DIGESTIVE SYSTEM

* functions of the digestive system:
  a. nutrition
  b. ingestion
  c. digestion
  d. absorption
  e. egestion

* tongue and teeth - accessory structures
  - function: help in the chemical breakdown of food
* simple animals - food is ingested by formation of a food vacuole and then digested intracellularly
  - in Amoeba and Paramecium

* 2 Types of Digestive System:
  1. Incomplete type - anus is absent
     - mouth serves both for ingestion of food and egestion of waste materials
     - found in Clonorchis and Fasciola
  2. Complete type - both mouth and anus are present
     - in frog and man

  ♥ Divisions of the complete type of digestive system:
  a. coelom, peritoneum, and mesenteries
  a.1 coelom - cavity containing the visceral organs
     a.1.1 pericardial cavity - containing the heart
     a.1.2 pleuro-peritoneal cavity - contains the rest of the visceral organs
  a.2 peritoneum - connective tissue membrane that lines the coelom
     a.2.1 parietal peritoneum - peritoneum lining the body wall
     a.2.2 visceral peritoneum - covers most visceral organs
  a.3 mesenteries - two layers of peritoneum that suspend the viscera from the dorsal body wall
     - generally named after the organ they suspend
     a.3.1 dorsal mesentery - suspends the digestive tube from the dorsal body wall
     a.3.2 mesogaster - suspends the stomach
     a.3.3 mesentery proper or mesenterium - suspends the ileum
     a.3.4 mesorectum - suspends the rectum
     a.3.5 ventral mesentery - suspends the digestive tube from the ventral body wall
     - represented by remnants only (lesser omentum)
a. Omentum - double membrane continuous with the mesenteries connecting the visceral organs with one another
   - also named after the organs they connect
     a.4.1 gastro-hepato-duodenal omentum or lesser omentum - connects the adjacent portions of the stomach, liver and duodenum
     - remnant of the ventral mesentery

b. Buccal Cavity
   ♥ Parts of the buccal cavity:
   b.1 maxillary teeth
   b.2 tongue - function: captures food that is later passed on to the esophageal opening
   - attached to the floor of the lower jaw anteriorly
   b.3 glottis - slit-like opening to the respiratory system
   * In males, there are vocal sacs that are near the angle of the jaw
   b.4 choanae or internal nares
   b.5 vomerine teeth
   b.6 opening or recess to the Eustachian tube

c. Digestive tube
   c.1 esophagus
   c.2 stomach - function: where digestion occurs; it releases enzymes which are used for breaking down food
      c.2.1 cardiac end - anterior portion of the stomach continuous with the esophagus
      c.2.2 pyloric end - posterior portion of the stomach continuous with the small intestine
      c.2.3 greater curvature - outer curvature of the stomach
      c.2.4 lesser curvature - inner curvature of the stomach
      c.2.5 rugae - longitudinal folds lining the inner wall of the stomach
      - function: increases the surface area of the stomach for absorption
   c.3 pyloric sphincter - a thickened muscular layer that encircles the exit of stomach
   c.4 small intestine - function: where most of the chemical digestion and absorption are completed
      - has 2 regions:
        c.4.1 duodenum - shorter and more anterior
        c.4.2 ileum - longer and more posterior
   c.5 large intestine - function: where further breakdown of undigested material by bacterial action and the absorption of water occur
   c.6 anus
   c.7 cloaca
   * Urine and gametes pass through the cloaca and anus
   c.8 spleen

d. The Digestive Glands
   d.1 liver - largest gland in the body
      - function: secretes bile, and monitors and controls the balance of the body by removing the toxins in the body
      - has three lobes:
        d.1.1 a left lobe subdivided into anterior and posterior lobules
        d.1.2 a small right lobe
        d.1.3 much reduced median lobe
   d.2 gall bladder - stores the bile secreted by the liver
   * bile - emulsifies fat, neutralizes the acidic food entering the intestine and creates a pH favorable for pancreatic and intestinal enzyme action
   d.3 pancreas - digestive gland and an endocrine gland
   * as a digestive gland:
      → secretes pancreatic juice which contains several enzymes for the chemical breakdown of food
→ these enzymes include lipase, deoxyribonuclease, amylase and carboxypeptidase
* as an endocrine gland:
→ secretes insulin

4 common bile duct - formed by the union of the cystic duct of the gall bladder, the hepatic duct, and the pancreatic ducts
- enters the anterior portion of the duodenum

