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## Lab 11: Heart Anatomy, Physiology and Brain Anatomy Lab

Name \_\_\_\_\_

Date \_\_\_\_\_

Lab safety: Full PPE required for this lab - lab coat, long pants, closed-toe shoes, gloves and safety goggles

### Learning Objectives:

1. Know the organs which form the circulatory system (Cardiovascular System or CV system).
2. Know the different circulatory route – pulmonary circuit, systemic circuit and coronary circuit.
3. Identify the different parts of heart in human heart model and sheep heart.
4. Know cardiac cycle, stroke volume and heart rate and how exercise influence the cardiac physiology.
5. Trace the pathway of blood through the heart.
6. Know the unit and division of nervous system
7. Know the different parts of brain and identify those parts in human brain model and sheep brain.
8. Know briefly the functions of major areas of brain.



### Introduction: The Heart

Heart is muscular pump. Birds and mammals, including humans, have four-chambered hearts. Two chambers receive blood and the other two pump blood out. The receiving chambers are known as **atria** (the singular form is atrium) and located superiorly. The **right atrium** receives oxygen-depleted blood from the different part of the body through the major veins and the **left atrium** receives oxygen-rich blood from the lungs. The atria transfer their blood, through one-way valves, into **ventricles**, two chambers located inferiorly. While both the ventricles receive blood from atria at the same time, but they pump blood out from the blood to two separate destinations. The **right ventricle** pumps oxygen-depleted blood (or carbon-di-oxide rich blood) to the lungs, where the blood is replenished with oxygen. When **left ventricle** contracts, it pumps oxygenated blood out to the rest of the body through arteries. Blood vessels, which carry blood away from heart, are called **arteries** and the blood vessels that carry blood towards the heart are called **veins**.

So ultimately, animals with four-chambered hearts have two circulation loops. The first loop travels to and from the lungs (**pulmonary circulation**). Blood with higher level of carbon dioxide pumped to the lungs through **pulmonary artery**, where carbon dioxide is replaced with oxygen, and then carried from the lungs through **pulmonary veins** back to the heart (right atrium) for pumping to the rest of the body. The second loop travels to and from the whole body (**systemic circulation**). Oxygen rich blood from the left ventricle is pumped out through **aorta** and then through other arteries blood is transported to all parts of the body, delivering oxygen and nutrients and gathering wastes for proper disposal. Aorta is the largest and strongest blood vessel in the body and becomes branched to smaller branches to deliver blood to every corner of the body. **Superior vena cava (SVC)** and **Inferior vena cava** or **IVC**, two major veins formed by merging the

smaller branches of veins collect carbon dioxide rich blood from the different parts of the body and bring back to heart (right atrium).

This very efficient pumping system keeps blood moving in the right direction, and to the right parts of the body, 24 hours a day. To keep the heart muscle healthy and active there is a separate circulation designated to supply blood to heart, which is called **coronary circulation**.

Cardiovascular system is a one-way route where blood flows from one structure to the next. To ensure this one directional flow and to prevent backflow there are 4 valves in the heart. Two valves are at the junction of atria and ventricles, which are called **tricuspid valve** (at the junction of right atrium and right ventricle) and **bicuspid** or **Mitral valve** (at the junction of left atrium and left ventricle), which allows blood only to move from atria to the ventricles. Tricuspid and bicuspid valves are also called atrioventricular valve or AV valves. Two other valves are located at the junction of ventricles and blood vessels. Pulmonary valve is located at the junction of right ventricle and pulmonary artery and the aortic valve is located at the junction left ventricle and aorta.

### Activity 1: Heart Anatomy

This activity focuses on the structure of the heart, its function as a pump, and the circulatory system's critical role in distributing oxygen and removing carbon dioxide. The circulatory system consists of the heart, blood and blood vessels. All vertebrates (animals with backbones) have closed circulatory systems, meaning their blood is contained within vessels, separate from the fluid surrounding cells in the body.

#### Materials needed

For a team of four students, you need:

- Heart Model
- Sheep heart
- Dissecting tray
- Blunt probe

#### Exercise A – Structure of the Heart

Identify the following structures, parts and blood vessels on sheep heart and human heart model.

