INTRODUCTION:

External Anatomy

Close study of the frog’s external anatomy reveals remarkable adaptations to its “double life” on land and in water. The frog's powerful hind legs are equally effective in jumping or swimming. On land frogs sit with their hind legs folded against the body, poised to jump at the first sign of danger. Most frogs can make leaps many times their body length. In water muscles working on the bones of the hind legs provide the strength for swimming.

Frog’s eyes also work equally well in or out of water. Because the eyes bulge out from the head, the frog can stay submerged while literally "keeping an eye out" for predators. Eyelids that can blink protect the frog's eyes from dust and dehydration. In addition to upper and lower eyelids, a third, transparent eyelid called a nictitating membrane covers each eyeball and joins the lower eyelid. This membrane keeps each eyeball moist and protects the eye when it is under water. Two nostrils located near the top of the frog's head allow the frog to breathe when all but the top of its head is under water.

Frogs have eardrums, or tympanic membranes, which are circular structures located behind the eye. The eardrums function well both in water and in air. A bone called the columella transmits sounds from the eardrum to the internal ear. A canal called a Eustachian tube connects each middle ear with the mouth cavity, allowing equalization of air pressure on both sides of the eardrum. Embedded in the skull is the inner ear, a minute system of sacs and canals that helps maintain balance and aids in hearing. Hearing is especially important during the mating season, when the male frog produces a distinctive mating call. The female frog's inner ear is attuned to the frequency of the male frog’s call.

The frog’s thick, moist skin serves two important functions—respiration and protection. Numerous mucus glands supply a lubricant that keeps the skin moist in air, a necessity for respiration through the skin. Granular glands secrete foul-tasting or poisonous substances that protect the frog from enemies. A frog's skin also protects it against predators by providing protective coloration. Some frogs, such as the Hyla versicolor, can change color in order to blend with the environment.

Internal Anatomy

The frog's skeletal, digestive, circulatory, respiratory, excretory, and nervous system reflect adaptation to land and water.

Skeletal System

The structure of early amphibians indicates that selection pressures favored a stronger skeletal system and the evolution of limbs. The frog's spine has nine vertebrae. The cervical vertebra at the anterior end of the spine allows neck movement, an adaptation that helps frogs catch prey. Posterior to this are seven trunk vertebrae, and then a single sacral vertebra that supports the hind legs. A long, slim bone called the urostyle extends from the sacral vertebra. The bones of the pectoral girdle, which form the shoulders, connect to the front legs. They also provide the primary protection to the internal organs, since the frog has no ribs. The pelvic girdle connects to the hind legs.
Digestive System

Most frogs feed on insects, and their digestive system is adapted to their diet. A frog's tongue is an excellent insect catcher. The frog simply flicks out its long sticky tongue, curls it around its prey, and pulls the insect back into its mouth. Then the frog snaps its mouth shut and swallows. Sometimes the frog pulls its eyes inward and presses them against the roof of its mouth, an action that helps push the food down its throat.

Frogs have two types of teeth that hold on to prey. A row of **maxillary teeth** lines the perimeter of the upper jaw. Two **vomerine teeth** project from bones in the roof of the mouth.

Digestion in frogs takes place in the **alimentary canal**, which includes the esophagus, stomach, small intestine, large intestine, and cloaca. The elastic esophagus and stomach allow the frog to swallow large amounts of small vertebrates, insects, and worms. Once food passes through the gullet to the stomach, tiny glands in the stomach walls secrete gastric juices that help break down the food. A muscle called the pyloric sphincter at the lower end of the stomach allows digested food to move into the small intestine.

The upper portion of the small intestine is called the **duodenum**. The coiled middle portion of the small intestine is the **ileum**. A fanlike membrane called the **mesentery** holds the small intestine in place. Inside the small intestine, nutrients from food broken down in the stomach pass through capillary walls into the blood, which carries them to all parts of the body.

The lower end of the small intestine leads into the large intestine. Here indigestible wastes are collected and pushed by muscle action into a cavity called the **cloaca**. Waste from the kidneys and the urinary bladder, as well as either eggs or sperm from the sex organs, also passes into the cloaca. Waste materials exit through the **cloacal opening**, or anus.

Other glands and organs aid in the digestion process. The liver produces bile, which is stored in the gallbladder. Bile helps break down fat into tiny globules that can be further digested and absorbed. A gland called the pancreas, located near the stomach, secretes enzymes that enter the small intestine and help break down food into products that can be absorbed by the blood.

The Circulatory System

Land-dwelling animals expend more energy than water dwellers, primarily because they must counteract the greater pull of gravity on land. An adaptation to the greater oxygen needs of land animals is a more efficient circulatory system than the fish's two-chambered heart. The amphibian's three-chambered heart partially separates oxygenated and deoxygenated blood which permits more oxygen-rich blood to circulate throughout the body than in fish.

The three chambers of the heart are the right atrium, the left atrium, and the ventricle. The left atrium receives oxygenated blood from the lungs, and the right atrium receives deoxygenated blood from the body. Both the atria empty into the ventricle, the main pumping chamber of the heart. In the ventricle oxygenated and deoxygenated blood mix partially and are pumped to the lungs and the rest of the body.

