Week 2 – Focus: Science and Engineering Practices

Analyzing Data

Directions: Please record your responses to the questions below in your science journal.

1. **Mouse Experiment**
   An experiment studies the effects of an experimental drug on the number of offspring a mother mouse has. 10 female mice are given the drug and then impregnated. The number of mice in their litters is compared to the litters of mice that did not take the drug. Based on the data, what would you conclude about the drug, did it work?

	Number of Babies in Litter										
	Group A (drug)	5	6	4	8	5	2	7	13	12	8
	Group B (control)	4	4	6	6	5	6	4	7	5	3

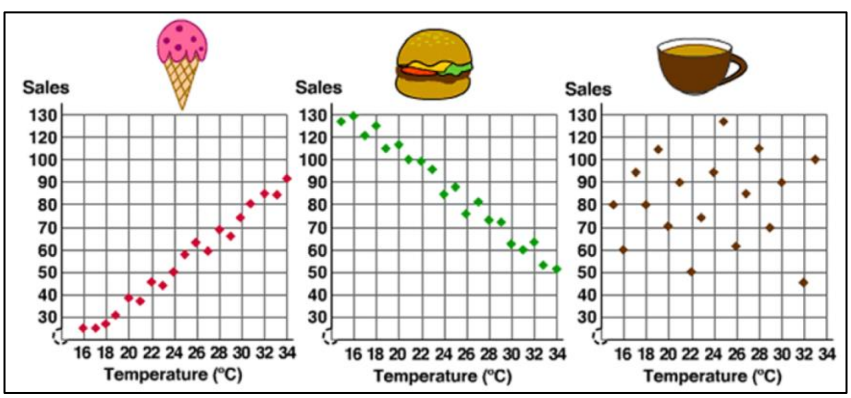
2. **Cow Growth Rates**
   A type of feed claims to boost the growth rate of cows. The feed is tested on two twin newborn cows. Bessie receives the experimental feed, and Bertha receives regular corn feed. Their weights are recorded below.

Month	April	May	June	July	Aug
Bessie	100 lbs	210 lbs	260 lbs	320 lbs	400 lbs
Bertha	100 lbs	250 lbs	290 lbs	340 lbs	400 lbs

   A. Graph the data; use a dotted line for Bessie and a straight line for Bertha. Make sure you label the X-axis and Y- axis.

   B. Both cows ended at the same weight, but did the experimental feed change the way they gained weight at all? Describe your conclusions about the experimental feed and explain why it is important that the experiment used twin cows?

3. **Food Sales (Scatterplot)**

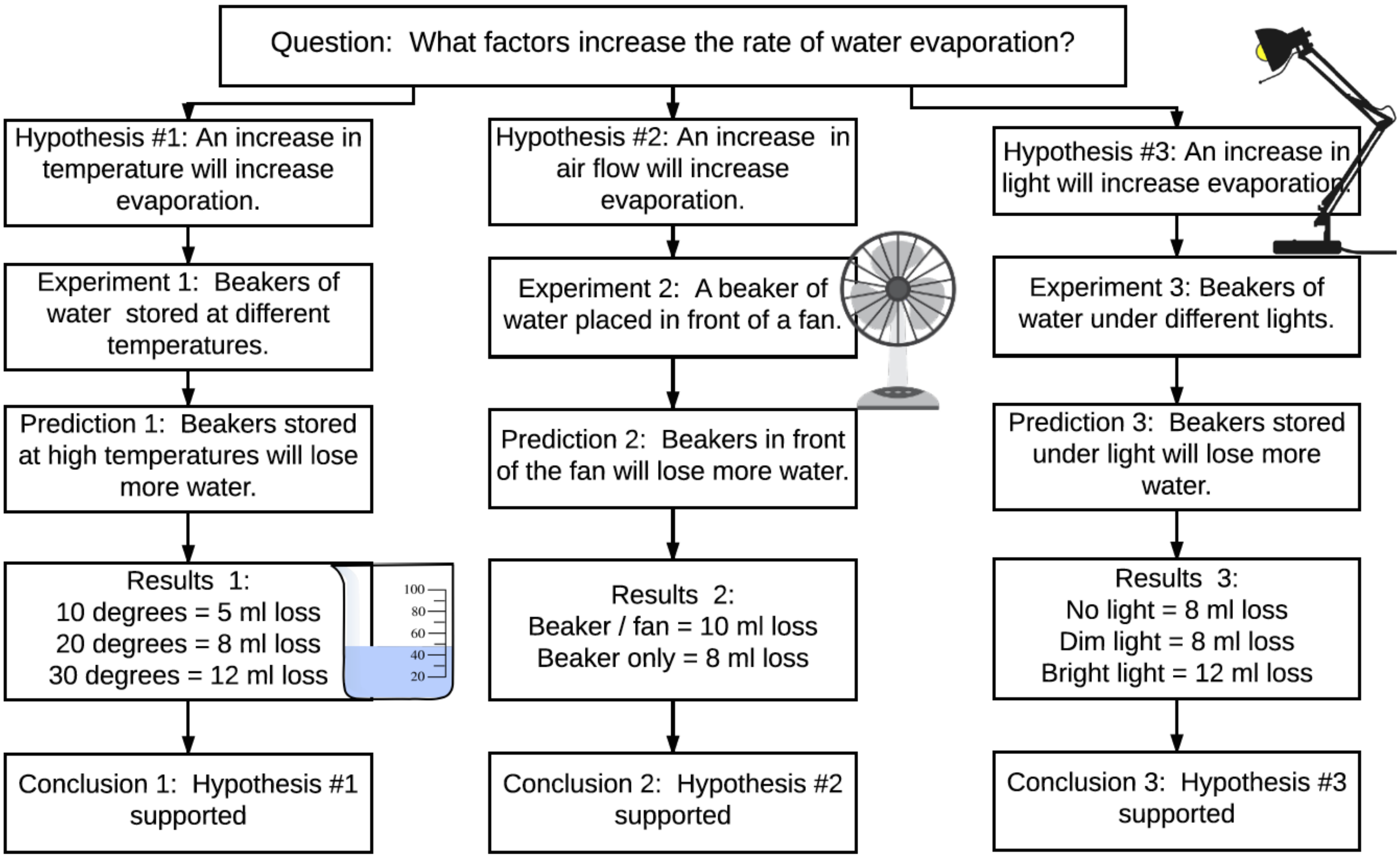


   A. A positive correlation occurs when one set of values increases, so does the other set of values. Which food shows a positive correlation between sales and temperature? Which shows no correlation?

   B. How could a park manager use this type of information?

Scientific Processes: How Can A Causal Question Be Answered?

Directions: Examine the flow chart below that considers a question about water evaporation. Multiple hypotheses are tested and conclusions are drawn from the given results of the experiments. In your science journal, answer the questions regarding the experiments.



1. What are the independent and dependent variables in each of the experiments?
2. What information should be added to the diagram to give the reader a better understanding of how these experiments were conducted?
3. What items should have been CONTROLLED in the experiments?
4. How much confidence would you have in the conclusion of experiment 3 if you found out that the temperature was not controlled? Explain your reasoning.
5. Create your own flow chart to answer a causal question.

Scientific Inquiry in Medicine
By Frank W. Jackson, MD

Science has been a latecomer in the world's history. Up until the 20th century, there was no precise testing of any treatment. If the patient didn't die and did recover, there was acceptance that whatever treatment was given must have worked. Most of what was done for the patient was not helpful, but not harmful either. At times, however, it was dangerous. For instance, our founding father, George Washington, was bled in 1799 when he had pneumonia, undoubtedly hastening his death. In the 1800s things hadn't really changed very much. One main reason was that there were so few good treatments for any medical condition. Even as late as the 1950s, the effective medications were few: the heart medicine digitalis, aspirin, sulfa and another new antibiotic called penicillin, a few toxic diuretics, some hormones, Maalox for indigestion and herbs. Even though there was little to offer (we didn't really know it at the time), patients still came to see physicians and patients did get better.