##### *Surface Anatomy*

- Auricles (left and right)
- Ventricles (left and right)
- Aorta
  - Aortic arch
- Superior vena cava (SVC)
- Inferior vena cava (IVC)
- Pulmonary Trunk
- Pulmonary Arteries
- Pulmonary Veins
- Coronary Artery

##### *Internal Anatomy*

- Right & Left atrium
- Right & Left Ventricles
- Tricuspid valve
- Bicuspid valve or Mitral valve
- Papillary muscles
- Chordae tendinae
- Pulmonary trunk
- Pulmonary semilunar valve
- Aorta
- Aortic semilunar valve

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

### Procedure 1

1. Identify the right and left sides of the heart. Look closely and on one side you will see a diagonal line of blood vessels that divide the heart. The pointed end of the heart is called **apex** which is at the left side.
2. Turn the heart so that the right side is on your right, as if it were in your body. Examine the flaps of darker tissue on the top of the heart. These ear-like flaps are called **auricles**. Find the large opening at the top of the heart next to the right auricle. This is the opening to the **superior vena cava**, which brings blood from the superior part of the body to the **right atrium**. Stick a probe down this vessel. You should feel it open into the right atrium.

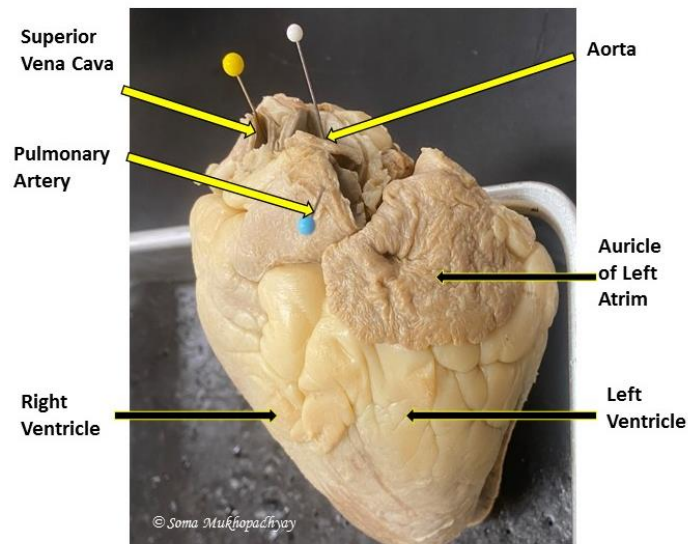
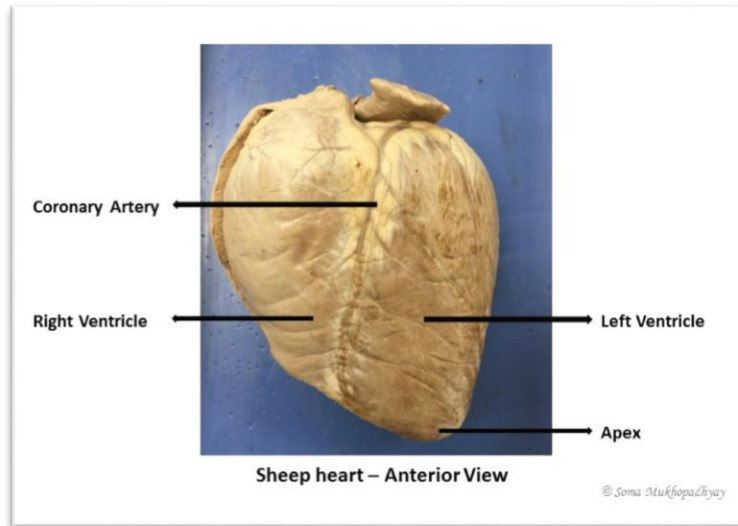


Figure 1. Anterior view of the sheep heart.

3. A little down and to the left of the superior vena cava there is another blood vessel opening into the right atrium. This is the **inferior vena cava**, which brings carbon di-oxide rich blood from the lower part of the body. You can also see another blood vessel next to the left auricle. This is a **pulmonary vein** that brings blood from the lungs into the **left atrium**.

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

4. Sticking straight up from the center of the heart is the largest blood vessel, **aorta**, which takes oxygenated blood from the **left ventricle** to the rest of the body. The aorta branches into right after it leaves the heart.

