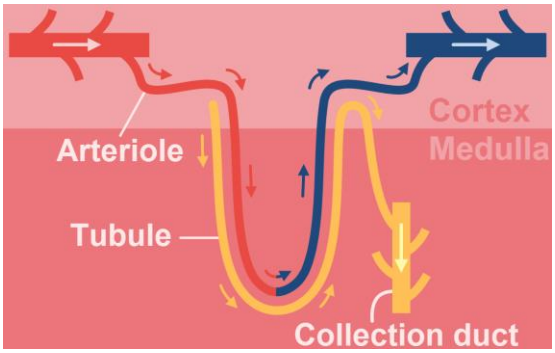


Many of the parts of the kidney are preceded with the word 'renal' because the kidney and bladder form the renal system.

The kidney is attached to three large tubes: the **renal artery, renal vein** and **ureter.** Blood enters through the renal artery and exits through the renal vein. Urine produced in the kidney exits through the ureter, travelling down to the bladder. The area these tubes are located in is called the **renal hilum.**

The kidney is divided into three distinct layers. The pink, outermost layer is the **renal cortex.** It is striated, meaning it has lines, or ridges, running along it. The middle layer is the **renal medulla.** It is a darker colour near the cortex because this is where it has the most blood vessels running through it. It is also divided into several triangular sections, called **renal pyramids.** The yellow-white inner layer of the kidney is the **renal pelvis.** The ureter is located at its centre. White tubes called **calyces** (singular: calyx) connect the medulla and pelvis.

How the Kidney Functions



Blood enters the kidney through the renal artery. The renal artery then splits into many smaller blood vessels called **arterioles.** These travel along the cortex, around the kidney. As these arterioles travel along, they loop down into the medulla and then back up into the cortex. During the journey into and out of the medulla, each arteriole is accompanied by a little **tubule.** Together, an arteriole and a tubule form a tiny structure called a **nephron.** Nephrons are too small to see with the naked eye, but there are over a million of them in a single kidney.

During this journey into and out of the medulla, the kidney removes wastes and excess substances from the blood in the arteriole. These unwanted substances collect in the tubule, where they form **urine.** When the arteriole and tubule return to the cortex, they go separate ways. The arteriole joins up with the renal vein, which takes the filtered blood out of the kidney. The tubule joins up with tubules from other nephrons, fusing and forming larger tubes called **collection ducts.** The collection ducts travel back down through the cortex and medulla, into the pelvis.

When the collection ducts reach the bottom of the medulla, they dump the urine they are carrying into larger tubes, called **minor calyces** (singular: minor calyx). Several minor calyces merge to form even larger tubes called **major calyces.** These major calyces empty out into the renal pelvis. The urine then exits the renal pelvis through the ureter and travels down to the bladder.

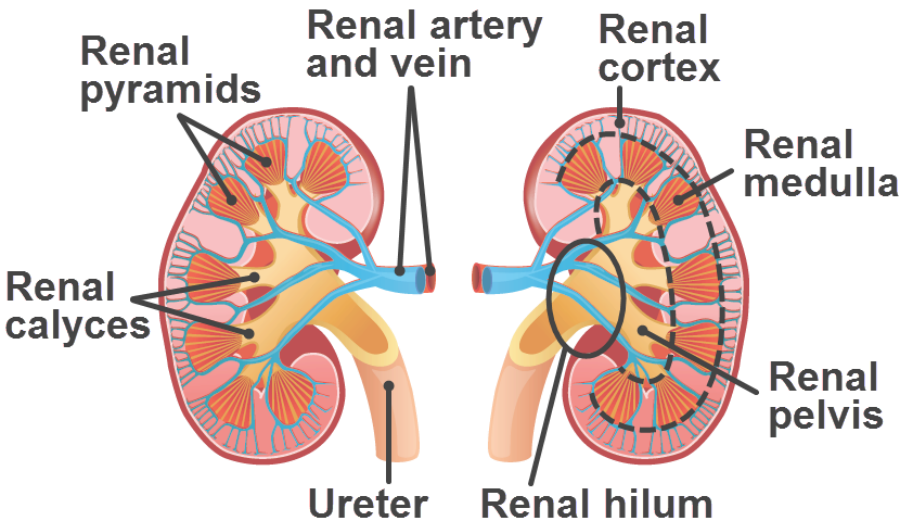
Pre-Practical Questions and Example Answers

1) **Briefly explain what role the kidneys play in the body, and how this helps maintain homeostasis.**

   The kidneys act as a filter for the blood. They remove toxic metabolic wastes, such as urea. They also remove excess water and salt when there is too much of these substances. This helps maintain homeostasis in the body by maintaining the correct concentrations of these substances in the blood.

