THE RESPIRATORY SYSTEM

1. Identify and give functions for each of the following:
   - larynx
   - bronchioles
   - alveoli
   - trachea
   - epiglottis
   - diaphragm and ribs
   - bronchi
   - pleural membranes
   - thoracic cavity

2. Explain the roles of cilia and mucus in the respiratory tract.

3. Explain the relationship between the structure and function of alveoli.

4. Compare and contrast the mechanics of the processes of inhalation and exhalation.

5. Describe the interaction of the lungs, pleural membranes, ribs, and the diaphragm in the breathing process.

6. Explain the roles of carbon dioxide and hydrogen ions in stimulating the breathing/respiratory center in the medulla oblongata.

7. Describe the exchange of carbon dioxide and oxygen during internal and external respiration.

8. List the conditions that cause the equations to proceed in one way at the lungs and the opposite way at the tissues.

9. Distinguish between the transport of CO₂ and O₂ in the blood by explaining the roles of oxyhemoglobin, carbaminohemoglobin, reduced hemoglobin, and bicarbonate ions.

10. Describe the process of acclimatization.

11. Describe the role of the nervous system in regulating the breathing rate.
The Respiratory System
The Respiratory System (Reference notes) Pages 282 - 285

1. Respiration – includes all of the following:
   a) Breathing – the inhalation and exhalation of air into and out of the lungs.
   b) External Respiration – exchange of gases between the alveolus and the blood.
   c) Internal Respiration – exchange of gases between tissues and blood.
   d) Cellular Respiration – production of ATP using oxygen in the mitochondrion.

2. Passage of Air

   As air moves along passages, it is warmed by blood vessels, filtered by nose hairs and cilia, and moistened by the wet surfaces of the passages. Air is 99.5% saturated by the time it reaches the end of the trachea. As air moves out, it cools and loses its moisture depositing it on the lining of the passage. This causes the dripping nose on cold days and the cloud of water droplets when you breathe out.

3. Parts of the Respiratory Tract

   a) Nose – has two nasal cavities containing specialized ciliated cells that act as odor receptors. Nerves lead from these to the brain where impulses are perceived as smell. Mucus traps dirt. Tears produced by the tear glands drain into the nose, which causes the nose to run when crying.

   b) Pharynx – here the food and air cross, with the trachea lying in front of the esophagus.

   c) Larynx – known as the voice box, a triangle-shaped structure whose apex (Adam’s apple) is at the front of the neck. The glottis is the opening at the top of the trachea covered by the epiglottis (a flap of tissue). The vocal cords are elastic ligaments that lie at the top of the glottis. Vibration of these causes sound. The length of the vocal cords influences the pitch of the sound.

   d) Trachea – has ‘C’ shaped cartilaginous rings to keep it open. Lined with cilia to sweep debris up and out.

   e) Bronchi – trachea divides into two bronchi, which divide into smaller branches called bronchioles. Each bronchiole terminates in a multitude of air sacs called alveoli.

   f) Lungs – alveolar sacs are surrounded by blood capillaries to allow for gas exchange. Alveoli contain about 100x the surface area compared to skin. There are two pleural membranes, one covering the lungs and the other lining the pleural cavity. The space between these membranes is the intrapleural space. The pressure in this space is less than one atmosphere—an important factor in breathing. If a puncture occurs allowing air into this space, the lung(s) will collapse. Thus it is often said that we breathe by negative pressure.
Functions of the Pleural Membranes

a) seals the pleural cavity.
b) maintains negative pressure around the lungs preventing them from collapsing.
c) reduces friction.

Negative Pressure Breathing – Mechanics of Breathing

1. Impulses from the breathing center cause the diaphragm to contract and move down. Intercostal muscles lift the rib cage up and out.

2. The outer pleural membrane moves out with the rib cage and because there is less than one atmosphere of pressure in the intrapleural space, the inner membranes move out as well. (in other words, we breath by negative pressure.)

3. The lungs expand decreasing the pressure in them and air rushes in. This is called inspiration or inhalation.

4. Stretch receptors in the alveoli wall send an inhibitory impulse to the respiratory center in the medulla. Without further stimulation, the intercostal muscles relax and the rib cage moved down and in. The diaphragm also relaxes and moves up.