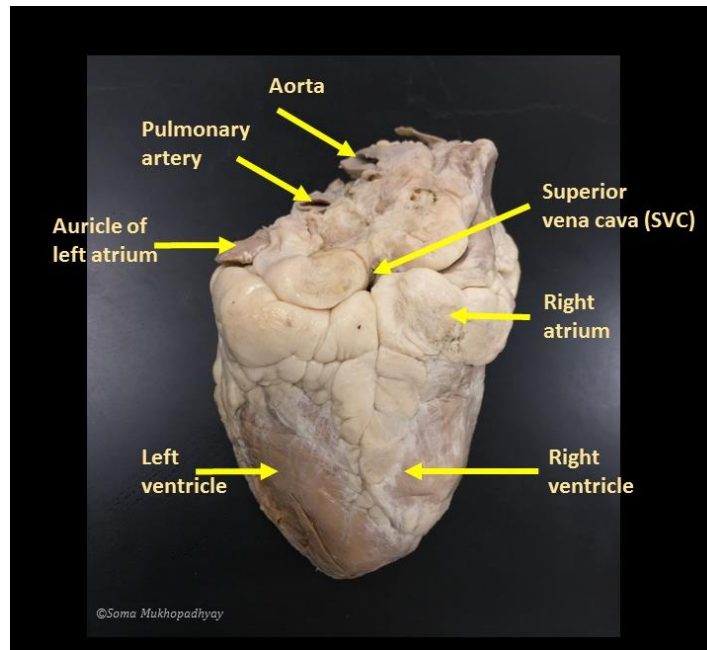


Figure 2. Posterior view of the sheep heart

5. Behind and to the left of the aorta there is another large vessel. This is the **pulmonary artery** which takes blood from the **right ventricle** to the lungs.
6. Two valves, which allow blood to enter the ventricle from the atrium, are the **tricuspid valve** and the **bicuspid valve or Mitral valve** between the left atrium and left ventricle. The membranes of the valves are connected to flaps of muscle called the **papillary muscles** by tendons called the **chordae tendinae** which looks like fine strings.

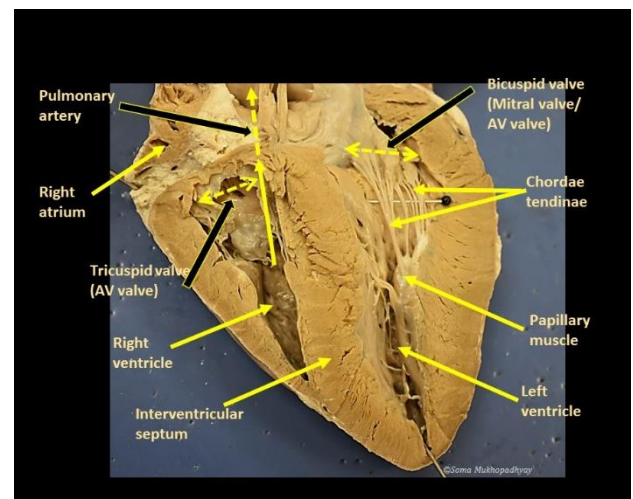
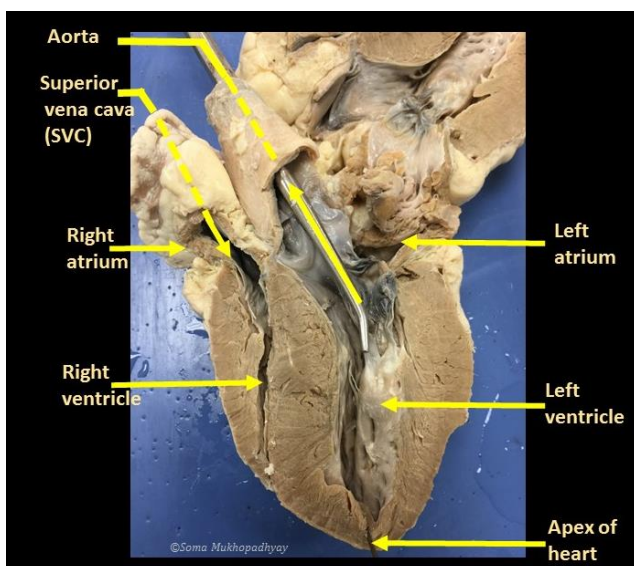