So what is [Scientific Inquiry]—on which all modern medicine and science are based?
Simply put, it means that a treatment or a hypothesis is subjected to rigorous testing to see if the treatment works or if the hypothesis is true. For example, a scientist hypothesizes that a drug will be effective in treating a certain disease. The fact that the scientist wants to believe it does not make it so. Testing must be done. Sometimes, it doesn't work or it actually makes the patient worse. [The research process allows the scientific community to accumulate information to verify scientific information.] Still, it is the best system we have. All scientists, not just doctors, use this technique in one form or another.

The federal Food and Drug Administration (FDA) uses these scientific guidelines to approve new treatments. So whenever someone or some published article mentions a great treatment for some disease, we need to question the data. Testimonials by individuals don't really mean much. They can sound great but, from a scientific viewpoint, they are almost meaningless. In fact, they may actually be damaging, as there may be a serious underlying problem such as cancer, which is not discovered early.

The FDA does an enormous amount of [regulation]. To the extent possible, they assure us that the food we eat is safe. They brought us the new food labels that provide a great deal of valuable information for the consumer on calories, fat, sodium and other nutrients. They regulate medical devices. We would never buy a heart valve from Best Buy and ask a physician to insert it just because a friend said it was great. Likewise, the FDA regulates the pharmaceutical drug industry [by creating a clear process for science to go through a systematic screening. This screening ensures that devices, drugs, and medical best practices are safe and lives up to their claims.] The public benefits by being assured that the prescription medicines they take and the medical devices used on them have undergone rigorous scientific testing.

Directions: Respond to the following questions in your science journal.

1. According to the author, what are characteristics of scientific inquiry in medicine?

2. Why is rigorous scientific testing required?

3. What do you think would happen if medicine didn't have rigorous scientific testing?

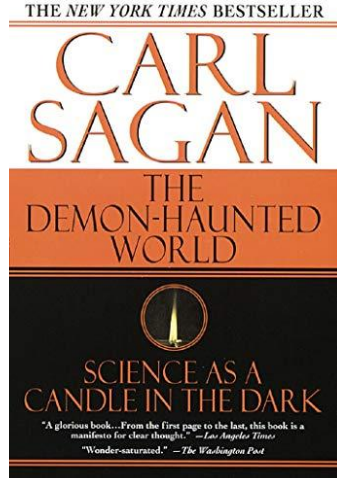
4. What is the FDA and what are some of its responsibilities?

5. Explain what it means to 'regulate' something?

6. Do you think it's a good idea to use scientific processes in medicine? Why or why not?

Demon Haunted Error Bars

(Excerpt from "The Demon-Haunted World: Science as a Candle in the Dark by Carl Sagan, 1996)



One of the reasons for its success is that science has built-in, error-correcting machinery at its very heart. Some may consider this an overbroad characterization, but to me every time we exercise self-criticism, every time we test our ideas against the outside world, we are doing science. When we are self-indulgent and uncritical, when we confuse hopes and facts, we slide into pseudoscience and superstition.

Every time a scientific paper presents a bit of data, it's accompanied by an error bar - a quiet but insistent reminder that no knowledge is complete or perfect. It's a calibration of how much we trust what we think we know. If the error bars are small, the accuracy of our empirical knowledge is high; if the error bars are large, then so is the uncertainty in our knowledge. Except in pure mathematics nothing is known for certain (although much is certainly false).

Moreover, scientists are usually careful to characterize the veridical status of their attempts to understand the world - ranging from conjectures and hypotheses, which are highly tentative, all the way up to laws of Nature which are repeatedly and systematically confirmed through many interrogations of how the world works. But even laws of Nature are not absolutely certain. There may be new circumstances never before examined - inside black holes, say, or within the electron, or close to the speed of light - where even our vaunted laws of Nature break down and, however valid they may be in ordinary circumstances, need correction.

Humans may crave absolute certainty; they may aspire to it; they may pretend, as partisans of certain religions do, to have attained it. But the history of science - by far the most successful claim to knowledge accessible to humans - teaches that the most we can hope for is successive improvement in our understanding, learning from our mistakes, an asymptotic approach to the Universe, but with the proviso that absolute certainty will always elude us.

We will always be mired in error. The most each generation can hope for is to reduce the error bars a little, and to add to the body of data to which error bars apply. The error bar is a pervasive, visible self-assessment of the reliability of our knowledge.

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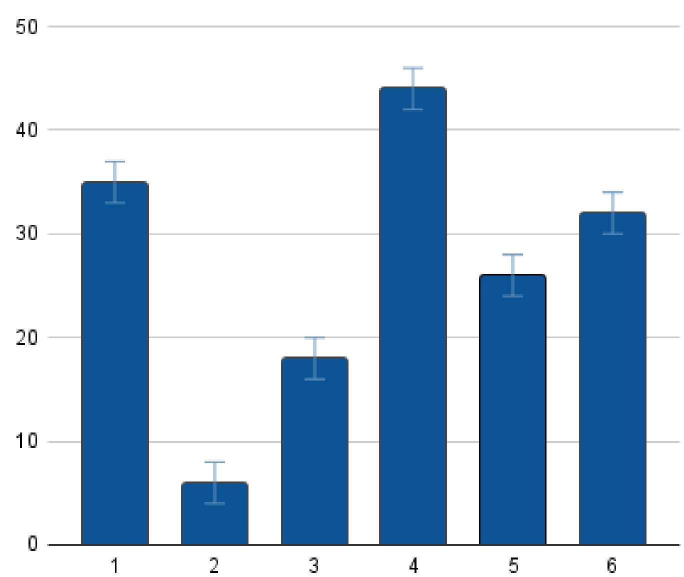
1. What do the error bars on the graph indicate?



2. Why are error bars important in data presentation?

3. Suggest labels for the X and Y axes

Frog Dissection - Remote

As you progress through the slides, you will be given descriptions and tasks to complete. Be sure to complete all tasks! Some instructions may include links to help you identify structures or answer questions.

Complete frog album can be accessed through Google Photos.

External Anatomy

The dorsal surface of the frog is darker than the ventral surface. Note that the skin of the frog appears smooth. Most of the frogs in the class are about the same size. The rule shown measures in centimeters.

1. Measure the length of the frog from nose to tail (exclude legs).

If you flip the frog over, you should notice differences in the color of the frog on the ventral surface (belly) compared to the dorsal surface.

This type of coloration is called **countershading**. This is observed in fish species also.

2. Propose a reason for a frog being lighter on the ventral side and darker on the dorsal side.

A careful examination of the forelimbs and hindlimbs reveals that only the back feet have webbing. Watch how the frog swims in the water.