5. With the increase in pressure in the lungs, air is pushed out. This is called expiration or exhalation.
You are going to measure your lung capacity known as the “vital capacity.” We will compare your results to others in the classroom. Observe the other types of lung capacity/volumes measurable during respiration.

**Procedure:**

Each person will have two attempts at measuring their vital capacity.

1. Set the pointer to 0 and place a new mouthpiece on the tube.
2. Inhale normally and then place your mouth over the tube and exhale. Have your partner record the value of the pointer in mL. This is your **tidal volume**.
3. Reset to 0, take as deep a breath as possible and exhale as much as possible. Record your results in mL. Reset and repeat. This is your **vital capacity**.
4. Record the number of breaths you take in one minute.

**Calculation:**

Your vital capacity can change from day-to-day and especially during different activities throughout the day.

**Vital Capacity**

\[
\text{Mass (kg)}
\]

Most athletes have a value greater than 80 mL/kg. The average person is about 50-60 mL/kg.
Questions:

1. Of what value are the first cries after birth? What information does this tell the doctor? (2)

2. What is the purpose of the residual volume in your lungs? (1)

3. A snorkel has a short tube causing you to swim very close to the surface. Why can they not make snorkels that are 5 metres long? (1)

4. Name three factors that tend to reduce lung efficiency. (3)
Thinking about the Mechanics of Breathing

1. Is air entering or leaving the lungs between Y and Z?

2. Which is higher in the blood at Z, HbO₂ or HbCO₂?

3. Would the intercostals begin contracting or relaxing at time X?

4. Do the lungs expand before or after time X?

5. Where is the PCO₂ the greatest, at time X, Y, or Z in the lung?

6. What causes (part of the body) the pressure change from Y to Z?

7. Where are the alveolar stretch receptors the most active?
Use the graph above to answer the following questions.

a) Describe two differences in this person’s blood that caused the change at “A”.

b) Give the feedback loop that caused this change.

c) List three differences between blood in the pulmonary artery and the carotid artery?
Respiration

The lungs continue to open on inhalation until ________________ in the alveolar walls send an impulse to the respiratory center in the ____________ inhibiting its action. Then the ________________ relaxes and moves up as the intercostal muscles to relax dropping the ________________ which ________________ the volume of the chest cavity, ________________ the pressure there. The lung volume then ________________, which ________________ the pressure there and air rushes out. In external respiration, ________ diffuses from the ________________ into the ________________ and is carried to the body cells. In these reactions, ________________ ions in the plasma diffuse into RBC’s joining with ____________ to produce ________________.

Then the enzyme ________________ causes it to dissociate into ________________.

_________ and _________ have the greatest effect on your breathing rate.

When oxygen levels are low in the blood, ________________ in the aorta and carotid arteries detect and tell the ________________ to turn up the ________________ nervous system, which ________________ the breathing rate. If the oxygen level remains low for long periods of time, the ________________ detects it and releases _________ which tells the bone marrow to increase RBC production.

The equations proceed in one direction at the lungs and the opposite at the tissue cells because:

_________________________________________
_________________________________________
_________________________________________
_________________________________________
**Respiration Matching**