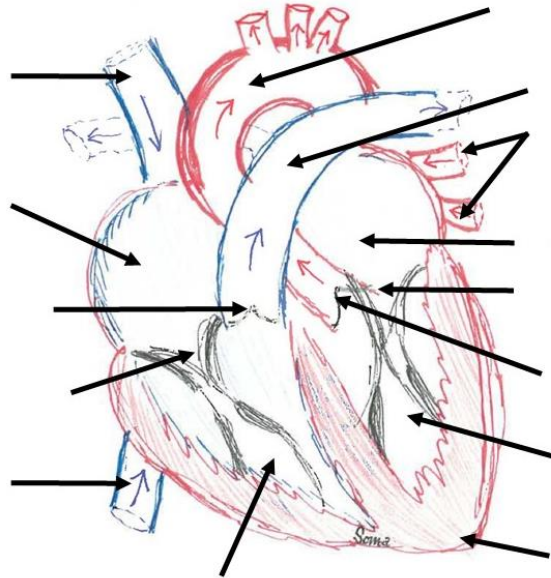
Figure 3. Cross-section (frontal plane) of the sheep heart.

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

7. Insert a blunt probe into the pulmonary artery (Fig 3) and to see how it come through to the right ventricle. At the base, there is **pulmonary semilunar valve, which** prevents blood from flowing back into the right ventricle.

### Procedure 2

Correctly identify the parts of the heart in the following diagrams:



### Critical thinking:

Cardiac muscle is thicker on left side of the heart than the right side. How does this structure is connected with the pumping function of the heart?

### Exercise B: Heart Rate and Exercise

Almost every day, we see, hear or read in the media about the importance of exercise for heart health. Why? What is the relationship between the heart, circulation, and exercise?

Even when you are sleeping, reading, or watching TV, your muscles, brain, and other tissues use oxygen and nutrients, and produce carbon dioxide and wastes. If you get up and start moving, your body's demand for oxygen and the removal of carbon dioxide increases. If you start running, your body demands even more oxygen and the elimination of more carbon dioxide. The circulatory system responds to these demands by increasing the **heart rate** (how many times heart beats or contracts per minute) and **stroke volume** (how much blood the heart pumps with each contraction), to increase the **cardiac output** (the amount of blood pumped from the left ventricle per minute). During exercise, heart rate can rise dramatically, from a resting rate of 60–80 beats per minute up to a rate about 200 beats per minute for a young adult.

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

While you are running, blood flow is diverted toward tissues that need it most. For example, muscles in the arteries in your legs relax to allow more blood flow. Meanwhile, muscles in the walls of the arteries that take blood to your stomach and intestines tighten, or constrict, so these organs receive less blood. Breathing rate increases to match greater output by the heart. The whole system works together to give your hard-working muscles what they need at just the right time.

Have you noticed that after you finish a run, your heart rate and breathing rate don't return to normal immediately? Why? It's because the circulatory and respiratory systems have to "catch up." You may not have realized it, but while you were running, the muscles of your body produced so much carbon dioxide and other wastes that the body's systems couldn't keep up with the increased demand for elimination. So even after your run ends, your heart rate and breathing rate remain elevated until the excess wastes are eliminated and body comes back to normal pace.

If the heart and circulatory system have to do so much extra work when you exercise, why is exercise good for you? One simple answer is, "Use it or lose it." The heart is a pump made of muscle. It needs regular exercise to remain strong, healthy and efficient. The same is true of the circulatory system. Exercise helps keep the arteries strong and open. The contraction of leg muscles during exercise helps to move the blood along. Without exercise, body chemistry actually changes. These changes can lead to a whole range of unhealthy conditions and diseases. So, to maintain a healthy heart pump and circulatory system, "use it."

The pumping heart makes the sound we refer to as the "heartbeat." The "lub-dub" of a heartbeat comes from the sounds of blood being pushed against closed, one-way valves of the heart. One set of valves (tricuspid and bicuspid) closes as the ventricles contract. This generates the the first sound or "lub" of our heartbeat. The other set of valves (pulmonary and aortic) close when the pressure in the ventricles is lower than the pressure in the pulmonary artery and aorta. This leads to the second sound or "dub" of our heartbeat.

As the heart beats, it presses the blood against the muscular, elastic walls of the arteries. Each artery expands as blood is forced from the ventricles of the heart. The artery wall then contracts to "push" the blood onward, further through the body. We can feel those "pulses" of blood as they move through the arteries in the same rhythm as the heart beats. The number of pulses per minute is usually referred to as pulse rate. The average pulse rate for a child ranges from 60 and 120 beats per minute.