3. Describe how a frog swims.

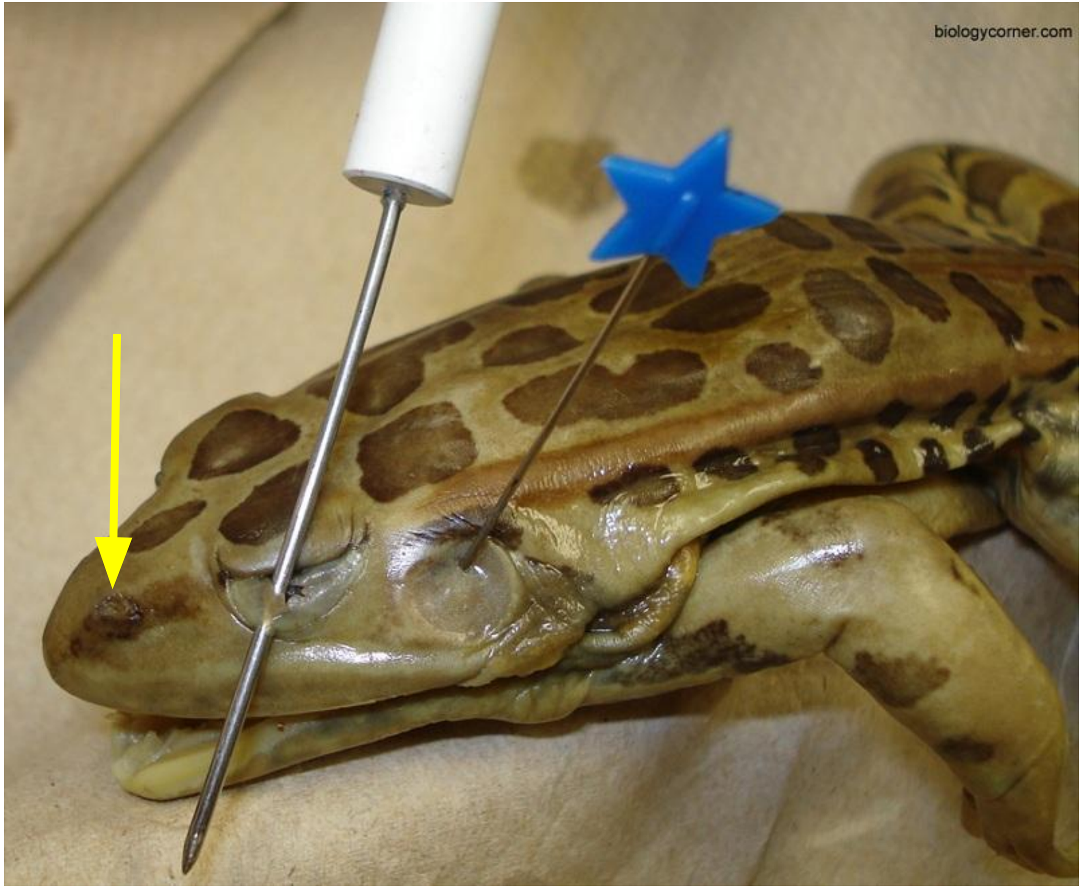
Frogs have a clear membrane that attaches to the bottom of the eye, called the nictitating membrane. It is clear and protects the eye while swimming.

Just behind the eye is a circular structure called the tympanic membrane. This is the eardrum of the frog and is used for hearing.

Toward the front of the frog is an opening called the external nares, or the nostrils of the frog. When floating, these stay above water to allow the frog to breathe.

4. Drag the labels to the structures on the frog image.

tympanic membrane	nictitating membrane
nostrils	



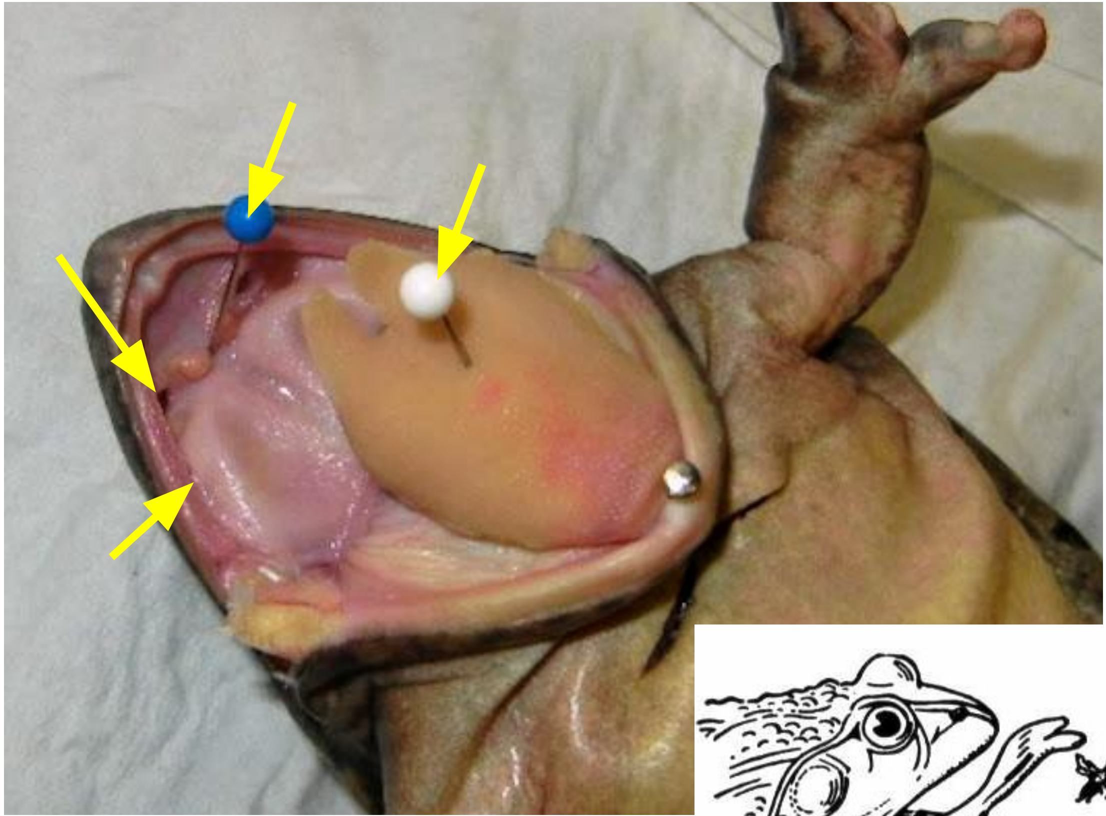
Opening the mouth can reveal several structures. Note that the tongue is attached to the front of the mouth. It is sticky and will uncurl to capture prey.

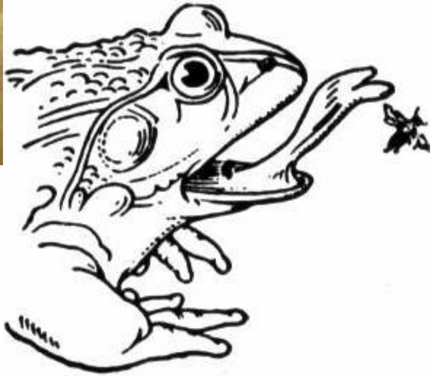
The internal nostrils are visible as openings, with two pointed teeth between them called vomerine teeth. Frogs do not chew, and use teeth to hold onto prey before swallowing objects whole.

A ridge of teeth around the outside of the mouth, called maxillary teeth will also hold prey.

5. Label each of the underlined structures on the frog image.

vomerine teeth	nostrils
tongue	maxillary teeth





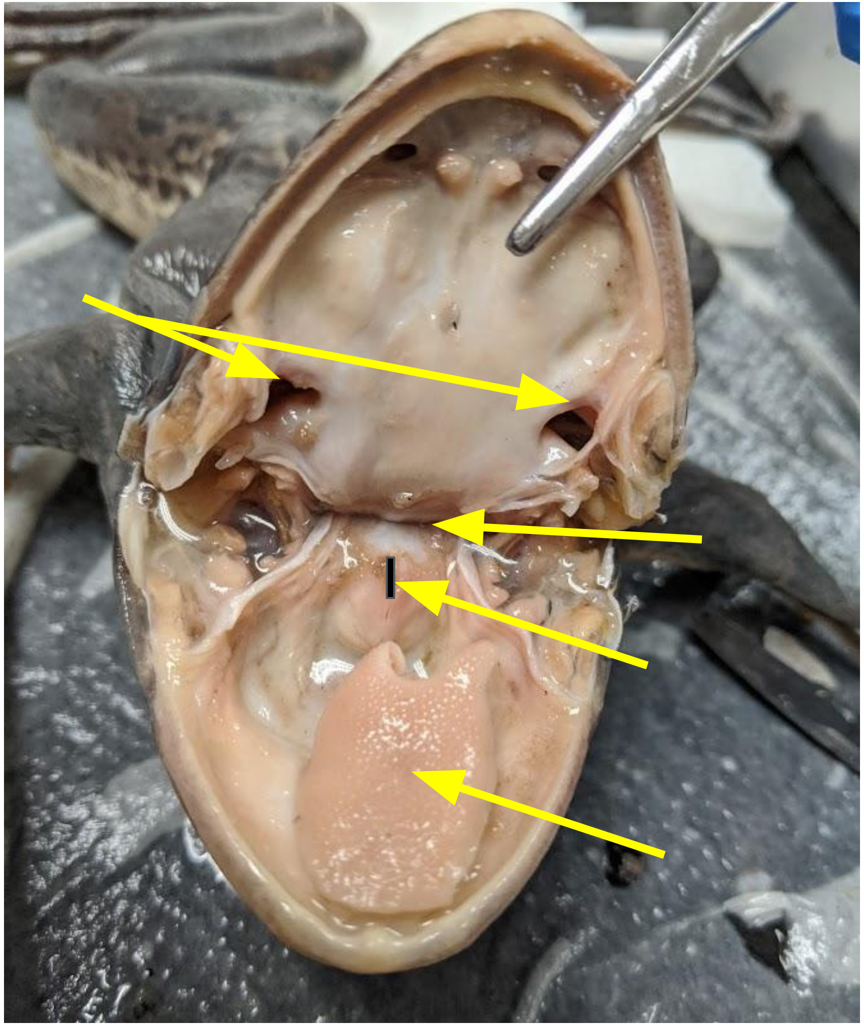
Removal of the tongue is necessary to view the eustachian tubes, which are just above the angles of the jaw. These pair of openings lead to the tympanic membrane and help to equalize pressure when the frog dives.