**RESPIRATORY SYSTEM**

* energy production - requires oxygen and results in the production of carbon dioxide
* oxygen - obtained from the environment
* carbon dioxide - given off by the organism
* Exchange of gases:
  a. in simple and small animals - occurs directly between the cells of the body and the environment
  b. in complex and large animals - by way of specialized respiratory organs
* respiratory organ - derived from the integument of the lining of the digestive tube
  - ideally, should be permeable, highly vascularized, and in contact with a medium rich in oxygen

* Respiratory organs:
  a. in aquatic animals
    → called gills
  b. in terrestrial organisms
    → b.1 lungs - evaginations (outpocketings) of the digestive tube
    → b.2 tracheal system - invaginations (inpocketings) of the integument

* Types of respiratory system:

  1. Aquatic respiratory system
  Parts of the aquatic respiratory systems
  1.1 gill chamber
  1.2 gills - will blood capillaries that give rise to the dark red color of the gills
  - significance of the blood capillaries:
    → needed for the movement of the gills for respiration
  1.3 gill arches - 4 pairs of gill arches
  1.4 pharyngeal clefts - wide slits between the gill arches
  - function: serve for the passage of water from the pharynx to the gill chamber

  2. Terrestrial respiratory system
  2.1 tracheal system of insects
  * tracheal system - branching system of air tubes which supplies oxygen directly to the tissues
  Parts of a tracheal system:
  a. tracheal trunk
  b. spiracles - opening to the outside
  - function: passage of air to the outside
  * There are 10 pairs of spiracles

  2.2 lung system of vertebrates
  Parts of the lung system of vertebrates:
  a. tongue
  b. glottis - leads to the larynx
  c. larynx
  d. arytenoids
  e. cricoid cartilage - ring-shaped cartilage that borders the arytenoids
  f. lungs
EXCRETORY SYSTEM

* homoeostasis - steady state of the internal environment of an animal
* forms of substances that are not needed in the body:
  a. excess water
  b. excess salts
  c. by-products of metabolism
* An effective excretory apparatus distinguishes wastes from nonwastes
* In lower animals - without excretory organs
  - excretion is through the body surface
* In higher animals - excretion is by specialized organs in close association with the body fluids, lymph, hemolymph or blood

These excretory organs may be in the form of:

- prothoracic ducts in lower metazoans (e.g., flatworms like Clonorchis and Fasciola)
- metanephridia in annelids (e.g., earthworm)
- nephridia in mollusks (e.g., snails)
- green glands in crustaceans (e.g., shrimp, crab)
- malpighian tubules in insects (e.g., cockroach)
- kidneys in mammals (e.g., frog and man)

1. Malpighian tubules
   * malpighian tubules - excretory organs of insects like cockroaches
     - thread-like diverticula located at the junction of the midgut and the hindgut
     - effective in precipitating nitrogenous waste in the form of uric acid crystals which are voided with the feces
     - form of waste eliminated by the cockroach: uric acid

2. The frog's excretory system
   Parts of the frog's excretory system:
   a. kidneys - unlike other organs, they are retroperitoneal
   * retroperitoneal - located behind or outside the peritoneum
   b. cisterna magna - space where the kidneys are located
   c. mesonephric or Wolffian duct -
     * counterpart of mesonephric duct in mammals: metanephric duct or ureter
   d. urinary bladder - function: serves for the storage of urine
   * mesonephros - functional kidney of the adult frog

3. Mammalian kidney
   Parts of the mammalian kidney:
   a. cortex - outer region of the kidney
     - contains microscopic renal corpuscles and tubules
   b. medulla - inner region of the kidney
     - contains the collecting tubules
   c. renal papilla
   d. renal pelvis - expanded beginning of the ureter or metanephric duct
   e. ureter or metanephric duct
     * counterpart of ureter or metanephric duct in frogs: mesonephric or Wolffian duct
   f. hilus - concavity
     * metanephros - functional kidney of the adult mammal
CIRCULATORY SYSTEM

* circulatory system - function: responsible for the transport of gases, nutrients, metabolic wastes, hormones, and other substances in different parts of the body
  - assists in maintaining constancy of the internal environment (homeostasis) of the organism