### Pre-Exercise Questions

1. Does your heart rate vary, or is it always the same?
2. What kinds of situations might cause heart rate to change?

### Procedure

1. Measure your heart rate (beats per minute) by feeling blood surge through an artery. Find your pulse by placing slight pressure on the wrist with the middle and ring fingers (this is radial artery). Do not use your thumb, as it has a pulse of its own. Sit quietly for one minute then count your pulse. Take your pulse rate a minimum of three times over a 30-second interval to make sure you are consistent. Multiply your pulse count by two to determine how many times your hearts beat in one minute. Record your pulse rates below. This will establish your resting, or beginning, pulse rate.



## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

Table 1. Resting pulse rate.

	Trial 1	Trial 2	Trial 3	Average Resting Pulse Rate (beats/min)
Pulse Rate				

2. Make a prediction on how your heart rate and to what extent your heart rate will change after each the following activities for one minute.
  - a. Standing up \_\_\_\_\_
  - b. Walking briskly around the room for one minute \_\_\_\_\_
  - c. Doing Jumping jacks for 30 seconds \_\_\_\_\_
3. You will record you pulse rate following three activities: standing up, walking briskly for 1 minute, and doing jumping jacks for 30 seconds. After each of the “activities” you will take and record your pulse rates below. Between each activity you will need to sit quietly until your heart rate returns to your resting pulse rate before beginning the next one.

Table 2. Pulse rates following various activities.

Activity	Resting Pulse Rate	Standing Up	After Walking Briskly	After Jumping Jacks
Pulse Rate (beats/min)				

4. For each activity calculate the difference between your resting heart rate and the rate after each activity. Record these numbers below:
  - a. Standing up \_\_\_\_\_
  - b. Walking briskly for one minute \_\_\_\_\_
  - c. Doing Jumping jacks for 30 seconds \_\_\_\_\_
5. Compare your data to your predictions. Then, compare your personal data with the data collected by your fellow group members.
  - a. What did you find? \_\_\_\_\_
  - b. Were there any surprises? \_\_\_\_\_

### Activity 2: Brain Anatomy

The nervous system of vertebrates is divided into:

- A. **Central nervous system**, which consists of the brain and spinal cord
- B. **Peripheral nervous system**, which contains nerves, sensory receptors, and neurons which direct the activity of more localized activities.

Nervous system is formed by nervous tissue which consists of:

- Highly excitable cells called **neurons** and
- A number of supporting cells called **glia** or glial cells.

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

Human brain is the overall control center of our body and is one of the amazing and complex structures. Human brain is located inside the skull or cranial cavity and is formed billions of neurons along with glial cells. Brain monitors our body condition, communicates with and coordinates different organs to maintain homeostasis. Structurally brain is divided into three major regions: a) forebrain, b) midbrain and c) hindbrain. Forebrain includes i) **Cerebrum** and ii) **Diencephalon**. The cerebrum is the largest and the most complex area of the brain and is divided into five lobes - **frontal lobe, temporal lobe, parietal lobe, occipital lobe** and **insula**. With all of these regions cerebrum controls learning, judgement, long term and short memory, voluntary muscle control, and all sensory perceptions. Outer part of cerebrum is called **cerebral cortex**.

Diencephalon includes **thalamus, hypothalamus** and **pituitary gland**. Thalamus is a relay center and hypothalamus is located below or inferior to the thalamus. Hypothalamus controls our basic metabolic activities (hunger, thirst, sex-drive and body temperature control) and secrete hormone to control the pituitary gland. Midbrain is a small area and houses nuclei of some cranial nerves. Cranial nerves are those, which originate from the brain. Hindbrain includes i) cerebellum, pons and medulla oblongata or medulla. **Cerebellum** located more posteriorly is the second largest area in the brain and mostly controls the involuntary movement and coordination. A region in the lower part of the brain is called **brain stem**, which includes midbrain and part of the hindbrain (**pons** and medulla oblongata). **Pons** is the respiratory control center as well controls some vital activities. **Medulla oblongata** plays an important role in maintaining our heart rate and respiration.

Watch the sheep brain video provided by your instructor.