At the back of the moth is the large opening of the esophagus. This tube leads to the stomach.

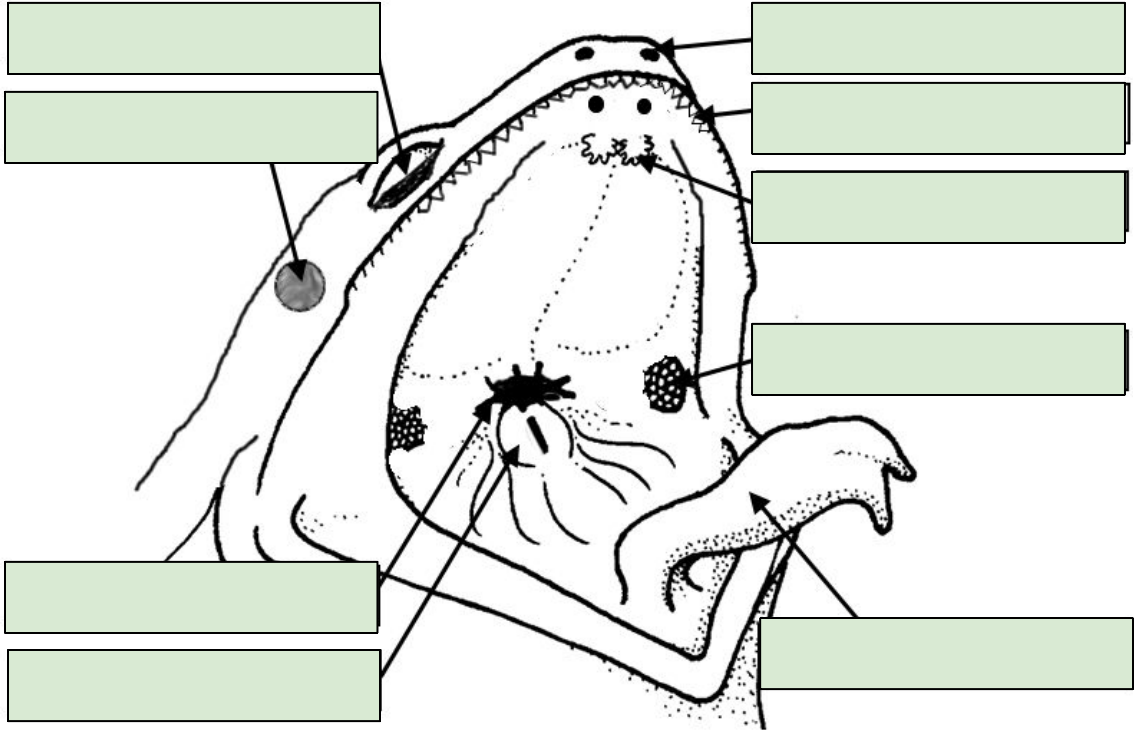
Just in front of the esophagus (toward the tongue) is a smaller opening called the glottis. This opening leads to the lungs. This is how frogs take in air.

6. Label each of the underlined structures.

glottis	eustachian tubes
esophagus	tongue



7. Identify all of the structures of the frogs you have just learned. You will need to type them into the text fields. Refer back to previous slides for spelling and names or use reference [this page](#).



Internal Anatomy

To view internal structures, the frog is cut from the lower stomach and up toward the jaw. The sides of the frog are pinned back to reveal the organs.

The most visible and largest organ of the body cavity is the liver, which can be seen as three green-ish lobes lying in the center. Each lobe is named for its location, from the frog's perspective. The left anterior lobe is on the frog's left side. Below it is the left posterior lobe. There is a single right lobe on the frog's right side.

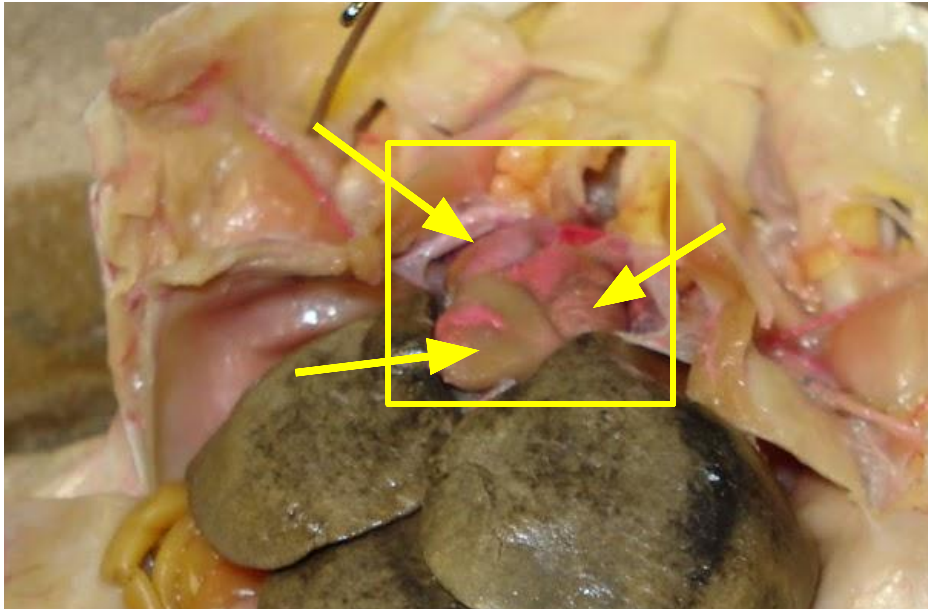
8. Drag the colored circles to the correct lobe.

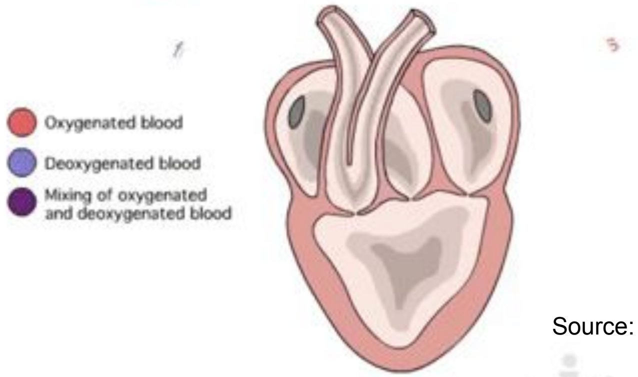
Lying above the liver is the heart (shown in yellow box), which is a pink triangular structure.

The bottom area is the single ventricle and the top part consists of a left atrium and right atrium.