2) **Label the parts of the kidney using the names listed below.**

Renal pyramids	**Renal artery & vein**	**Renal cortex**	**Renal pelvis**
Ureter	**Renal hilum**	**Renal calyces**	**Renal medulla**



Practical

Instructions

Find a partner to perform the investigation with.

Go through the safety information with the teacher.

Collect protective gear: a lab coat and safety goggles.

Ensure all long hair is tied back.

Make sure the area is clear.

Read through the instructions and begin when ready.

Materials

- Kidney
- Dissection board
- Scalpel
- Forceps
- Ruler

Method

1) Observe the outside of the kidney. It has a concave (inward bending) side and a convex (outward bending) side. The concave side has a white region in the middle, called the renal hilum. This is where three large tubes leading into and out of the kidney are located. These tubes are the ureter, renal artery and renal vein. The tubes may have been cut off, leaving behind three holes.

2) Lay the kidney flat on the table, so that the concave side is pointing towards you and the convex side is pointing away. Draw a diagram of the kidney, including the tubes if they are present. Label the features listed below. Next to the diagram, write down the colour of the kidney and its length in centimetres.

Concave side Convex side Renal hilum

3) Describe the outside appearance of the kidney. Also, describe the hilum. In these descriptions, consider factors such as colour, size, shape and location. All observations and descriptions made in this investigation should be recorded in the Features of the Kidney chart in the Student Worksheet.

4) Reposition the kidney so that the concave side is facing down into the dissection board and the convex side is facing upward towards the ceiling.

5) Using the scalpel, cut down the long side of the kidney, producing two equal halves. Do not cut all the way through: leave a few millimetres intact so the kidney can be folded open like a book. Try to make the cut clean and smooth. When the kidney is opened flat along the cut, it should look similar to a tomato slice, with a white centre, red outer rim and several red and pink lobes in-between. The kidney may be discoloured, depending on how it has been stored and preserved.

6) Identify the three main layers in the kidney and describe each layer in the Features of the Kidney chart.

- The outer layer is the renal cortex. It is striated, meaning it has many ridges or lines running along it.
- The white, inner-most layer is the renal pelvis.
- Everything in between is the renal medulla. Depending on how the kidney has been preserved, the medulla may be darker on the end closer to the cortex and lighter on the end closer to the pelvis.

7) Inside the medulla there are several triangular sections, called renal pyramids. Describe the renal pyramids in the Features of the Kidney chart.

8) There is a hole, or tube, at the centre of the renal pelvis leading to the outside of the kidney. This is the ureter. Insert the forceps through the ureter to see how it leads to the outside of the kidney. Describe the location and size of the ureter in the Features of the Kidney chart.

9) Make sure the kidney is laid flat on the table, like an open book. Draw a diagram of the inside of the kidney. The two halves should be identical, so it is only necessary to draw one of them. On the diagram, label the structures listed below.

Renal cortex Renal medulla Renal pelvis

Renal pyramid Ureter

10) Using the forceps, investigate how the medulla attaches to the pelvis. It should be possible to lift the inner edge of the medulla up and look underneath. This should reveal small, white tubes, called minor calyces (singular: minor calyx). These join to form larger tubes, called major calyces (singular: major calyx) that drain into the pelvis. Urine produced in the medulla is transported to the pelvis via these tubes. It then travels out of the kidney via the ureter.

11) Use the scalpel to cut into the calyces and investigate how urine would flow from the minor calyces, to the major calyces, to the renal pelvis and ureter. Describe the calyces in the Features of the Kidney chart.

12) Double check that every feature in the Features of the Kidney chart has been identified and described. Two diagrams should also have been drawn: one of the outside of the kidney and one of the inside.

13) Clean up according to the teacher's instructions.

Example Results

Features of the Kidney Chart

Write down any observations in the chart below. All features should be described by the end of the investigation.

Structure	Definition	Description
Outside of the kidney		The kidney was 10 cm long and a deep red. It was smooth and soft, without any wrinkles. It was bean-shaped, with one concave side and one convex side. In the centre of the concave side was a white region called the renal hilum.