### Materials needed

For a team of four students, you need:

- Brain model
- Sheep brain
- Dissecting tray
- Blunt probe

### Procedure 1

When it comes to the anatomy of brain, mammals have similar structural distribution. So we will observe and identify the following structures and landmarks on a preserved sheep brain:

#### *Cerebrum*

- 4 lobes – Frontal, parietal, temporal and occipital
- Longitudinal fissure
- Corpus callosum
- Ventricle (lateral)

#### *Diencephalon*

- Hypothalamus
- Olfactory bulbs
- Olfactory tracts
- Optic Nerve

- Optic chiasma

#### *Brain stem*

- Midbrain
- Pons
- Medulla oblongata

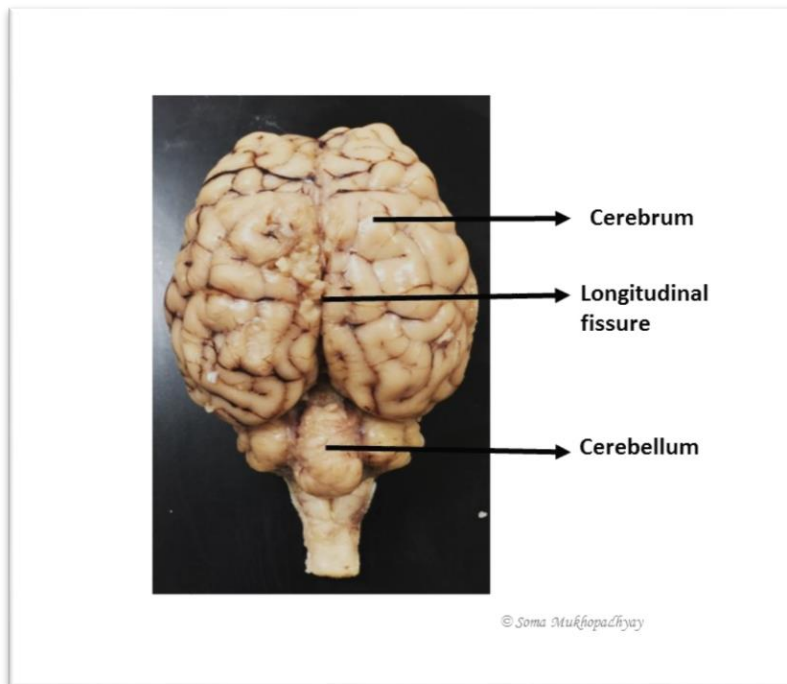
#### *Cerebellum*

#### *Spinal cord*



### *Superior View*

1. As mentioned above, as cerebrum is the largest part in the brain it is again divided into two hemispheres by a deep **longitudinal fissure**. Among the five lobes, **frontal lobe, temporal lobe, parietal lobe, and occipital lobe** are distinctly visible from outside while insula is a smaller and deeper area.
2. Just behind or posterior to the cerebrum, is the **cerebellum**. The cerebellum coordinates voluntary movement and maintains equilibrium. The surface of both the cerebrum and the cerebellum display folds (**gyri**) and grooves (**sulci**) which increase the surface area of these regions.



*Figure 4. Superior view of the sheep brain.*

### *Inferior View*

3. On the undersurface of the brain (inferior view), the **olfactory bulbs** sit at the anterior end of the cerebrum. The olfactory nerves from the nasal cavity synapse with cells in this brain region. Olfactory bulbs and nerves are involved with the sensation of smell.
4. The **optic nerves** enter the brain just after a region called the **optic chiasma**, where some of the visual fibers “cross-over” to the opposite side of the body. This cross-over allows for increased depth perception.
5. The pons and the medulla oblongata are distinct from the inferior view.
6. **Spinal cord** begins from the posterior end of the medulla oblongata. It is the relay center between brain and the body
7. **Ventricles** are fluid filled cavity in the brain which separate the brain into its three major region (forebrain, mid-brain and hind brain).
8. In the sagittal section view, you can see the **corpus callosum**. **Corpus callosum** is a neural tract, which separates as well as link the right and left cerebral hemispheres.

