

**Biology 3B Laboratory**  
**Nervous System: Brain and Eye**  
**Urogenital system of Shark, Mudpuppy and Rat**

**Objectives:**

- Identify and learn the five basic regions of the brain and the structures contained in them
- Understand and learn the structure and function of a typical vertebrate eye
- To be able to distinguish between the structures of the urogenital systems of the rat, mudpuppy and shark
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**The Sheep Brain**

The brain is encased in membranes called **meninges**. In mammals, there are three meninges, an outer **dura matter**, a middle **arachnoid membrane** and an inner, **pia matter**. The cerebrospinal fluid also circulates within the cavities (ventricles) of the brain, the spinal cord and subarachnoid space.

Please examine whole and bisected sheep brains.

In the **Telencephalon**, the two large symmetrical structures overlying the anterior portion of the dorsal aspect are the **cerebral hemispheres**. They are convoluted with ridges (**gyri**) and furrows (**sulci**). Within the hemispheres are two paired cavities; these are the **lateral ventricles (first and second ventricles joined together)**, which is roofed by the **corpus callosum** (seen in the sagittal section), a commissure that relays information between the cerebral hemispheres. The **longitudinal fissure** divides the hemispheres.

The **Diencephalon** lies inferior to the cerebral hemispheres and anterior to the midbrain. The cavity within the diencephalon is the **third ventricle**. The posterior dorsal projection of this part of the brain is the **epiphysis** or **pineal body**. The pineal is light sensitive; it affects pigmentation, circadian rhythms, and reproductive rhythms; it synchronizes them with the external environment. In the central region you will find the **mass intermedia** of the **thalamus**. This band connects the right and left thalamic regions. The hypothalamus is found in the ventral portion of this region. It may have been lost in the dissection leaving behind the stalk on which it sits, the **infundibulum**. Immediately posterior to the infundibulum is the **mammillary body**. Anterior to the infundibulum is the **optic chiasm**.

The **Mesencephalon** is concealed by the cerebellum, and cerebral hemispheres from the dorsal aspect. In the sagittal section, you will see the cavity of the midbrain, the **cerebral aqueduct**; it connects the third ventricle with the fourth ventricle. Superior to the aqueduct you will find four small bumps, two on each side. These are the **corpora quadrigemina**. These are divided into the **superior** and **inferior colliculi**. These serve as relay stations for visual and auditor information. Inferior to the aqueduct are the cerebral peduncles, bundles of white fibers that pass between the pons and the cerebrum.

The **Metencephalon** is composed of the **cerebellum** and the **pons**. The pons appears as a bulge on the ventral midline between the cerebral peduncles and the medulla. The cerebellum is a mass that lies dorsal to the pons and medulla. In sagittal section the white and gray matter form a tree-like structure called the **arbor vitae**. Three cerebellar peduncles attach the cerebellum to the pons and mesencephalon.

The most posterior portion of the brain is the **medulla oblongata** of the **Myelencephalon**. This cavity in this section is the **4th ventricle**.

Twelve cranial nerves leave the base of the brain and exit from various foramina of the skull. Some of these nerves are sensory, some are motor, and some have both sensory and motor function. We will ask you to find and identify four of the cranial nerves.

1. **Olfactory nerve (I)** This nerve consists of many small nerve fibers which leave the olfactory bulb and pass through opening in the cribriform plate of the ethmoid bone penetrating the nasal epithelium.
2. **Optic nerve (II)** This sensory nerve originated at the optic chiasm; it passes through the optic foramen of the skull into the posterior portion of the eye.
3. **Trigeminal nerve (V)** The trigeminal is the largest of the cranial nerves. It provides sensory reception from the skin of the face, mucous membranes and internal structures of the head. It is the motor nerve of mastication.
4. **Auditory (VIII)** This nerve brings sensory information from the inner ear into the brain. It enters the brain in the medulla under the cerebellum.

Primary Brain Region		
Telencephalon	rhinencephalon	olfactory bulbs
		olfactory tracts
	corpus striatum	
	cerebral cortex	
Diencephalon	thalamus	
	epithalamus	pineal body
		posterior commissure
	hypothalamus	mamillary bodies
		infundibulum
		hypophysis (pituitary)
optic chiasm		
Mesencephalon	cerebral aqueduct	
	cerebral peduncle	
	corpora quadrigemina	superior colliculus
		inferior colliculus
Metencephalon	pons	
	cerebellum	
Myelencephalon	medulla oblongata	