<table>
<thead>
<tr>
<th></th>
<th>Vital Capacity</th>
<th>a) increase volume, decrease pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nasal cavity</td>
<td>b) formed with excess Hydrogen ions</td>
</tr>
<tr>
<td></td>
<td>Diaphragm</td>
<td>c) low PO$_2$ and high PCO$_2$</td>
</tr>
<tr>
<td></td>
<td>Alveoli</td>
<td>d) exchange of gases between alveoli and blood</td>
</tr>
<tr>
<td></td>
<td>Hemoglobin</td>
<td>e) inhibit muscular contractions</td>
</tr>
<tr>
<td></td>
<td>Respiratory center</td>
<td>f) needed to produce carbonic acid</td>
</tr>
<tr>
<td></td>
<td>Residual volume</td>
<td>g) constructed using iron</td>
</tr>
<tr>
<td></td>
<td>Inspiration</td>
<td>h) formed when high PO$_2$</td>
</tr>
<tr>
<td></td>
<td>Expiration</td>
<td>i) no longer useful for gas exchange</td>
</tr>
<tr>
<td></td>
<td>Epiglottis</td>
<td>j) site of gas exchange in lungs</td>
</tr>
<tr>
<td></td>
<td>Internal Respiration</td>
<td>k) decrease volume, increase pressure</td>
</tr>
<tr>
<td></td>
<td>Carbonic anhydrase</td>
<td>l) maximum air moved in a single breath</td>
</tr>
<tr>
<td></td>
<td>Tidal Volume</td>
<td>m) air is filtered, warmed and moistened</td>
</tr>
<tr>
<td></td>
<td>Larynx</td>
<td>n) prevent food from entering the trachea</td>
</tr>
<tr>
<td></td>
<td>HbO$_2$</td>
<td>o) dome shaped</td>
</tr>
<tr>
<td></td>
<td>External Respiration</td>
<td>p) air moved in and out with each breath</td>
</tr>
<tr>
<td></td>
<td>Stretch receptors</td>
<td>q) triggers an increase in the breathing rate</td>
</tr>
<tr>
<td></td>
<td>HCO$_3^-$</td>
<td>r) sound production</td>
</tr>
<tr>
<td></td>
<td>H$^+$</td>
<td>s) not effected by a decrease in O$_2$</td>
</tr>
<tr>
<td></td>
<td>HHb</td>
<td>t) 70% of CO$_2$ is carried in this way</td>
</tr>
</tbody>
</table>
THE EXCRETORY SYSTEM

1. Identify and give functions for each of the following:
   - kidney
   - ureter
   - urinary bladder
   - renal cortex
   - renal pelvis
   - urethra
   - renal medulla

2. List the organs involved with excretion.

3. List the functions of the kidney.

4. Identify and give functions for each of the following:
   - nephron
   - Bowman’s capsule
   - afferent/efferent arterioles
   - proximal convoluted tubule
   - glomerulus
   - collecting duct
   - loop of Henle
   - distal convoluted tubule

5. Contrast blood in the renal artery and the renal vein with respect to urea and glucose content.

6. Identify the source glands for ADH and Aldosterone and explain how these hormones are regulated in a feedback loop.

7. Relate ADH, Aldosterone, and the nephron to the regulation of water and sodium levels in the blood.

8. Explain the process of CAPD and outline its shortcomings as a replacement for the kidney.

9. Explain how the kidney regulates blood pH.
Excretion  

- ridding the body of the end products of metabolism

Excretory Substance:

1. Ammonia – arises from deamination (the removal of the amino group from amino acids), it is very toxic and is converted to urea by the liver
2. Uric acid – comes from the breakdown of nucleotides, is an insoluble solid, causes gout if it builds up in the joints
3. Creatinine – from muscle metabolism
4. Bile pigments – from the hemo portion of hemoglobin, forms bile, if it gets into the blood it causes a yellowing of the skin = jaundice
5. Carbon dioxide – from Kreb’s cycle, most excreted by the lungs by kidney excretes bicarbonate ion
6. Ions – these give blood its proper pH, osmotic balance, and electrolyte balance
7. Water – is an end product of metabolism (end of ETC, from dehydration synthesis) determines the OP of the blood, too much can cause high blood pressure (hypertension)

Organs of Excretion:
Below is a simple diagram of the excretion anatomy parts in a human. Study the diagram below and read chapter 16 on Excretion.

Fill in the following functions:

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urethra</td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td></td>
</tr>
<tr>
<td>Ureter</td>
<td></td>
</tr>
<tr>
<td>Kidney (made up of 1 million microscopic nephrons)</td>
<td></td>
</tr>
</tbody>
</table>

Under normal conditions approximately 1600 L of blood flows through a pair of kidneys each day. Processing this enormous amount of blood yields about 180 L of initial filtrate. Of this, about 99% of the water and nearly all of the sugars, amino acids, vitamins, and other organic molecules are reabsorbed leaving about 1.5 L of urine to be transported daily to the bladder.
Each kidney has an outer renal cortex and an inner renal medulla. Both regions are supplied with blood by the renal artery and drained by a renal vein. Within the cortex and medulla lie tightly packed excretory tubules and associated blood vessels. The inner renal pelvis collects urine from the excretory tubules and passes it to the urinary bladder.