9. Label the chambers of the heart.

right atrium	left atrium
ventricle	



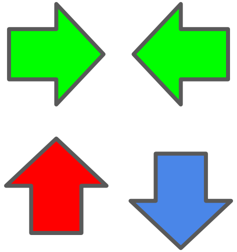


Source: Giphy

On this image the liver has been removed to show the spongy lungs that lie close to the heart.

Blood travels to the heart, then to the lungs and then back to the heart before being pumped to the body.

10. Drag the green arrows to indicate the left and right lung on either side of the heart. Use the red arrow to indicate the ventricle of the heart. And the blue arrow to show the atrium.

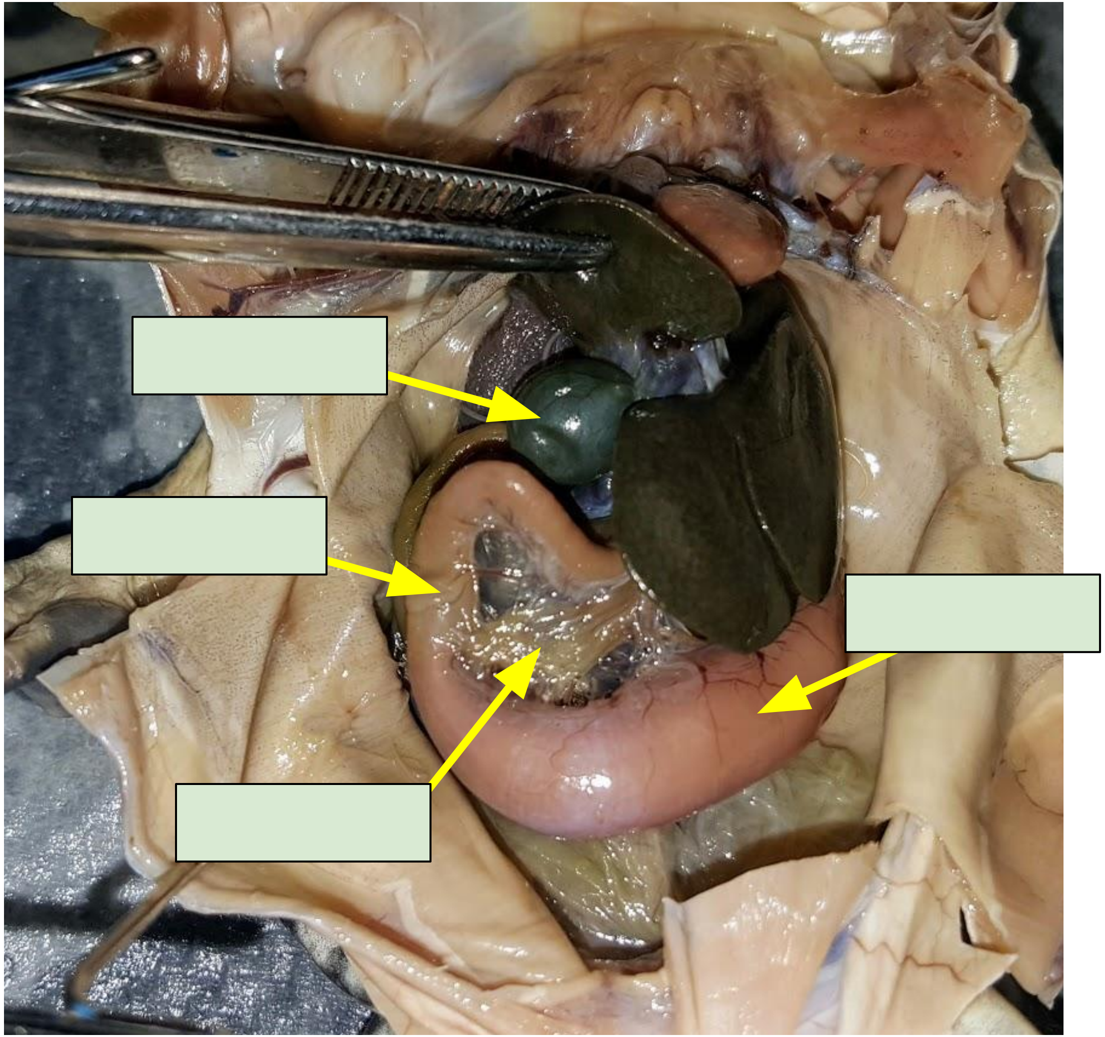


Use tweezers to lift the right lobe of the liver and reveal the sac-like gallbladder that lies underneath it. One of the many jobs of the liver is to produce bile. This bile is stored in the gallbladder.

Also laying partially under the liver is the curved stomach which leads to the straight section of the small intestine called the duodenum.

Within the interior curve of the stomach is the pancreas, which is a gland. It appears stringy or web-like in the preserved frog.

11. Label the underlined structures on the image.



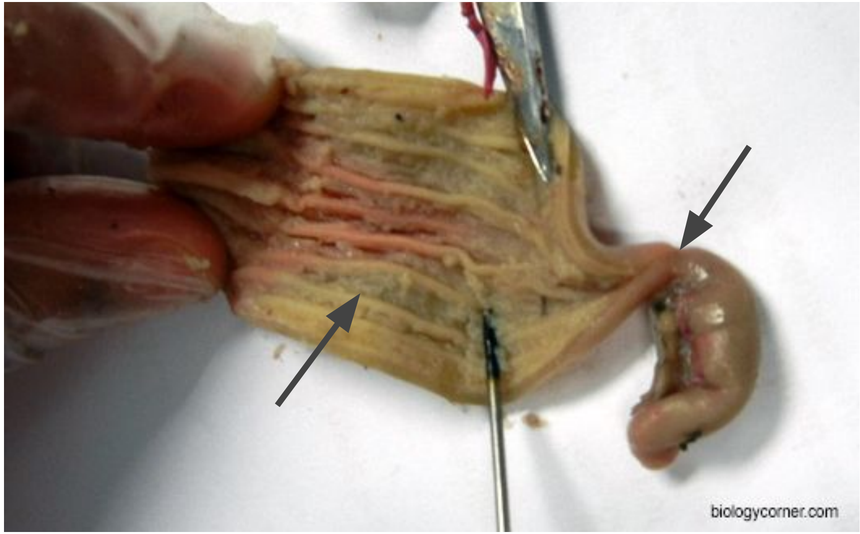
In this image the stomach has been removed to show the folds on the inside called rugae. Rugae allow for the expansion of the stomach for digestion. The layer of the stomach on the inside, called the mucosa which release enzymes to help digest food.

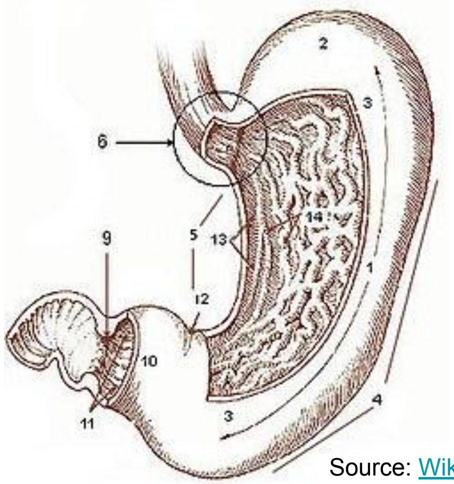
The lower end of the stomach where it connects to the small intestine has a circular valve (9) called the pyloric sphincter. This valve opens and closes to allow partially digested food to enter the small intestine where digestion will continue.

12. Label the rugae and pyloric sphincter valve.

rugae

pyloric sphincter





Sometimes, the remains of the frog's last meal are found in the stomach, usually insects or worms.