* lower metazoans (like Clonorchis and Fasciola) - no circulatory system
  - distribution of body fluid or lymph, in the space between cells and tissues is brought about by the body movements
* higher metazoans (like cockroach, frog and man)
  - have either an open or closed type of circulatory system
    → open system - blood is not always contained in vessels
    - in most mollusks (ex. tahong, tulya, bivalves, snails)
    - in arthropods (ex. shrimp and crab)
    → closed system - blood is always contained in vessels
    - in vertebrates (frog, man)
    - in annelids (earthworm)
    - in squids and octopus

1. Open system
Parts of an open circulatory system of a cockroach
a. heart
   * There are 8 chambers of the heart in the cockroach
b. pericardial sinus - a cavity that encloses the heart
   - open at the posterior end
c. dorsal diaphragm - ventral wall of this pericardial sinus
d. aorta - opens into the sinuses of the head
e. ostia - guarded by valves
   * valves - function: regulate the blood flow in the chambers of the heart and prevent backflow
   * The blood is kept in circulation by the rhythmic contraction of the chambers of the heart from the posterior to the anterior chambers to the aorta

2. Closed system
Two closely associated systems of the closed circulatory system:

2.1 Lymphatic system
Parts of the lymphatic system:
a. dorso-lateral subcutaneous connective tissue - tissues connecting the skin to the body wall
b. dorsal subcutaneous lymph space - space between the skin and the dorsal body wall
c. lymph hearts
   - anterior pair: found between the 3rd vertebra and the posterior corners of the suprascapula
   - posterior pair: on both sides of the urostyle beside the anus
d. lymph - circulating fluid
   * Exchange of gases and other materials takes place between the capillaries and body tissues through the intercellular fluid or lymph

2.2 The blood vascular system
a. capillaries - connect the small arteries (arterioles) with the small veins (venules), thus completing the circuit for blood circulation

b. the heart
   * The pumping action of the heart creates pressure that drives the blood to the different parts of the body
b. 1 The external anatomy of the frog’s heart
Parts:

b.1.1 pericardial cavity
b.1.2 parietal pericardium or parietal sac - lines the pericardial cavity
b.1.3 visceral pericardium - inseparably fused to the outer wall of the heart
b.1.4 transverse septum - separates the pericardial cavity from the pleuro-peritoneal cavity
b.1.5 atrium - thin-walled
b.1.6 ventricle - thickened-walled
b.1.7 conus arteriosus
b.1.8 sinus venosus - also contracts
  * The pacemaker of the heart is a specialized area of heart muscle that controls and regulates heart beat
  * During contraction (systole), the heart decreases in size and its color changes to light red. During relaxation (diastole), the heart returns to a larger size and its color changes to dark red

b.2 The internal anatomy of the frog’s heart and its blood vessel
Parts:

b.2.1 right atrium - larger
b.2.2. left atrium - smaller
  * significance of the difference in size:
    → The right atrium is bigger than the left atrium since the former receives blood from all organs of the body except the lungs. Blood from the lungs is received by the left atrium
b.2.3 interatrial septum - divides the atrium
b.2.4 sinoatrial aperture - oval opening on the dorsal wall of the right atrium
  - function: serves as the entrance of blood from the sinus venosus
b.2.5 opening of pulmonary veins - on the dorsal wall of the left atrium near the interatrial septum
b.2.6 ventricle - with muscular pockets in the inner wall
b.2.7 atrioventricular apertures - connects the atrium and ventricle
  - function: serve as the entrance of blood to the ventricle
  - guarded by valves which prevent the backflow of blood
b.2.8 spiral valve - ventral edge is free
  * The spiral valve in the conus arteriosus direct oxygen-poor blood into the aortic arches leading to gills or lungs, and they direct oxygenated blood into arches that supply other parts of the body. The spiral valve is a modification arising from the formation of a typhlosole-like septum
b.2.9 truncus arteriosus - has 3 channels
  * The channels lead to the three branches of the truncus arteriosus namely, the common carotid artery, systemic artery, and the pulmonic artery
  * The spiral valve in the conus arteriosus, longitudinal septa and interatrial septum play an important role in maintaining selective distribution in order to prevent mixing of oxygenated and unoxygenated blood in the frog’s heart
  * There are 3 chambers of the frog’s heart: right atrium; left atrium; ventricle

b.3 Internal anatomy of the mammalian heart
Parts:

b.3.1 ventricles - constitute the bulk of the heart
  - thick-walled and highly muscular
    b.3.1.1 apex - posterior narrow portion of the ventricle
    b.3.1.2 base - broad anterior portion
b.3.2 atrium - thin-walled and dark-colored
  * right atrium is bigger than the left atrium
  * oxygenated blood from the lungs enters the left atrium