Renal hilum	**The location where the ureter, renal artery and renal vein attach to the kidney.**	The hilum was a white region in the centre of the concave side of the kidney. The renal artery, renal vein and ureter connected to the kidney in this region. These tubes were cut off before the dissection was started, so appeared as holes in the renal hilum.
Renal cortex	**The outer layer of the kidney.**	The cortex was pink and striated, with small ridges running from the outside of the cortex to the edge of the medulla. It was about 1 cm thick.
Renal medulla	**The middle layer of the kidney.**	The medulla was deep red with dark lines running from the outside to the inside. It was divided into several triangular sections, called renal pyramids.
Renal pelvis	**The inner layer of the kidney.**	The pelvis was off-white. At the boundary between the pelvis and medulla, the pelvis branched out into thick tubes, called major calyces. The major calyces branched again, each splitting into two to three minor calyces. Each minor calyx was associated with the tip of a renal pyramid. In the centre of the pelvis was the ureter.
Renal pyramids	**Triangular segments in the renal medulla.**	The medulla was divided into several triangular sections, called renal pyramids. Each pyramid was deep red with dark lines running from the end near the cortex to the end near the pelvis. The bottom of each renal pyramid was associated with a minor calyx. There were 7 renal pyramids in this kidney.
Ureter	**The tube that carries urine from the kidney to the bladder.**	The ureter was located in the middle of the pelvis. The opening was only a few millimetres thick, and led to the outside of the kidney. It was off-white, like the rest of the pelvis.
Renal calyces **(Singular: Renal calyx)**	**Tubes that carry urine from the bottom of the medulla to the interior of the renal pelvis.**	The renal calyces were off-white tubes that ran from the bottom of the renal pyramids to the renal pelvis. Off of each renal pyramid came one minor calyx, which were a few millimetres wide. Two or three minor calyxes joined up to make a major calyx. There were four major calyces in this kidney, each of which was almost a centimetre wide.

Diagram of the outside of the kidney

In the space below, draw a diagram of the outside of the kidney. Make sure each of the following structures is labelled:

Concave side Convex side Renal hilum

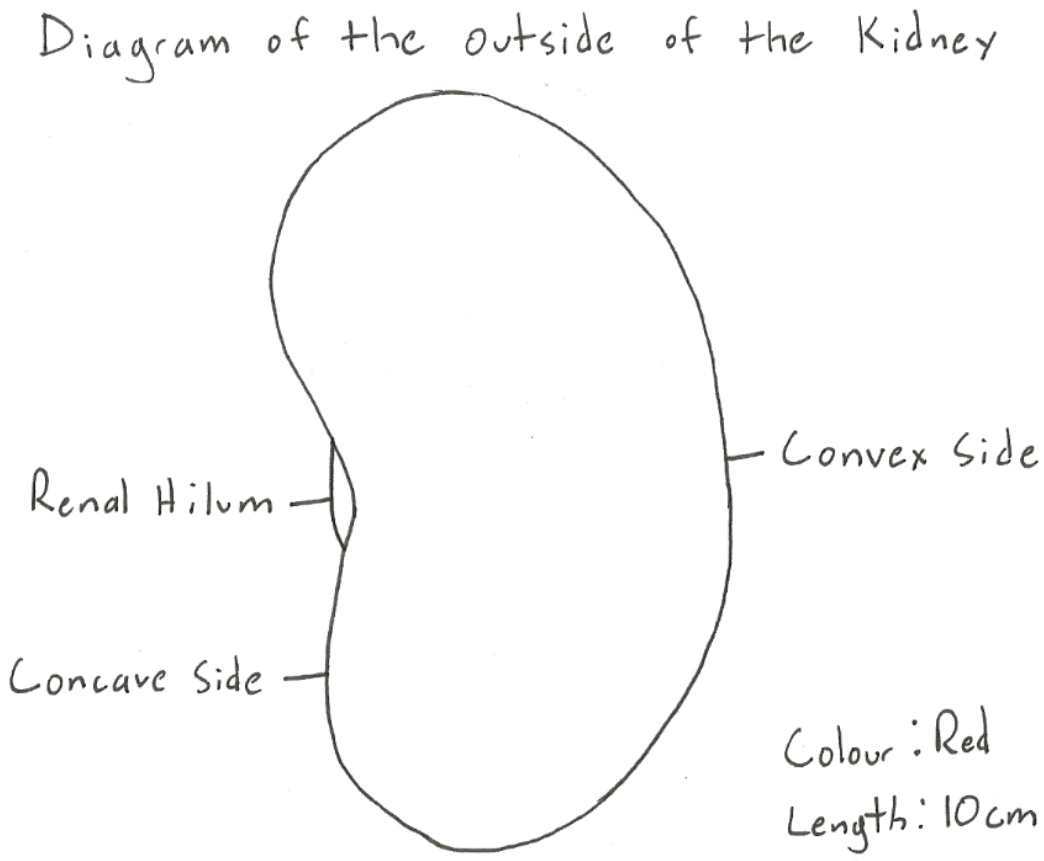
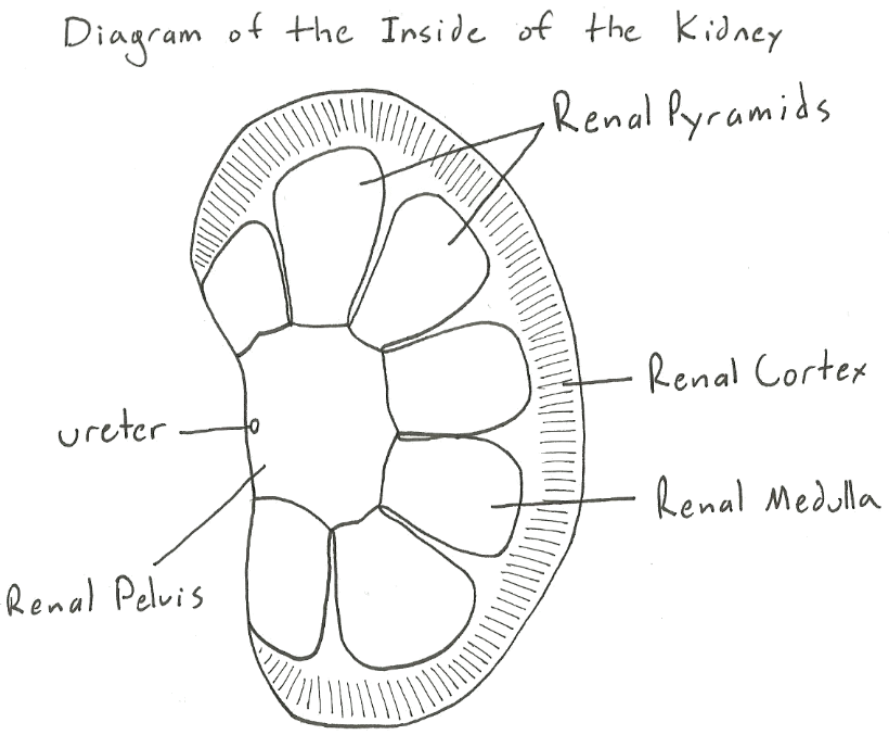