From the right atrium the blood enters the single ventricle. The ventricle then contracts, pumping some blood to the lungs to receive oxygen and some to the rest of the body. The blood going to the body leaves the ventricle through the **conus arteriosus**, a large vessel that lies against the front side of the heart. This vessel divides into a right and left **truncus arteriosus**, which immediately branch again into three arches that carry blood to various parts of the body. Deoxygenated blood travels in veins back to the right atrium from...
the various regions of the body. Oxygenated blood returns from the lungs to the left atrium via the pulmonary veins.

**The Respiratory System**

Tadpoles respire, or exchange carbon dioxide and oxygen, through gills. Adult frogs lose the gills but can respire in three ways; through the lungs, through the skin, and through the mouth. No other group of animals uses all these methods of respiration.

Respiration through the lungs is called **pulmonary respiration**. A frog inhales and exhales by changing the volume and pressure of air in its mouth. When a frog inhales, air is forced from the mouth into the glottis, the passage between the throat and the lungs. To exhale, the frog lifts the floor of its mouth, pushing air out of its nostrils.

Because the frog's lungs are small, **cutaneous respiration**, or respiration through the skin in both air and water, is very important, especially during estivation or hibernation. In the winter a frog may stay buried in the mud at the bottom of a pond for months, respiring only through its skin.

Oxygen can diffuse across the lining of the mouth and into the blood. Frogs use mouth breathing for only a relatively small amount of there respiration.

**The Excretory System**

Amphibians eliminate two primary types of metabolic waste products—carbon dioxide from respiration and waste compounds from the breakdown of foods. Most of the carbon dioxide is excreted through the frog's skin, although some exits through the lungs.

The kidneys are the primary excretory organs and lie on either side of the spine against the dorsal body wall. The kidneys filter nitrogenous wastes from the body. These wastes, flushed from the body with water, are commonly known as urine. Frog urine flows from the kidney through tiny tubes called urinary ducts to the urinary bladder and from there into the cloaca. Urine and wastes from the digestive system are eliminated through the anus.

It is vital that the frog regulate the concentration of water in its body. When the frog is in water, its permeable skin allows the water to enter its body. Frogs that live primarily in water rid themselves of excess water by excreting a large volume of very dilute urine. Frogs that live mainly on land conserve water by producing a small volume of more concentrated urine.

**Reproduction in Frogs**

The frog's life cycle, like its anatomy, reflects the amphibian's double life. Most frogs have two life stages—an aquatic tadpole stage and a partially terrestrial adult stage. Frog eggs are usually laid in water and hatch into gilled tadpoles that live in water until metamorphosis.

**Reproductive System**

Because both male and female frogs have internal sex organs, it is difficult to distinguish the sex of a frog during most of the year. However, as the breeding season approaches, the male frog's foreleg muscles and first fingers swell. These swellings help the male maintain his grasp on the female.

The reproductive system of the male frog includes two bean-shaped creamy white or yellowish testes located near the kidneys. During the breeding season, sperm cells develop in the testes and pass through tubes to the kidneys and urinary ducts. During mating season, sperm leave the body through the cloacal opening.
In female frogs a pair of large, lobed ovaries containing thousands of tiny immature eggs lies near the kidneys. During the breeding season eggs enlarge, mature, and burst through the thin ovarian walls into the body cavity. Cilia move the eggs forward into the funnel like openings of the oviducts. As the eggs pass down the oviducts, they receive protective coats of jellylike material. They remain in structures called ovisacs until ovulation is complete and then leave the body through the cloaca opening.

**Fertilization**

Most frogs breed once a year. In the first warm days of spring in the temperate zones, frogs emerge from hibernation. They migrate in great numbers to ponds and slow-moving streams. Males establish territories and call to females of their species. Each species has its own mating call. Air that is driven back and forth between the mouth and the lungs vibrates the vocal cords, producing the frog's croak. Male frogs have vocal sacs that amplify their calls, so they call more loudly than females do.

When a female approaches, the male frogs climb onto her back. He grasps her firmly, just behind the forelegs, in an embrace called **amplexus**. The male will cling to her, sometimes for days, until she lays her eggs. When the female finally releases her eggs into the water, the male frog discharges his sperm over them, and direct external fertilization takes place. The frogs then separate and resume their solitary lives. Within 12 days or so of fertilization, the eggs hatch into tadpoles.

The vast majority of eggs and tadpoles are eaten by predators such as fish, birds, snakes, and turtles. Some species of frogs have unusual reproductive cycles that may be adaptations to severe predation. In one species, *Pipa dorsalis*, the eggs develop in pouches on the mother's back. In the genus *Rhinoderma* the male "swallows" the eggs, taking them into his vocal sacs. He later releases fully formed froglets by yawning.

**Metamorphosis**

Newly hatched tadpoles live off yolk stored in their bodies. They gradually grow larger and develop three pairs of gills. Like fishes, tadpoles have a two-chambered heart. Eventually, a tadpole's mouth opens, allowing it to feed. Tadpoles can also regenerate injured or lost body parts such as a leg or tail.