b.3.3 interatrial septum - separates the right and left atrium
b.3.4 sinus venosus
* The sinus venosus in the adult is incorporated into this region as the sinoatrial (SA) node (pacemaker)
b.3.5 interventricular septum - partitions the ventricle
b.3.6 right ventricle - significance or function: pumps deoxygenated blood to the lungs through the pulmonary arteries
b.3.7 left ventricle - includes the apex
* The right ventricle is smaller and has a thinner wall than the left ventricle (pumps blood to the different parts of the body)
* advantage of having 2 ventricles → there is no opportunity for the mixing of oxygenated and deoxygenated blood. Another advantage is the increase in the efficiency of the heart since each ventricle has a specific task. The right ventricle pumps blood to the lungs while the left ventricle to the other parts of the body
b.3.8 right atrio-ventricular aperture - opening between the right atrium and the right ventricle
- guarded by 3 membranous flaps, the tricuspid valves
b.3.9 left atrio-ventricular aperture - opening between the left atrium and left ventricle
- guarded by 2 membranous flaps, the bicuspid or mitral valve
b.3.10 trabeculae carnae - muscular ridges of the inner walls of the ventricles
b.3.11 papillary muscles - pointed finger-like muscles
b.3.12 chordae tendinae - fine thread-like fibers that functions in connecting the free edges of the tricuspid and bicuspid valves to the tip of the papillary muscles
* The blood leaves the right ventricle through an opening leading to the pulmonary arteries
b.3.13 semilunar valves - guard the exits of the left and right ventricles to the aorta and pulmonary arteries, respectively

* Pulmonary circulation - brings blood back and forth the lungs

**Pulmonary circulation pathway of the frog's heart**

```
sinus venosus
   ↓
right atrium
   ↓
ventricle
   ↓
conus arteriosus
   ↓
truncus arteriosus
   ↓
pulmocutaneous artery
   ↓
pulmonary artery
   ↓
capillaries of the lungs
   ↓
pulmonary vein
   ↓
left atrium
   ↓
conus arteriosus
   ↓
truncus arteriosus
```
**Pulmonary circulation pathway of mammalian heart**

- common carotid or systemic artery

  ↓

- precava/post cava

  ↓

- right atrium

  ↓

- right ventricle

  ↓

- pulmonary artery

  ↓

- capillaries of the lungs

  ↓

- pulmonary veins

  ↓

- left atrium

  ↓

- left ventricle

  ↓

- aorta
c. The Venous System

- veins - convey blood back to the heart
  - thin-walled, dark colored and generally superficial

Note: The dark appearance of veins is due to the thinness of the walls of these vessels making blood more visible

♥ Divisions of the venous system:
1. systemic veins - carry unoxygenated blood from the different parts of the body directly to the right atrium
2. portal veins - carry unoxygenated blood through a system of blood capillaries in the liver or kidney from where the blood is recollected by the systemic veins to be brought back to the right atrium of the heart
3. pulmonary veins - carry oxygenated blood from the lungs directly to the left atrium

♥ Other veins:
- left and right precaval veins or anterior vena cava - enters the antero-lateral of the sinus venosus
- postcaval veins or posterior vena cava - enter the posterior angle of the sinus venosus

Three blood vessels that join the precava before it enters the sinus venosus:

a. external jugular vein - anterior portion
Two veins that join the external jugular vein:
  a.1 lingual vein - drains blood from the tongue
  a.2 maxillary vein - drains blood from the lower jaw

b. innominate vein - middle portion
Two vessels that join the innominate vein:
  b.1 internal jugular vein - receives blood from the head, brain and spinal cord
  b.2 suprascapular vein - receives blood from the shoulders

c. subclavian vein - posterior portion
Two blood vessels that join the subclavian vein:
  c.1 brachial vein - drains blood from the entire forelimb
  c.2 musculocutaneous vein - formed by the union of two smaller vessels which drain blood from the sides of the body and head

* Tributaries of the postcava:
  a. from the lower region - blood is collected by the postcaval vein which enters at the sinus venosus
  b. posteriorly, there are 3 tributaries to the postcaval veins:
    b.1 hepatic portal vein - from the liver
    b.2 renal portal vein - from the kidneys
    b.3 ovarian or spermic veins - from the gonads
  c. lumbar veins - from the dorsal portion of the body