Each nephron consists of a single long tubule and a ball of capillaries called the glomerulus. The blind end of the tubule forms a cup-shaped swelling, called Bowman’s capsule, which surrounds the glomerulus. Fluid leaving the blood and entering the tubule network is called filtrate. As the filtrate passes through several regions of the nephron it’s concentration changes and it eventually becomes urine.
Nephron Anatomy

Study the diagram of the anatomy of the nephron below:

Three major regions of the nephron include the **proximal tubule**, the **loop of Henle** (descending/ascending) and the **distal tubule**. A **collecting duct** receives urine from many nephrons and transports it to the renal pelvis.

Each nephron is supplied with blood by an **afferent arteriole**, an offshoot of the renal artery that branches and forms the capillaries of the **glomerulus**. The caps converge as they leave the glomerulus to form the **efferent arteriole**. Branches of this vessel form the **peritubular capillaries**, which surround the proximal and distal tubules. Other branches extend downward and form the **vasa recta** surrounding the loop of Henle.

The Steps in Urine Formation

1. **Pressure Filtration**

   Blood enters the glomerulus under high pressure. The efferent arteriole can constrict causing the blood pressure in the glomerulus to increase even higher. About 80% of all the small molecules from the blood are filtered out of the blood to enter the first part of the nephron called Bowman’s capsule. The fluid is called filtrate. The filtrate contains water and small solutes, such as salts, sugars, amino acids, and nitrogenous wastes (urea). It will eventually be called urine once the concentration of substances change along the nephron.
2. **Selective Reabsorption**

The filtrate now enters the proximal convoluted tubule (PCT). This is the site of selective reabsorption. The cells that line the PCT are cuboidal epithelial cells. The shape of these cells is conducive to forming a tube and they are lined by microvilli and many mitochondria. Selective reabsorption recovers useful molecules and water from the filtrate and returns them to the body fluids and eventually the blood. Valuable solutes—including glucose, certain salts, vitamins, hormones, and amino acids—are reabsorbed by active and passive transport. Non-essential solutes and waste are left in the filtrate.

3. **Tubular Secretion**

The blood has another chance to pump wastes into the filtrate at the distal convoluted tubule (DCT). The filtrate is isotonic to blood plasma as it approaches the DCT. Critical wastes in the blood such as creatinine, uric acid, penicillin, and H\(^+\) ions are pumped into the nephron.

### From Blood Filtrate to Urine: A Closer Look
1. **Proximal Tubule**
Reabsorption in the proximal tubule is critical for the recapture of ions, water, and valuable nutrients from the huge volume of initial filtrate. Na⁺ in the filtrate diffuses into the cuboidal epithelial cells lining the tube and is actively pumped into the blood. Cl⁻ passively follow. The resulting NaCl draws water from the filtrate by osmosis and returns it to the blood. Glucose, amino acids, potassium ions, and other essential substances are also actively or passively transported from the filtrate to the blood.

2. **Descending limb of the Loop of Henle**
Reabsorption of water continues as the filtrate moves into the descending limb of the loop of Henle. Here numerous water channels (aquaporins) make the limb permeable to water as it leaves by osmosis and gets picked up by the blood. There are almost no other channels for salt or other small solutes so they stay inside the filtrate in the descending loop. For water to continue to move out of limb by osmosis, the interstitial fluid of the kidney's tissues surrounding the limb increases in solute concentration as water moves further down the descending limb.

3. **Ascending limb of the Loop of Henle**
The filtrate returns to the cortex within the ascending limb. Unlike the descending limb, the ascending limb lacks water channels causing any water in the tube to remain inside. The ascending limb has two specialized regions: a thin segment followed by a thick segment near the distal tubule. As filtrate ascends in the thin segment, NaCl, which becomes concentrated in the descending limb, diffuses out of the permeable tubule into the kidney tissues. This movement helps make the tissues hypertonic the deeper into the medulla the loop goes. In the thick segment of the ascending limb, the movement of NaCl continues into the kidney tissues but active transport pumps NaCl out. As a result of losing salt and but not water, the filtrate becomes progressively more dilute as it moves up to the cortex near the distal tubule.