Diagram of the inside of the kidney

In the space below, draw a diagram of the inside of the kidney. Make sure the following structures are labelled:

Renal cortex Renal medulla Renal pelvis

Renal pyramid Ureter



Discussion Questions and Example Answers

Answer the following questions on a separate piece of paper.

1) **Were all of the following structures found during the dissection? If any structures were not seen, explain why this was the case.**

Renal hilum Renal cortex Renal medulla Renal pelvis

Renal pyramids Ureter Renal calyces

The ureter was cut off the kidney before the dissection began. However, the hole to the ureter could still be found in the centre of the renal pelvis. Otherwise every structure was found.

2) **Were some structures more difficult to identify than others? If so, explain why.**

The calyces were difficult to find at first. This is because it was necessary to look under the ends of the renal pyramids to find them. Once under the renal pyramids, they were difficult to differentiate from connective tissue, as both are white and long.

3) **Describe the path urine takes when travelling from the renal cortex to the bladder. Be sure to mention the following structures:**

Collecting duct **Minor calyx** **Major calyx**

Renal pelvis **Ureter**

When urine is produced in the medulla and cortex, it is collected in small tubules. Many tubules join to produce collecting ducts. Collecting ducts travel down from the cortex, passing through the medulla. They end at the tip of the renal pyramids. The end of each renal pyramid is associated with a moderate sized tube called a minor calyx. The collecting ducts dump the urine they are carrying into this tube. Two or three minor calyces join up to make a larger tube, called a major calyx. The major calyces empty out into the renal pelvis. The urine then exits the kidney via the ureter, which is located in the centre of the renal pelvis, and is carried by the ureter down to the bladder.

4) **What were some difficulties encountered during this dissection? How could they be avoided in the future?**

It was difficult cutting the kidney in half cleanly. As a result, the cut surface ended up being very rough. This made it more difficult to identify fine structures, like the renal pyramids and calyces. This could be improved by practicing how to cut the kidney open with the scalpel.