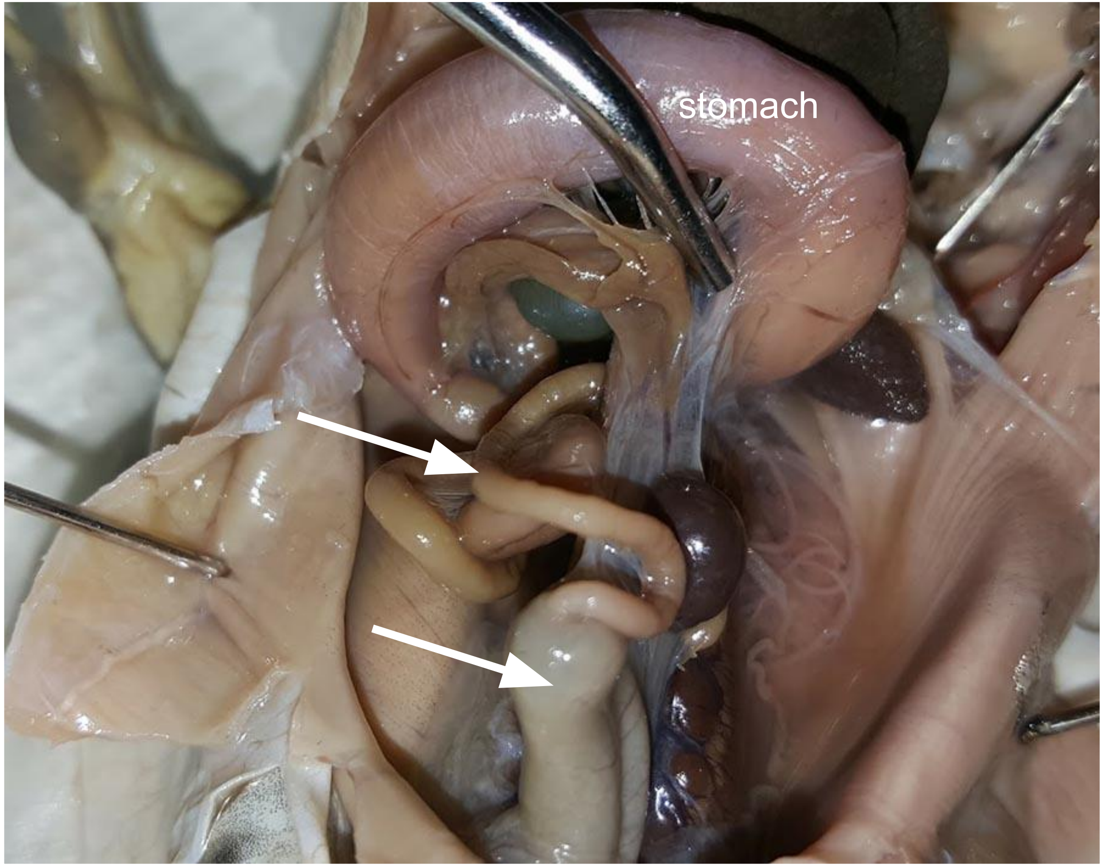
Source: Wikimedia Commons

In this view, the stomach has been pushed up to reveal the small and large intestine. Recall that at the stomach leads to the duodenum The duodenum leads to a curly portion of the small intestine. Near the lower end of the abdomen the small intestine widens and becomes the large intestine (also known as the colon).

13. Label the small and large intestine.

small intestine

large intestine



The small intestine is coiled in the body cavity and held together by a thin membrane called the mesentery. This membrane contains tiny blood vessels that carry nutrients from digested food into the bloodstream.

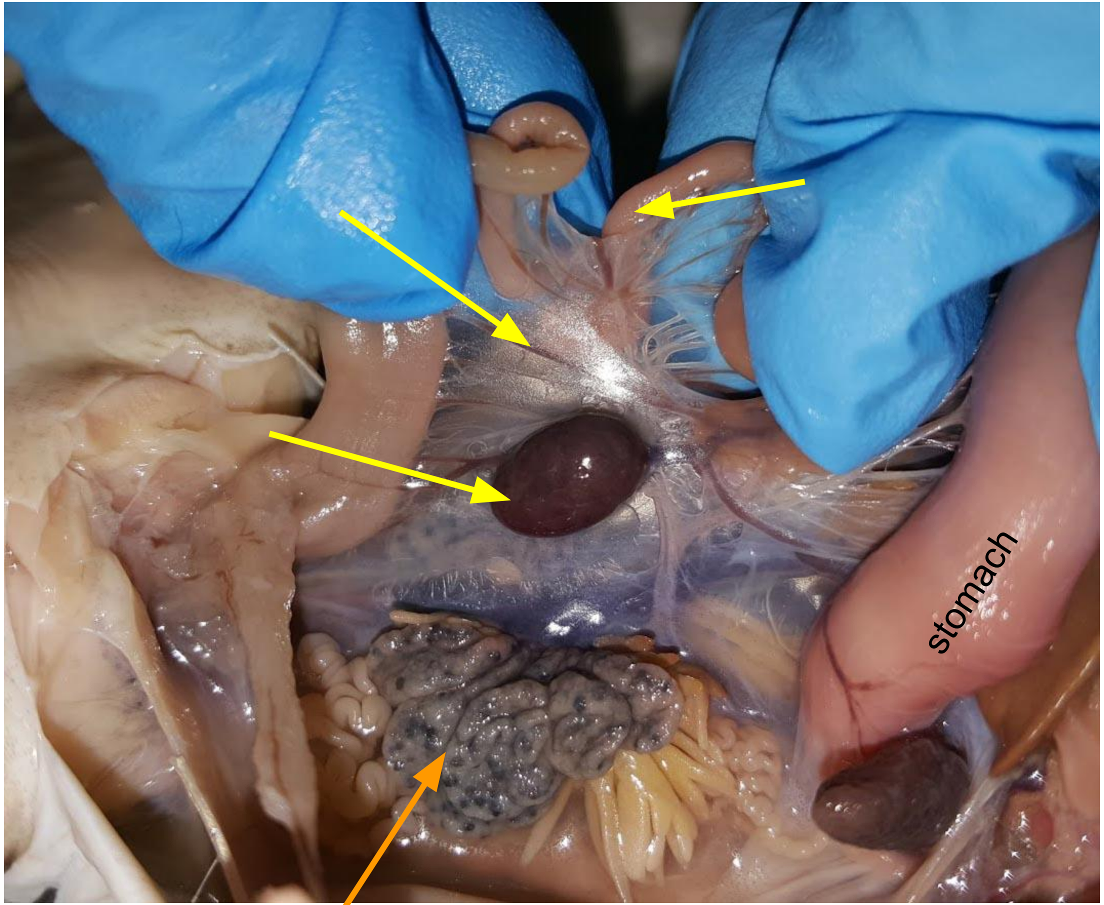
Embedding in these coils is the spleen, shown as a reddish sphere. This organ is responsible for filtering the blood and replacing worn-out blood cells.

14. Label the structures on the diagram.

small intestine

spleen

mesentery



These are eggs, so we know this frog is female.