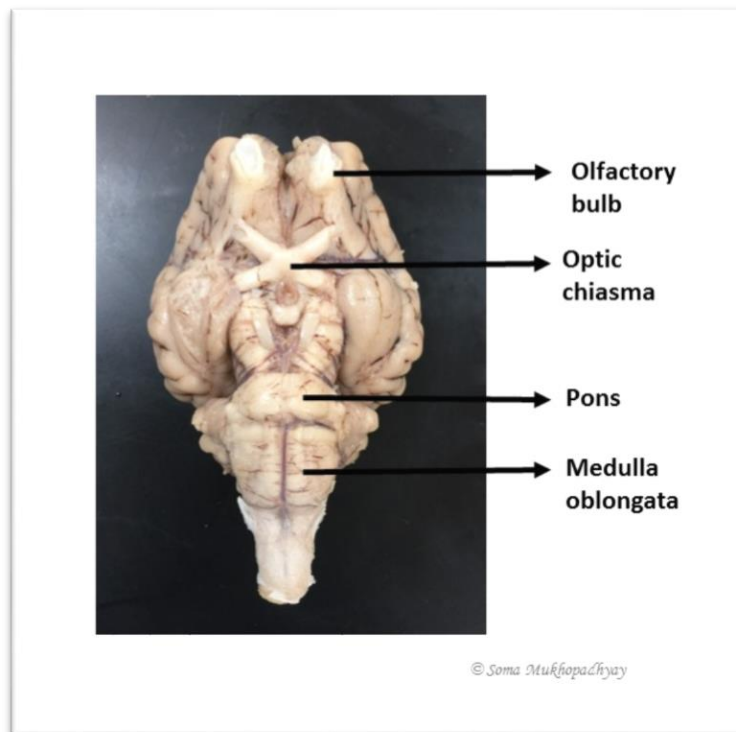


Figure 5. Inferior view of the sheep brain.

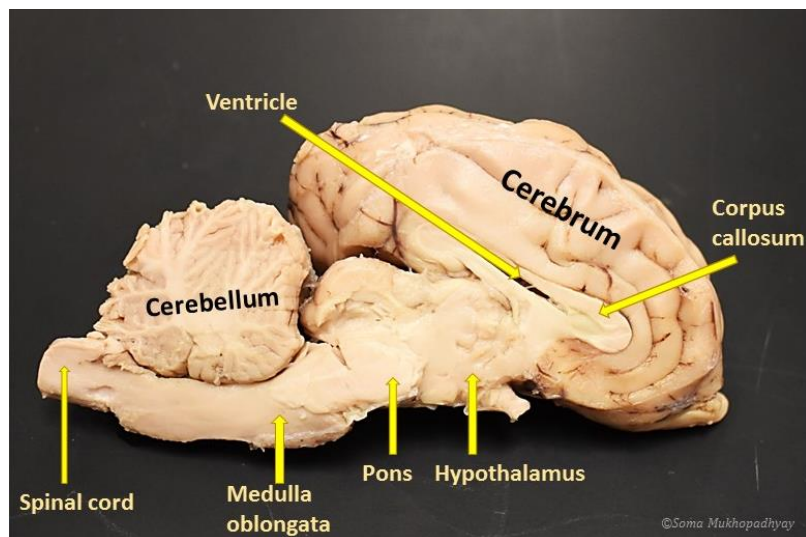


Figure 6. Interior view of the sheep brain (sagittal section).

### Procedure 2

Identify also the following structures and landmarks on models of human brain:

#### *Cerebrum (right and left hemispheres)*

- Four lobes – frontal, parietal, temporal, and occipital
- Gyri
- Longitudinal fissure
- Corpus callosum
- Ventricle