4. **Distal Tubule**
The distal tubule plays a key role in regulating the acid content of the blood. If the blood is too acidic, H⁺ are pumped into the blood and HCO₃⁻ are reabsorbed to make the blood less acidic. If the blood is too alkaline, then H⁺ remain in the blood. Salt and potassium ions are adjusted to their final concentrations in the blood and filtrate. Creatinine, uric acid, and penicillin are pumped into the filtrate.

5. **Collecting Duct**
When the filtrate enters the collecting duct, it is now called urine. The collecting duct is impermeable to water. Water stays inside the tubes unless certain hormones adjust the permeability of the collecting duct. When the kidneys are conserving water, the hypertonic tissues of the kidney pull water out of the nephron and back into the peritubular capillaries. Near the inner medulla, the collecting duct has a high concentration of urea. Up to 44% of all urea can be reabsorbed back into the blood. The collecting duct using hormones acts to maintain homeostasis for osmolarity, blood pressure, and blood volume.
Label the Nephron structures and functions
**Work of the Kidney**

Water, nitrogenous wastes, nutrients and ions (salts) all leave the ____ by the process of ___________________________ and enter the first part of the tubule called ___________________________. These molecules then flow into the next part of the tubule called the ___________________________. From there most of the “good materials” undergo the process of ___________________________ and re-enter the blood capillaries. In fact, ____ % of ___________ and amino acids are taken out of the filtrate by the processes of ___________________________. Large plasma proteins and formed elements ________________ leave the glomerulus. The above two parts of the nephron are found in the ___________________________ of the kidney. The remaining materials then flow down the ___________________________.

As water and dissolved materials flow up the ___________________________, it remains impermeable to ___________________________ keeping it inside the tube as _______ is actively pumped out. This builds up a concentration of _______ in the renal medulla to a level 4X the concentration found anywhere else in the body. As a result, an ________ filtrate to blood plasma enter the next part called the ___________________________. Here, another process called ___________________________ occurs to allow the blood to get rid of unwanted H+ as well as penicillin, uric acid and creatinine.

**Two possibilities:**

**You have no water to drink:** The distal convoluted tubule and the ___________ are normally impermeable to _______. However, if the ___________________________ in the hypothalamus measures ________________ in the OP of the blood, the hormone ___________ is released from the ___________________________ which makes the walls of the distal convoluted tubule and the collecting duct _______ permeable to water causing the water to be ________________ and a ________________ urine will result.

**You do not need water:** the distal tubule and collecting duct remain ___________________________ to water since no _______ hormone is present and a ___________________________ urine results. After exercising, the renal vein has a(n) ___________________________ pH level compared to the renal artery.
**pH Control of Blood by the DCT of the Nephron**

Two possible scenarios:

a) Blood is too acidic:  
H\(^+\) and NH\(_3\)\(^+\) are excreted and HCO\(_3\)\(^-\) are reabsorbed.  
This creates an acidic urine.

b) Blood is too alkaline:  
Fewer H\(^+\) are excreted and less HCO\(_3\)\(^-\) is reabsorbed.  
This creates an alkaline urine.

**CAPD**

When kidney failure occurs in an individual, dialysis may be needed to keep them alive. CAPD stands for **continuous ambulatory peritoneal dialysis**. Dialysate fluid is dumped into the peritoneal cavity and left for several hours. Wastes diffuse through the walls of the mesenteric and peritoneal capillaries into this fluid. The waste filled fluid is now drained into a bag and replaced with new fluid. The dialysate is isotonic to blood plasma, except for the waste products.

Most patients are connected permanently to a surgically implanted catheter. A patient can usually dialyze while sleeping making every-day life more manageable.
Make a feedback loop below for renin-angiotensin-aldosterone to solve the problem of low BP. Show your teacher when done.

Make a feedback loop below for ADH to solve the problem of dehydration. Show your teacher when done.

Alcohol blocks the release of ADH = more urine production.

*Diabetes Insipidus*
The body does not make enough ADH and the collecting duct remains relatively impermeable to water (water stays inside tubes) producing a hypotonic (watery) urine.
**Blood, Filtrate, and Urine**

Should the components of blood listed vertically, be associated with the structures, processes, or substances listed horizontally? Place a √ in the box opposite the component of blood if it should be associated with the structure, process, or substance. Include the % value for anything reabsorbed.