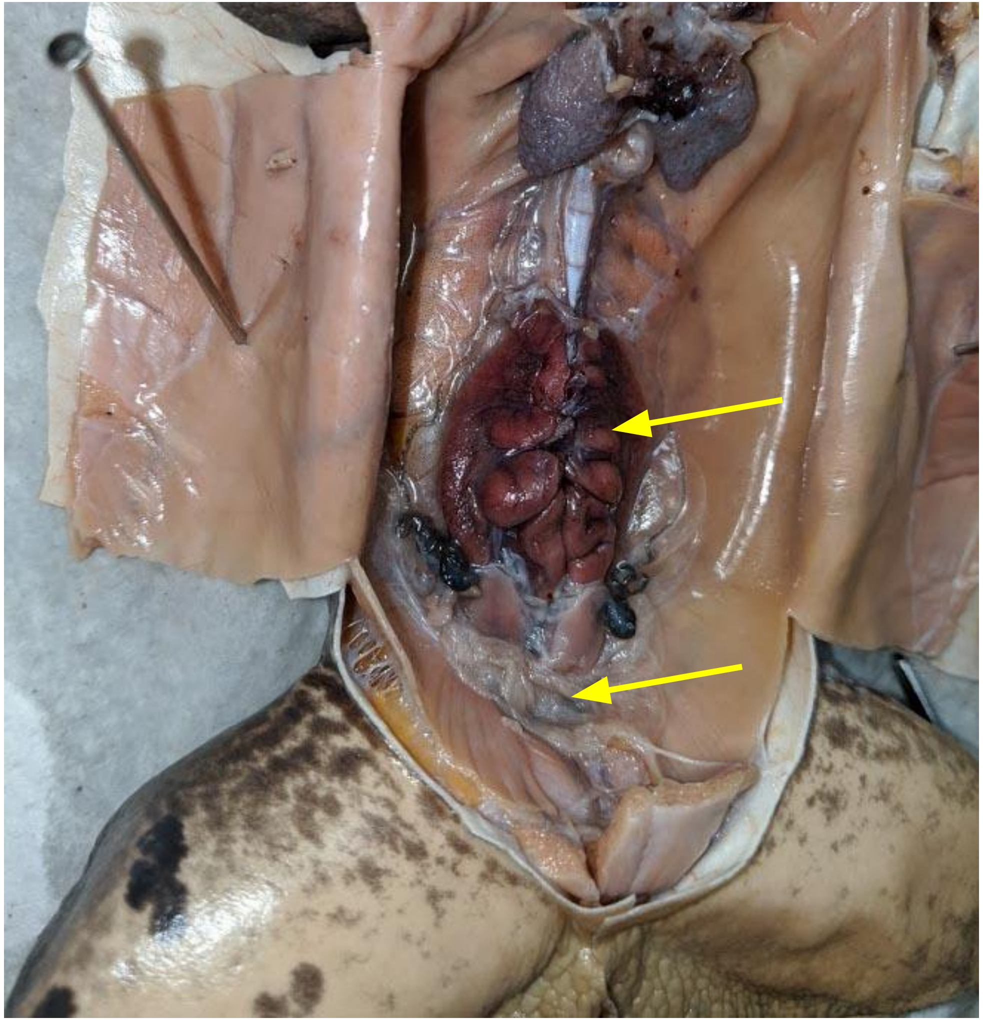
Removing most of the digestive system and other internal organs, a pair of flattened reddish organs can be seen lying alongside the spine. These are the <u>kidneys</u>.

Kidneys filter waste from the blood and transport urine to the <u>urinary bladder</u>. In this frog, it looks like a deflated balloon.

Urine will then pass out of the frog through the cloaca.

15. Label the structures on the diagram

kidney	bladder



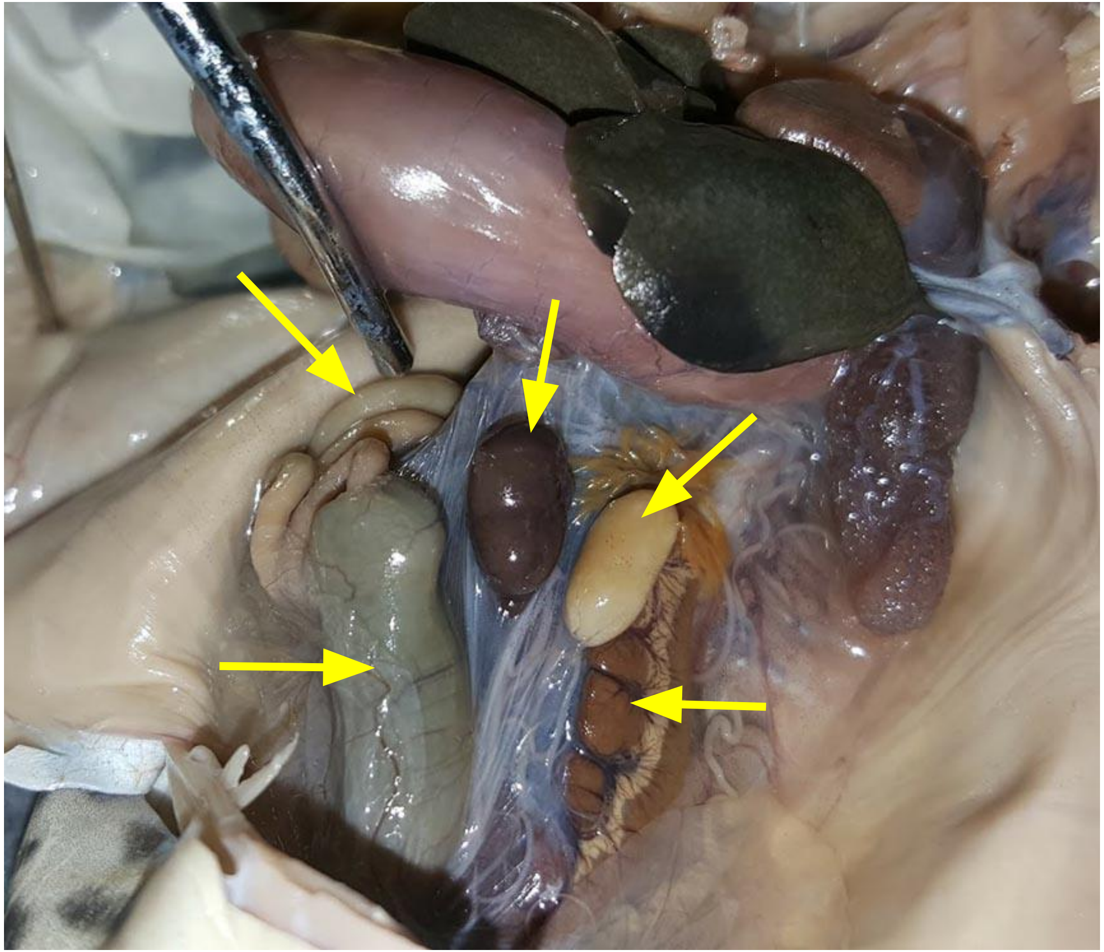
On this frog, you can see the large intestine and small intestine and the reddish spleen embedded in the mesentery.

To the right of the spleen is a cream colored organ that sits on top of the kidney. This is the testis, and it is only found in male frogs. There is another one that sits on the left side kidney (not visible in this image).

Singular: Testis
Plural: Testes

16. Label each of the underlined structures.

large intestine	spleen
small intestine	testis
kidney	



This is a female frog without eggs. You cannot see testes near the kidney, but you can see a small curly structure along the outside of the kidney. This is the oviduct. Eggs produced by the ovaries travel through the oviduct.

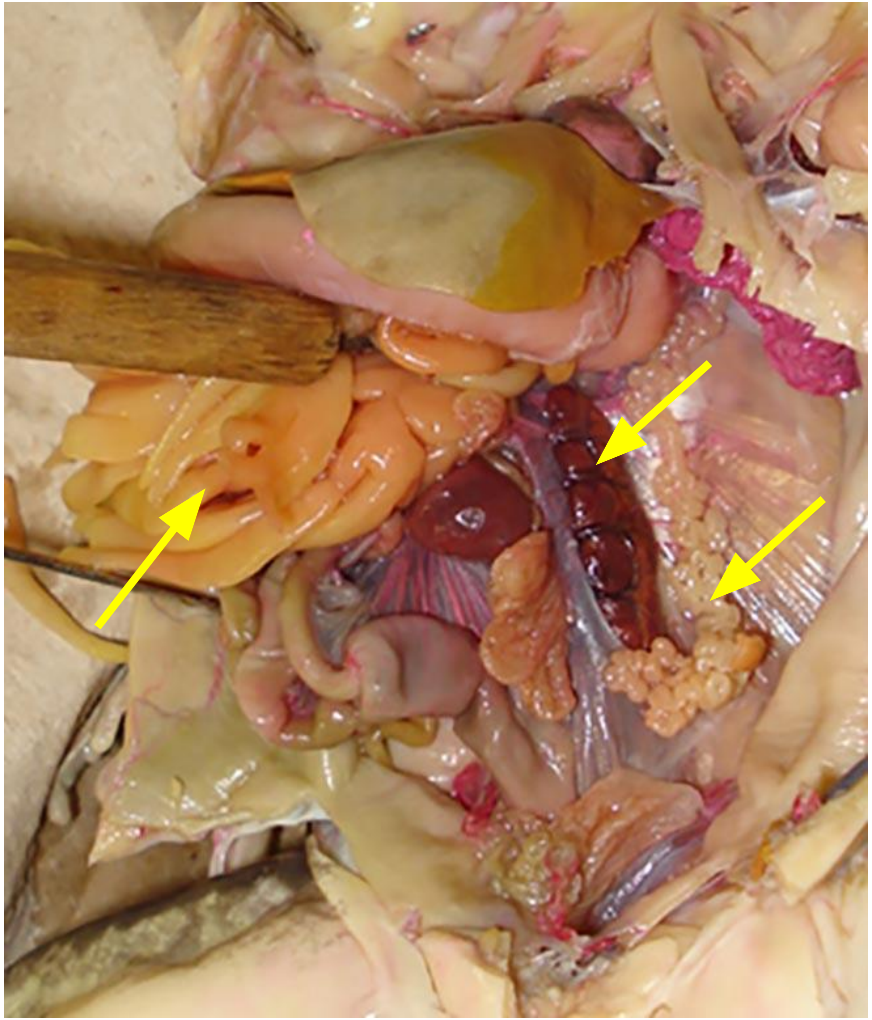
This frog also has a lot of fat bodies. These are the orange structures being pushed aside. Most frogs have fat bodies, but underfed frogs may not have noticeable ones.