Two portal systems in the frog:

a. hepatic portal system
a.1 hepatic portal vein - enters the liver
  - joined by the ventral abdominal vein shortly before it enters the liver
  - drains blood from the various visceral organs through the following tributaries:
    a.1.1 gastric vein - from the stomach
    a.1.2 splenic veins - from the spleen
    a.1.3 pancreatic veins - from the pancreas
    a.1.4 - intestinal veins - from the small intestine

b. renal portal system - composed of:
  b.1 renal portal vein
  b.2 veins that drain blood from the dorsal body wall
  b.3 femoral vein - drains blood from the anterior and dorsal sides of the thigh and the rest of the hindlimb
  b.4 sciatic vein - drains blood from the posterior side of the thigh
* left and right pelvic veins - receive short veins from the urinary bladder, and then unite ventrally to form the anterior abdominal vein
* There are 2 pathways in which blood from the hindlimbs may return to the heart, through the renal portal circulation or through the anterior abdominal vein by way of the liver
* pulmonary vein - coming from the lungs

d. The Arterial System
* arteries - convey blood from the heart to the different parts of the body
  - thick-walled, light-colored, and generally deeply set in the body
  - do not have internal valves while veins have internal valves
  - carry oxygenated blood except for the pulmocutaneous artery

Parts of the arterial system:
  * conus arteriosus - function: serves as the base of all arteries
  * truncus arteriosus - divides into left and right trunks
    Branches of the truncus arteriosus:
    a. common carotid artery - anterior branch
      - divides into:
        a.1 internal carotid - supplies the roof of the mouth, brain and eyes
        a.2 external carotid artery - supplies the tongue
    Note: carotid gland - small, rounded, yellowish gland
      - function: it is a baroreceptor that respond to distension of their walls resulting from an elevation in blood pressure

b. systemic artery - middle branch
  - gives small branches to the larynx and muscles of the jaw, the dorsal side of the esophagus, orbit, nose, and vertebral column
  * subclavian artery - supplies the shoulder and neighboring parts
  * branchial artery - continuation of the subclavian artery in the forelimb
  Note: The left and right systemic arches unite medially and continue posteriorly as the dorsal aorta

* coelico-mesenteric artery - divides into:
  1. coeliac artery
    Branches of the coeliac artery:
    1.1 left and gastric artery - supplies the stomach and pancreas
    1.2 hepatic artery - supplies the liver and the anterior portion of the pancreas
    2. anterior mesenteric artery
    Note: Arteries from the dorsal wall of the dorsal aorta supply the lumbar/back region, kidneys, urogenital system
    * posterior mesenteric artery - unpaired
      - supplies the posterior portion of the rectum and the dorsal wall of the uterus in the female reproductive system
    * left and right common iliac arteries
      Branches of the common iliac artery:
      1. epigastric artery - supplies the ventral abdominal vein
      2. recto-vesicular artery - supplies the rectum and urinary bladder
      3. femoral artery - supplies blood to the skin and the muscles of the anterior part of the thigh
    * sciatic artery - extension of common iliac artery to the rest of the hindlimb

c. pulmocutaneous artery - posterior branch
  - to the lungs and skin
  * significance of the branch of the pulmocutaneous artery that goes to the skin: it enables the frog to perform cutaneous breathing or respiration
* In general, arteries and veins are named after the organs they supply or drain

**NERVOUS SYSTEM AND SENSE ORGANS**

* roles of the nervous system:
  a. to perceive stimulus
  b. effect responses
  c. coordinate and integrate the functions of the different parts of the body
* protozoans - no distinct nervous system
* Amoeba - undifferentiated protoplasm of the body serves as the receptor, conductor, effector, and coordinator
* ciliates - kinetodesmata (fine threads) connect the bases of the cilia to one another and serve for coordination of ciliary beat
* sponges - no specialized structures for nervous control
- each cell of the body acts as a direct stimulus to neighboring cells
* starting with coelenterates, a definite or distinct nervous system is present in the rest of the metazoan animals

♥ Four types of nervous system:
1. Diffuse type or nerve net
   - simplest type of nervous system
   - found in coelenterates like Hydra
* called nerve net because → it consists of a network of nerve cells, each with a number of processes radiating from the cell body in all directions; the processes of neighboring nerve cells connect to one another to form a continuous network
* called diffuse type because → the primitive nerve cells (neurites or protoneurons) are non-polar, i.e., the nerve impulses are conducted in all directions from the point of stimulation, and there are no definite pathways
* In higher types of nervous system, the nerve impulses travel in one direction only (from dendrite to cell body to axon)
* main distinguishing characteristic of the diffuse or nerve net type of nervous system → lack of centralization or the absence of concentration of nerve cell bodies at certain areas of the body of the animal