<table>
<thead>
<tr>
<th>Component of blood</th>
<th>Afferent arteriole</th>
<th>Filtrate</th>
<th>Efferent arteriole</th>
<th>Reabsorb %</th>
<th>Tubular excretion</th>
<th>Urine</th>
<th>Absent in urine</th>
<th>Venous blood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma proteins</td>
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<td>Erythrocytes</td>
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<td>Leucocytes</td>
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<td>Glucose</td>
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<tr>
<td>Amino Acids</td>
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<td>Sodium chloride</td>
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<tr>
<td>Water</td>
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<tr>
<td>Urea</td>
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<tr>
<td>Uric acid</td>
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<td></td>
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<tr>
<td>Penicillin</td>
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</tr>
</tbody>
</table>

The three basic processes involved in the overall function of excretion are:

_________________________________________________________________

How does the nephron solve the problem of reabsorbing H₂O by osmosis as less and less H₂O is found in the loop of Henle?

_________________________________________________________________

Name two locations of active transport pumping out of the tubule network.

_________________________________________________________________

_________________________________________________________________
Excretion

The three basic processes involved with the production of urine by the nephron are:

The order of the blood vessels around the nephron are ____________________________

______________________________

______________________________

About _____% of the small molecules, such as ____________________________,

______________________________ leave the blood capillary and enter the first part of the nephron, called the ____________________________

______________________________. This filtrate is ____________________________ to the blood. As the filtrate passes through the next part, the ____________________________,

_____% of the good molecules are reabsorbed back into the blood. A cell in this part would look like:

(draw a picture)

As the filtrate moves down the ____________________________, __________ leaves due to the higher salt concentration outside of it. The filtrate is now ____________________________ to the blood. As the filtrate flows up the ____________________________, ______ is actively transported out. Since this part is ____________________________to water, the filtrate entering the next part, the ____________________________, is now ____________________________ to the blood.

Due to the active transport of ________, the ____________________________ of the kidney becomes 4X salt concentration.
At the ______________________, H+ ions, bicarbonate ions, etc. can be dumped during tubular secretion. The last part, the ________________

Is normally relatively __________________ to water. If the blood’s OP __________________________ receptors in the __________________________ detect and cause the release of the hormone ____________

from the __________________________ gland. This hormone acts on the __________________________

____________________________ and makes it more permeable to water. Water leaves and enters the __________________________ leaving a __________________________

urine behind.

Name the parts of the nephron where active transport is carried out:

__________________________________

Name the parts of the nephron where osmosis occurs:

__________________________________

Name the parts of the nephron found within the renal medulla:

__________________________________

Explain how the kidney acts to solve the problem of the blood being too acid.

__________________________________

List the four functions of the kidney. State the function of any hormones, involved.

__________________________________

__________________________________

__________________________________

__________________________________

__________________________________

__________________________________
List **six** differences between blood in the renal artery and renal vein.

Name two substances that are not filtered by the nephron.

What is a diuretic and why are diuretic drugs prescribed?

Give **two** reasons why the OP increases as you do deep into the renal medulla.

What is ANH and state its function?
Excretory System Matching

Try this exercise with your book closed after reading Ch. 16.

1. Blood vessels entering glomerulus
2. Nitrogenous waste material
3. Stimulates release of aldosterone
4. Always impermeable to water
5. Loop mostly found in this area
6. Takes urine to urinary bladder
7. Reabsorbed when blood pH is 6 or less
8. Allows for pressure filtration
9. In hypothalamus
10. Site of active transport of glucose
11. Site of tubular secretion
12. Carries urine from the urinary bladder
13. Causes reabsorption of sodium
14. A type of dialysis
15. Released when you are thirsty
16. Permeable to most molecules
THE REPRODUCTIVE SYSTEM

1. Identify and give functions for the following:
   - seminiferous tubules
   - scrotum
   - penis
   - interstitial cells of testis
   - vas deferens
   - epididymis
   - Cowper’s gland (bulbourethral)
   - prostate gland
   - seminal vesicle