17. Label the fat bodies,oviducts, and kidney.

kidney

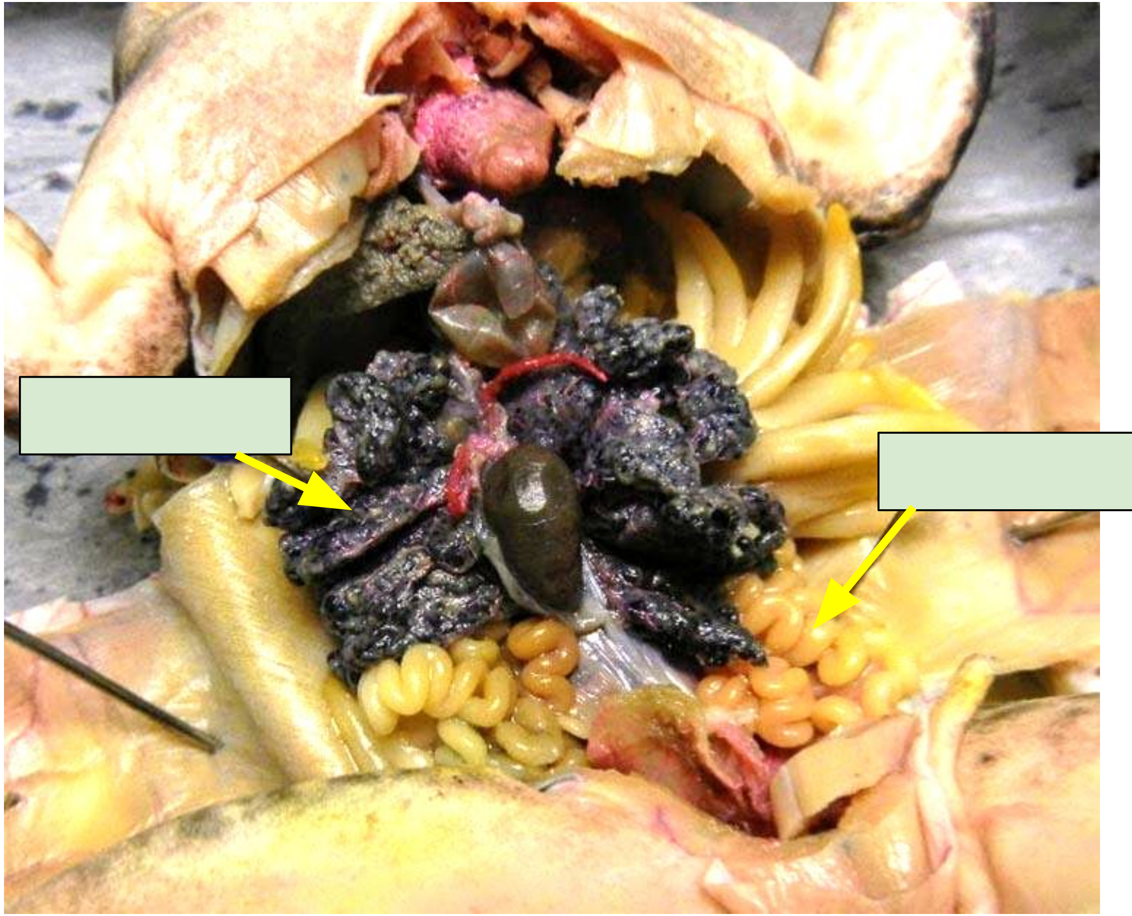
oviduct

fat bodies



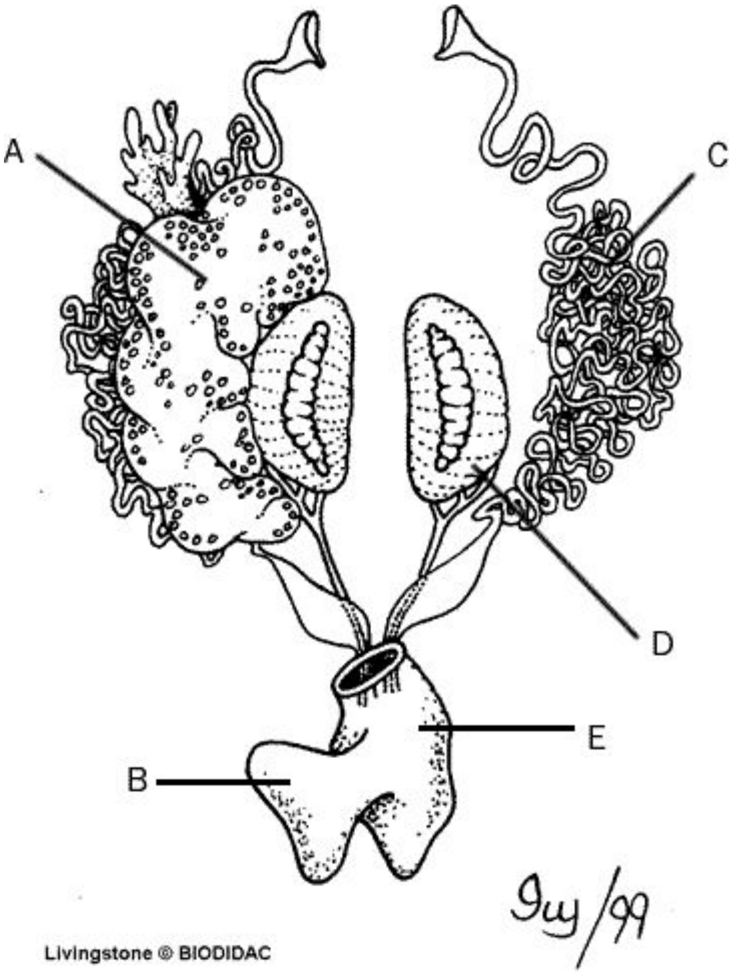
The body cavity of this female frog is filled with eggs. They appear as dark or speckled structures. You can also see the curly oviducts to the side of the eggs that appear larger in frogs that are reproducing.

18. Label the eggs and oviducts.



19. The image shows the female reproductive system. Identify each of the following by letter:

Urinary Bladder	
Cloaca	
Eggs	
Kidney	
Oviducts	



20. Now that you have learned all the major structures. Practice labeling the frog. You may need to refer back to previous slides.

esophagus	gallbladder
large intestine	pyloric valve
heart	stomach
liver	small intestine
urinary bladder	spleen
duodenum	fat bodies
pancreas