## The Cow Eye

Examine the outside of the eye. You should find the **sclera** and the clear covering over the front of the eye, the **cornea**. You should also be able to see some of the muscles on the exterior of the eye. Make your first incision where the sclera meets the cornea. Cut until the **aqueous humor** is released. Rotate the eye and cut around the cornea. Be careful not to cut too deeply or you may cut the **lens**. You can now examine the cornea. Next, with the cornea removed, pull out the **iris**. It should come out in one piece. If you are careful, you can remove the **lens** with the **vitreous humor** attached. Examine the lens. Hold up the lens and look through it. With the vitreous humor now removed, you can turn the eye inside out. The thin pink colored tissue on the back of the eye is the **retina**. Try to find the spot where the retina is attached to the back wall. Find the spot where all the retina's nerves collect. It is called the **blind spot**. This is where all the nerves leave the back of the eye, forming the **optic nerve**, visible on the outside of the eye. The shiny blue-green material is called the **tapetum**. The darkly pigmented layer is the **choroid**.

## Urogenital System

The Urogenital system is really two closely related systems, the excretory system and the reproductive system. In the excretory system, the kidney originally evolved for osmoregulation in marine, freshwater and terrestrial environments. However, nitrogenous waste that is easily lost by diffusion through the skin in aquatic environments, presents a more complex problem in terrestrial environments. Thus on land, the removal of nitrogenous waste is a primary function of kidneys.

In the reproductive system, gonads produce gametes and maintain secondary sex organs and secondary sexual characteristics. The gonads arise from genital ridges medial to the future kidneys tissue. Germ cells migrate into the genital ridges. Genes and hormones determine whether the germ cells will form ovaries or testes. In females, eggs are released into the coelom before entering the oviduct. Sperm, however, is always passed through a closed system of vessels. Since there are two sexes, you must trade animals with a group that has an animal of the opposite sex

## Dogfish Urogenital System

### Excretory System

Locate the **opisthonephric** kidneys on the dorsal body wall. They are flat grey bands running the full length of the body cavity behind all of the other organs and the peritoneum (retroperitoneal). Although sharks retain urea, as part of the osmoregulatory process, they also possess **rectal salt glands** that secrete excess salts. The kidney and gonad ducts enter a common urogenital chamber, which is partly separated by the **urogenital papillae** from the **rectum** in the **cloaca**.

## Genital System

In the male, locate the two large **testes**; they may look like small lobes of the liver. These are connected to a series of small ducts, **vasa efferentia**, which are undeveloped kidney tubules. These lead into the **opisthonephric (mesonephric) duct**, which is convoluted and on top of the kidney. The urine also passes through this duct. This duct widens and straightens into a seminal vesicle and the '**ureter**' forms a bypass for the urine. The **sperm sac**, which may be full or empty depending on the season, stores mature sperm. The male uses the **claspers** for internal fertilization. Inside the claspers is a siphon sac that adds sugars to the sperm.

In the female, locate the two large **ovaries**, which also look like small lobes of the liver. They may be swollen with eggs covered in yolk. The eggs are shed into the body cavity and then move into the openings (**ostia**) of the two **oviducts**, called **Muellerian ducts**. They are silvery tubes on top of the kidneys. The **oviductal gland** provides albumen and makes egg cases in some species. It may be large or small depending on the season. Before birth, the 4-5 embryos grow in the **uterus** for 20-22 months being nourished by the yolk sac.

## ***Necturus* Urogenital System**

### **Excretory System**

The **kidneys** are long flat strips, narrower on their anterior margin. They are dorsal, close to the midline, in the posterior of the pleuroperitoneal cavity. Unlike other vertebrate kidneys, they are not retroperitoneal, but are supported by a peritoneal fold. Urine is produced and collected by tubules, which enter the **mesonephric duct** (ureters). In males this duct is large and coiled in the anterior half of the kidney. In females, it is small, on the outside edge of the kidney. The **bladder** forms as a pocket in the floor of the cloaca. The mesonephric ducts open into the **cloaca** and urine backs up into the bladder when the **vent** is closed.

### **Reproductive System**

In **males**, the **Muellerian** ducts do not mature, but persist as a rudiment. It can be seen anterior to the kidney as a thin, pigmented duct close to the midline. The **testis** is attached to the dorsal wall by a peritoneal sheet, the **mesorchium**. Sperm passes through the upper (genital) portion of the kidney by **efferent ducts**, which can only be seen when filled with white sperm. The tubules are collected in a longitudinal duct and tubules to the **mesonephric duct** which joins the cloaca. The papillate **cloacal gland** secretes gelatinous envelopes, which form around clumps of sperm and make spermatophores for sperm transfer. The male deposits these spermatophores in front of a female, who picks them up with her cloacal lips.