2. Describe the path of sperm from the seminiferous tubules to the urethral opening.

3. List and state the functions of the components of seminal fluid.

4. Identify the tail, midpiece, head and acrosome of a mature sperm and state their function.

5. Describe the secondary sex characteristics in males. Explain how secretion of testosterone is controlled.

6. Diagram negative feedback loops involving testosterone, inhibin, GnRH, FSH and LH.

7. Identify and give functions for each of the following:
   - urethra
   - oviduct (fallopian tube)
   - ovary
   - follicle
   - corpus luteum
   - clitoris
   - uterus
   - cervix
   - vagina
   - endometrium

8. Describe the functions of estrogen and progesterone.

9. Describe the sequence of events in the ovarian and uterine cycles.

10. Describe the control of these cycles by the following hormones: GnRH, FSH, LH, estrogen and progesterone.

11. Describe the hormonal changes that occur as a result of implantation. (HCG)

12. Discuss various methods of birth control in both males and females.

13. Describe positive feedback loops for oxytocin and estrogen.
The Male Reproductive System

The testis lie outside the body cavity since sperm cannot live at 37 °C. The interstitial cells which lie between the seminiferous tubules (which make sperm) make androgens, of which testosterone is one. Once the sperm are made they are stored in the epididymis until they mature. Upon ejaculation, the seminal vesicles, prostate gland and Cowper's gland secrete seminal fluid. Sperm + seminal fluid = semen. The purpose of the alkaline solution is to counteract the acidity of the vagina and male urethra. Sugar is present to provide nutrients for the sperm. Prostaglandins are also present.

The hypothalamus causes the anterior pituitary to release FSH and LH, two gonadotropic hormones. Copy the diagram from page 417 (10e) of your text. FSH stimulates the production of sperm while LH promotes the production of testosterone, which causes the development of secondary sex characteristics, such as enlarged vocal cords, a beard, more muscle mass, baldness, sex drive, etc.

The Female Reproductive System

Females are borne with over 400,000 follicles, each containing an egg. Since eggs age as a woman ages, older women (over 40) have children with more genetic defects than do younger women. Once a month, one follicle matures and releases an egg (if two are released, fraternal twins can result). Look at table on page 420 (10e).

Estrogen and progesterone produced by the ovaries are the female sex hormones. They foster the development of the reproductive organs, maintain the uterine cycle, and bring about the secondary sex characteristics in females. Estrogen is largely responsible for the secondary sex characteristics in females, including body hair, wider pelvic girdle and fat distribution. Both progesterone and estrogen are required for breast development. Progesterone is called the pregnancy hormone.

Menopause, the period in a woman’s life during which the ovarian and uterine cycles cease because the ovaries no longer respond to the gonadotropic hormones.
Male Reproductive System
Female Reproductive Anatomy

The female reproductive system is specialized to produce a haploid (1N) gamete, the egg, approximately once a month. It also prepares for possible fertilization of that egg, by producing a lining in which the egg can implant. This also occurs approximately once a month.

The Ovaries and Oviducts

The ovaries are the organs, which produce the female gametes (eggs). They are held in the abdomen by ovarian and suspensory ligaments. There are two ovaries, one on the left of the abdomen and one on the right. The outer layer of the ovary, the cortex, contains thousands of follicles. Each follicle consists of a group of cells surrounding an undeveloped egg or oocyte. When a female is born, she has a complete set of undeveloped eggs. No new eggs will be produced during her lifetime.

Contrast this to the male, who produces millions of new gametes (sperm) every day! There are about two million of these undeveloped female eggs at birth; however, over the course of a female’s reproductive lifespan, only about four hundred will ever mature into eggs.

The cells of the follicle provide nourishment for the developing egg. They are also a source of estrogen, a female hormone. A single follicle and egg usually matures about once every twenty-eight days. The mature follicle is known as a graffian follicle.

When it is mature, the follicle moves to the surface of the ovary, where it blisters out and ruptures, releasing the egg. Release of the egg from the ovary is known as ovulation.