2. Ladder type - exemplified by Dugesia, a flatworm
   - there is a definite head region (cephalization) with an aggregation of nerve cells which form a pair of cerebral ganglia or primitive “brain”
* called a ladder type because → there are 2 longitudinal nerves (parallel to each other) with transverse nerves that run across them forming a “ladder”
* Dugesia - exhibits bilateral symmetry while the Hydra exhibits radial symmetry
* The ladder type of nervous system is more probable to occur in animals which can be divided into 2 similar halves. The diffuse type or nerve net is more probable to occur in animals without a definite head region and exhibit radial symmetry

3. Ganglionic type - found in annelids (ex. earthworm) and arthropods (ex. shrimp and crabs)
   - consists of:
     a. dorsal brain (cerebral ganglia)
     b. ventral nerve cord - consists of a segmental series of paired, closely approximated ganglia, connected by 2 longitudinal nerve strands
* The nervous system of the arthropods - more centralized and has fewer ganglia because of migration and fusion in the thorax and abdomen
→ 2 longitudinal nerve starnds - fuse into a single strand

**Important note:**
* Invertebrate: dorsal brain<br>ventral nerve cord
vertebrates: dorsal brain
- dorsal nerve cord (spinal cord)

4. Tubular Type
- found in vertebrates
- called tubular because the vertebrate brain and spinal cord are hollow
- brain cavities called ventricles - continues with the central canal of the spinal cord

**Overall Organization of the Vertebrate Nervous System**

- The nervous system is composed of:
  1. Peripheral nervous system
  2. Sense organs
  3. Central nervous system

1. The peripheral nervous system
- consists of nerve cells and nerve fibers which connect the central nervous system to all parts of the body

Parts of the peripheral nervous system:

- cranial nerves
- frog: 10 pairs of cranial nerves
- man and higher vertebrates: 12 pairs of cranial nerves
- 1st cranial nerve: olfactory nerves
- 2nd cranial nerve: optic nerves

- spinal nerves
- frog: 10 pairs of spinal nerves
  - The number of spinal nerves vary in different group of vertebrates because of the different number of vertebra found in the spinal cord
  - The spinal nerves consists of:
    - sensory or afferent nerve fibers - arise from the spinal cord by the dorsal root
    - transmit impulses from the receptors to the central nervous system
    - motor or efferent nerve fibers - arise from the spinal cord by the ventral root
    - transmit impulses from the central nervous system to the effectors

spinal nerves:
- 1st to 9th - exit through the intervertebral foramina
- 10th - gets out through the lateral foramina at the anterior end of the urostyle
- 1st, 2nd and 3rd - forms the branchial plexus
  - The main trunk of 2nd spinal nerve extends to the forelimb as the branchial nerve
  - 1st and 3rd spinal nerves - innervates the forelimbs and shoulder region
- plexus - a network of communicating nerve fibers
- 4th, 5th and 6th - do not form a plexus
- innervate the muscles of the abdominal wall and the skin
- 7th, 8th and 9th - form the lumbo-sacral or sciatic plexus
  - sciatic nerve - largest branch of the sciatic plexus
  - found between the biceps femoris and the semimembranosus muscles
- 10th - lies close to the side of the urostyle
  - difficult to see

Divisions of the peripheral nervous system:
1. somatic nervous system - innervates the skeletal muscles, skin, and certain other parts
  - function: responsible for the movement of various parts of the body through reflex actions as well as through conscious control of the will
  - under voluntary control
2. autonomic nervous system - innervates the cardiac muscles, smooth muscles, and glands
- function: governs and controls the functions of the viscera (heart, digestive tract, glands, etc.)
- carried out automatically at the level of unawareness and unconsciousness
- under involuntary control

The autonomic nervous system includes:
2.1 sympathetic divisions
2.2 parasympathetic divisions
* These 2 divisions are antagonistic, for example