#### *Diencephalon*

- Hypothalamus

#### *Brain Stem*

- Pons
- Medulla oblongata

#### *Cerebellum*

#### *Spinal Cord*

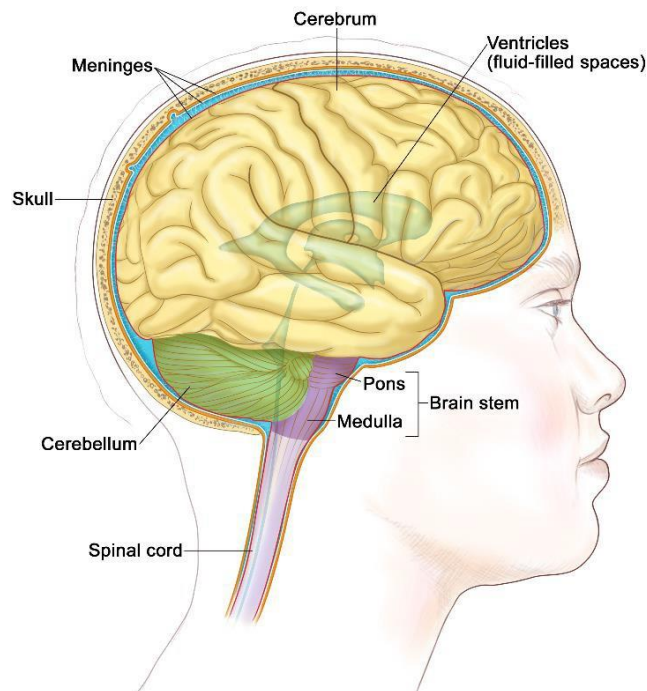
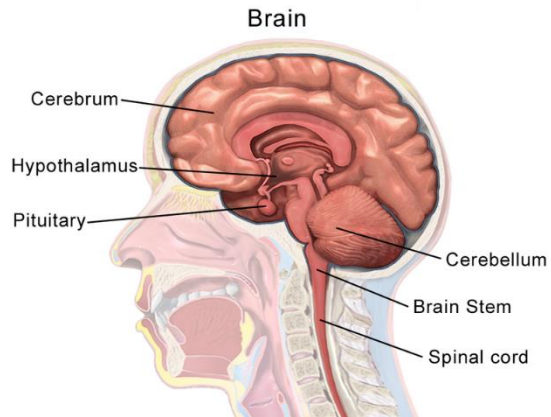


Figure 7. Human Brain - (Picture source: Wikimedia)



*Figure 8. Sagittal section of the human brain*

*(Picture Source: Wikimedia.org, <https://commons.wikimedia.org/w/index.php?curid=29055751>)*

Reference:

ReBarbara Tharp et al, *The Science of the Heart and Circulation*, Baylor College of Medicine 2009

Michael Johnson, *Human Biology Concepts and Current Issues*, 2<sup>nd</sup> Edition Benjamin Cummings 2004

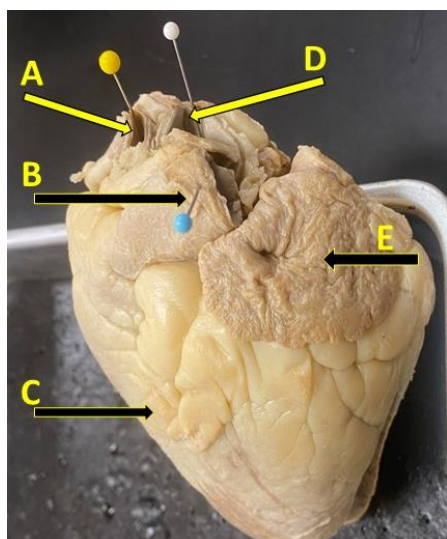
*Sheep Heart Dissection*, Home Science Tools ([www.hometrainingtools.com](http://www.hometrainingtools.com))

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

### Post-Lab Activity:

Name: \_\_\_\_\_

1. Make a prediction on how your heart rate and to what extent your heart rate will change after each the following activities for one minute.
  - a. Listening to slow music for one minute \_\_\_\_\_
  - b. Listening to fast music one minute \_\_\_\_\_
  - c. Breathing deeply for one minute \_\_\_\_\_
2. Why do we need to do exercise?
3. Discuss some similarities between the Human Brain and the Sheep Brain.
4. Discuss some differences between the Human Brain and the Sheep Brain.
5. What is the function of Cerebrum?
6. Cerebrum is divide into two cerebral hemispheres by \_\_\_\_\_.
7. Answer the following questions from the diagram of heart.



A. Identify the blood vessel \_\_\_\_\_

B. What type of blood is transported by this blood vessel \_\_\_\_\_

C. Identify the chamber \_\_\_\_\_

D. This blood vessel is coming off from \_\_\_\_\_

E. \_\_\_\_\_ (blood vessel) brings oxygen rich blood from \_\_\_\_\_ to this chamber.

## FUNDAMENTALS OF BIOLOGY (BIOL 1101)

8. Identify and label the following structures in the sheep brain.  
a) Frontal lobe, b) hypothalamus, c) spinal cord, d) ventricle, e) cerebellum and f) pons.