A tadpole grows and eventually changes from aquatic larva into an adult. This process of change is called metamorphosis. Legs grow from the body, and the tail disappears. The mouth broadens, developing teeth and jaws. A saclike bladder in the throat divides into two sacs that become lungs. The heart develops a third chamber. The ability to regenerate disappears.

Biologists have long studied the process of metamorphosis and regeneration to learn what controls such dramatic physical changes. A hormone called thyroxine circulates throughout the bloodstream and stimulates metamorphosis. The cells of the tadpole are genetically programmed to respond to thyroxine at the appropriate stage of development. These developmental processes are important in the adaptation of all amphibians to a life spent both in water and on land.

**MATERIALS:**

<table>
<thead>
<tr>
<th>Dissecting pan</th>
<th>Probe</th>
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<tr>
<td>Dissecting scissors</td>
<td>Paper towels</td>
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<td>Forceps</td>
<td>Gloves</td>
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PROCEDURE:

1. Failure to cooperate and work with the teacher and/or lab partner will be a deduction of 10 points.

2. Mutilation of the frog will be half credit of the lab.

3. Make an attempt to identify the sex of your frog. If the frog is male and it is breeding season, the thumb will be greatly enlarged.

SEX of your frog: ________________________________

4. EXTERNAL DORSAL VIEW

LABEL the following parts:

1. eye
2. nictitating membrane
3. tympanic membrane

MOUTH OF A FROG

5. MOUTH
Clip the sides of the jaw to open the mouth. LABEL the above diagram:

1. vomerine teeth
2. maxillary teeth
3. internal nostril
4. tongue
5. tongue attachment
6. esophagus
7. eustacian tube
6. Cut the frog open using the "I" cut described in the video. When you attempt the "I" cut, you will need to cut through the bones of the arms and shoulder.

7. **DIGESTIVE SYSTEM**
   When you first open the frog, you will find the 3 LARGE LOBES OF THE LIVER high in the body cavity. Spread the lobes apart and find the bright green GALL BLADDER. Raise the STOMACH to find the LARGE INTESTINE. Examine the MESENTERY and the manner in which it holds the intestine in place. Find the SPLEEN on the mesentery. The PANCREAS is attached to the lower part of the STOMACH.

Carefully raise the liver being careful not to damage organs in order to observe the organs underneath. Cut through the GULLET at its upper end. Raise the stomach and carefully loosen the intestine from the mesentery. Cut through the large intestine as far down as possible. The CLOACA lies below the large intestine between the hind legs.

**LABEL:**

1. esophagus
2. liver
3. cloaca
4. stomach
5. pancreas
6. small intestine
7. large intestine
8. Describe the contents of the stomach: ____________________________________

__________________________________

__________________________________

**Abdominal & Chest Cavities of the Frog**
9. REPRODUCTIVE AND EXCRETORY SYSTEMS

Dark red, lobed KIDNEYS lie along the back of either side of the spine. The URINARY BLADDER attaches to the cloaca and removes urine from the cloaca for storage. If your frog is an immature female, you will find two lobed grayish OVARIES lying close to the kidneys. In a mature female, you may find the body cavity filled with eggs. Look under the eggs and you will find two long coiled white OVIDUCTS leading from the anterior end of the body cavity to the posterior end on either side of the vertebral column. If your frog is male, the TESTES are in a corresponding position. You are responsible for viewing both male and female frogs. Make sure you view someone else's frog. FAT BODIES appear as bright yellow finger-like bodies. Trace the fat bodies to the POINT OF ATTACHMENT.

LABEL the following (only used once):

1. fat bodies
2. fat body attached
3. kidney
4. testes
5. ovary
6. oviduct
10. CIRCULATORY AND RESPIRATORY SYSTEMS
Refer back to the directions on the digestive system to locate the spleen. LABEL the following (remember your frog is laying ventral side up):

1. lungs
2. left atrium
3. right atrium
4. ventricle
11. IDENTIFICATION
When you feel confident as a group you need to identify each of the following structures in front of your instructor. These are structures you should know for the Frog Practical.

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<thead>
<tr>
<th>Frog Anatomy</th>
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<tr>
<td>Fat Bodies</td>
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<td>Lungs</td>
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<td>Gall Bladder</td>
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<td>Heart</td>
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<td>Maxillary Teeth</td>
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<td>Internal Nares</td>
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<td>Kidney</td>
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<td>Vomerine Teeth</td>
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<td>Liver</td>
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<td>Cloaca</td>
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12. **QUESTIONS**

1. What does amphibious mean?

2. How do amphibians live part of their life on land and part in water?

3. What are four characteristics of amphibians?

4. What can you infer about the frog’s field of vision by looking at the position of the eyes?

5. How does the position of the eyes benefit the frog while it is swimming?

6. How does a frog hear?

7. How can a frog breathe while swimming in water?

8. Why must a frog keep its skin moist while on land?

9. How are the hind legs of a frog adapted for life on land and in water?

10. What is the adaptive advantage of the coloration of the frog's skin? Include the coloration of the dorsal side as well as a comparison of the coloration of the dorsal to the ventral.