<table>
<thead>
<tr>
<th>SYMPATHETIC DIVISION</th>
<th>PARASYMPATHETIC DIVISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>stimulatory to the heart</td>
<td>inhibitory to the heart</td>
</tr>
<tr>
<td>inhibitory to the digestive tract</td>
<td>stimulatory to the digestive tract</td>
</tr>
<tr>
<td>dilates the pupils of the eyes</td>
<td>constricts the pupils of the eyes</td>
</tr>
</tbody>
</table>

* Parts of the sympathetic autonomic nervous system:
a. sympathetic trunk - originate from the cranial cavity
   - exit out of the skull through the jugular foramina (located lateral to the occipital condyles)
b. sympathetic ganglia - node-like structures along the sympathetic trunk
c. rami communicantes (singular: ramus communicans) or visceral rami

* The parasympathetic nervous system doesn't form an orderly chain of ganglia

II. Sense organs
A. The Eyes
Parts:
1. sclerotic coat - function: maintains the shape of the eyeball
2. cornea
3. conjunctiva
4. optic nerve - 2nd spinal nerve
5. retractor bulbi - muscles attached to the sclerotic coat
   - function: pulls the eyeball into the orbit

B. The Ears
* ears - sense organs of hearing and equilibrium
Parts:
1. inner ear
2. middle ear
2.1 tympanic membrane
2.2 columella
2.3 Eustachian tube - function: permits pressure equalization on both sides of the tympanic membrane

Note: The frog has no outer ear

III. The central nervous system
Parts of the central nervous system:
1. dura mater - outer membrane of brain and spinal cord
2. pia mater - inner membrane of brain and spinal cord
3. subdural space - space between dura mater and pia mater
   - filled with cerebrospinal fluid
function of the cerebrospinal fluid:
  → cushions the brain and spinal cord against mechanical injury
  → selectively exchanges metabolites with the tissues it bathes
4. telencephalon or cerebral hemispheres
  - function: where complex centers of consciousness and sensations are located
5. olfactory bulbs - where the olfactory nerves (1st cranial nerves) arise
6. diencephalon or thalamencephalon or twixtbrain
  - function: relay center for sensory impulses, centers for regulating body temperature, water balance and carbohydrate and fat metabolism
7. anterior choroid plexus and posterior choroid plexus
  - function: deposition of cerebrospinal fluid into the brain vesicles
8. pineal body or epiphysis - endocrine function
9. mesencephalon or optic lobes - function: where visual and auditory reflex are located
10. metencephalon or cerebellum - function: part of the brain the is responsible for muscular coordination and proprioception
11. myelencephalon or medulla oblongata - function: reflex centers that control respiration, heart rate, dilation and constriction of blood vessels and swallowing
12. fourth ventricle - triangular cavity of the medulla
13. filum terminale - occupies the cavity of the urostyle
  → filum terminale and roots of the spinal nerves form cauda equina
14. dorsal median fissure/sulcus
15. ventral median fissure
16. brachial enlargement - where paired spinal nerves innervating the forelimbs originate
17. lumbar enlargement - where paired spinal nerves innervating the hindlimbs originate
18. optic chiasma - point where the optic nerves meet
19. optic nerves - 2nd cranial nerves
20. infundibulum
21. hypophysis or pituitary body - lies in a depression, sella turcica
  - has endocrine functions regulated by neurosecretions produced in the diencephalon
  * neurosecretions - hormones produced by the nervous system that are synthesized by neurosecretory neurons
  - small peptides, that are combinations of a few amino acid molecules
  - secretions stored in the hypophysis: ACTH, MSH, oxytocin, vasopressin, vasotocin, mesotocin, gonadotropins

Ventricles:
- 1st and 2nd lateral ventricles - cavity of cerebral hemispheres
  - communicates with the cavity of the olfactory bulbs (rhinocoeles)
- 3rd ventricle - cavity of the diencephalon
  - communicates with the lateral ventricle through foramen of Monro
- optic ventricles or opticocoeles - cavities of the mesencephalon
  - communicates with the 4th ventricle through the iter or aqueduct of Sylvius
- 4th ventricle - cavity of the medulla
  - continuous posteriorly with the cavity of the spinal cord (central canal or canalis centralis)
  * function of the ventricles - serve as the passageway of cerebrospinal fluid
  - helps to hold the soft brain tissue in place against the wall of the cranium

To all my beloved students,

This is your last exam for the laboratory as we end a semester full of learning and experiences. I hope to see you shine not only in this exam but in all your future endeavors. Thank you for all the fond memories. You will not be forgotten for you have left me memorable thoughts that will last me for a long, long time. Good luck, God bless and farewell!