In **females**, the **ovaries** are folded, thin walled sacs, containing many large eggs. Eggs rupture into the coelom and are wafted by cilia to the large **ostia** (openings) of the **oviduct**. The linings of the oviducts have glands, which produce jelly to coat the eggs. The convoluted oviducts are attached to the kidney and body wall by a peritoneal fold, the **mesovarium**. Eggs are accumulated in the terminal end, called ovosacs until they are laid. The oviducts enter the **cloaca**.

Spermatophores from the male are collected in the fall and stored in the cloaca until spring when the eggs are laid.

## **Rat Urogenital System**

### **Excretory System**

The structures of the mammalian excretory system are paired kidneys and ureters and an unpaired urinary bladder and urethra. Locate the **kidneys** on the dorsal part of the abdominal cavity on either side of the vertebral column, embedded in fat. Note a small adrenal gland is seen on the anterior pole of each kidney. Each kidney has a duct, the **ureter**, leading from it. The kidneys are bean shaped and are **metanephric**. They are retroperitoneal (outside the coelomic space). The notch or **hilus** of the kidney is the site of entrance and exit of the blood vessels and the ureters. Section a kidney and identify the **cortex** (outer layer), **medulla** (inner layer), the **pelvis** (a cavity) and the **renal papilla** of the **calyx**, which project into the pelvis. Excretory products in the urine pass into the pelvis, then into the ureter. The ureters pass posteriorly and enter the neck of the **urinary bladder**. The urinary bladder is a pear-shaped sac supported by ligaments (remnants of the ventral mesentery). The bladder has a narrow neck, which terminates in a tube, the **urethra** that exits the body. In mammals, the bladder comes from the stalk of the allantois and is endodermal in origin.

### **Reproductive System**

The **male** reproductive system consists of testes, ducts, glands, urethra and penis. The **testes** are located in an external pouch, the **scrotum**, which is a projection from the peritoneal cavity. Scrotal sacs have descended outside the abdominal cavity to aid in sperm thermoregulation. An **epididymis** lies on the dorsal surface of each testis, consisting of a head, a body in which sperm mature and a caudal portion, which holds sperm like the seminal vesicles of the shark. The epididymis joins to a convoluted tube, the **vas deferens**. The vas deferens from each testis carries sperm to the urethra. It is looped over the ureters in the region of the neck of the urinary bladder and enters the **urethra** a short distance posterior to the bladder. Find the **prostate** gland at the point of entrance of the vas deferens into the urethra, and **bulbo-urethral glands** at the base of the penis. **Bulbo-urethral** glands are located between the posterior and lateral muscles at the base of the penis. The prostate and bulbo-urethral glands both contribute seminal fluid to the urethra. In the male rat, there are a number of additional prostatic glands. Trace the urethra posteriorly, and identify the **penis**, **glans penis** (acorn shaped tip) and the **prepuce** (foreskin). Note that the neck of the urinary bladder, in males, continues as the urethra, through the penis to the exterior. The sperm uses the same passageway as the urine in the urethra, but not at the same time.

The **female** reproductive system consists of a pair of ovaries, a pair of fallopian tubes, a pair of uteri and a vagina. The **ovaries** lay posteriorly to the kidneys, held in position by a mesentery, the **mesovarium**. From each ovary eggs are shed into the coelom and a **fallopian tube** with a wide mouth (**ostium**) receives ova. The tube coils and enters the **uterus**. The uteri from both sides join in the

midline to form a "V" shaped structure. Each arm of the "V" is formed by the cornua, or horns of the uterus, and the base is the body of the uterus. Such a type of uterus is termed a bicornuate uterus. The uterus joins the **vagina** at its posterior. The projection of the uterus into the vagina is known as the **cervix**. The **urethra** is joined ventrally onto the vagina. The common passageway housing the urethra and uterus is the **vestibule**. Trace these ducts. The external portion of the vagina is the **vulva**. At the ventral side of the vestibule near its orifice is a small structure, the **clitoris**, which is the homologue of the penis of the male. In rats, it encloses the end of the urethra and conducts urine to the outside. At the edges of the vestibule are the **labia minora** and the **labia majora**, which are homologues to the scrotal sac of males. It possible, examine the enlarged uterine horns of a pregnant female. Cut them open to see the fetus in the amniotic sac. The fetus is attached to the uterine wall by the **umbilical cord**, which contains two arteries and a vein.

<b>Comparison of Rat, Mudpuppy and Shark Urogenital Tracts</b>			
<b>Mammalian Structure</b>	<b>Function in rat</b>	<b>Equivalent structure in Mudpuppy</b>	<b>Equivalent structure in Shark</b>
kidney			
ureter			
urinary bladder			
urethra			
testes			
epididymis			
vas deferens			
penis			
ovary			
fallopian tube			
uterus			
vagina			