The follicle does not degenerate immediately after ovulation. Instead, the follicle cells begin to grow and form the corpus luteum, which secretes estrogen, and another hormone, progesterone. If pregnancy does not occur, the corpus luteum is reabsorbed and ceases hormone production, after about ten days. In other words, females produce a new ‘gland’ once every month. If fertilization and pregnancy occur, the corpus luteum persists as a source of hormones for up to six months.

After ovulation, the newly released egg passes into the oviduct, or fallopian tube. This structure is basically a thin tube, which leads to the uterus. It is not directly joined to the ovary, and therefore, the egg must be picked up by fingerlike projections found in the opening of the oviduct called fimbria. The fimbria sweep across the surface of the ovary. The beating of the cilia, which line the inside of the oviduct also help to draw in the egg. They also help the egg move along the oviduct towards the uterus. Peristaltic contractions of the smooth muscle walls of the oviduct also help the egg move along. It takes about three days for the egg to travel from the oviduct to uterus. However, the lifespan of the egg is only about six to twenty-four hours. Fertilization, therefore, must occur while the egg is still in the oviduct.
The Uterus

The oviducts enter into the uterus, one from each ovary. You can see from your female reproductive diagrams that the uterus is a pear-shaped organ. The lining of the uterus, the endometrium, consists of two layers. Every month the inner layer grows thicker, and if pregnancy does not occur, this layer is sloughed off during menstruation.

The monthly building-up and subsequent sloughing-off of the inner layer of the endometrium constitutes the menstrual cycle. If pregnancy does occur, the fertilized egg (now called a zygote) will implant itself in the endometrium. The fetus therefore, grows and develops from this fertilized egg, in the uterus.

The uterus is both strong and elastic. Its walls contain many layers of smooth muscle. Powerful contractions of this muscle tissue will help expel the baby during childbirth. Its elastic properties are needed to accommodate the fetus as it grows in size.

The uterus leads into the vagina via an opening in a circular muscle known as the cervix. The cervix is the strongest sphincter muscle in the body. You may recall that a sphincter is a muscle whose contractions close off some opening or tube (such as the pyloric or cardiac sphincter). Why do you think the cervix would need to be so strong? During birth, the cervix dilates to allow the baby to pass into the vagina.

By looking at the female anatomy diagram again, you can see that the uterus leads into the vagina at almost a right angle. It is believed that this almost horizontal positioning of the uterus helps a woman carry a baby in the uterus while maintaining a typical upright human posture. The drawback is that childbirth is more difficult in humans than in animals who walk on ‘all fours’.

The Vagina

The vagina is an elastic, muscular tube leading from the bottom of the uterus to the exterior. It is the pathway for a baby to the outside world during childbirth. It also functions as the receptive organ for the penis during sexual intercourse. It connects the external genitalia with the internal features of the female reproductive system.
Confirm You Understanding

1. What is the name of the ligaments, which hold the ovaries in place?

2. What is the principal function of the ovaries?

3. Define ‘follicle’.

4. What is an oocyte?

5. What is a Graafian follicle?

6. What is ovulation?

7. After ovulation, what happens to the follicle?

8. What is the source of progesterone?

9. Describe what happens to the corpus luteum:
   a) if the egg is fertilized
   b) if the egg is not fertilized

10. What is the purpose of an oviduct?

11. Name two ways in which passage of the egg along the oviduct is aided.
12. True or False. If false, state why.

a) The fetus grows and develops in the uterus.

b) The endometrium is part of the ovary.

c) The cervix is a circular muscle.

d) During menstruation, the uterus is shed.

13. Why does fertilization usually occur in the oviduct?
HORMONAL CONTROL OF FEMALE REPRODUCTION

Hormonal regulation of reproduction in females is more complex than that in males. It involves a cyclic change in the amount of the hormones involved, as well as a cyclic change in the structures involved. Let’s first briefly look at the four hormones:

1. **Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH)**

   You will recall that LH and FSH are two of the trophic hormones released by the anterior pituitary. You may also recall that these two hormones function in the hormonal control of male reproduction. As in the male, their release is stimulated by gonadotropin-releasing hormones from the hypothalamus.

2. **Estrogen**

   Estrogen is an important female hormone. Estrogen is secreted by the follicle as it matures in the ovary, and later, when the follicle develops into the corpus luteum, it is secreted by the corpus luteum. So essentially, it is secreted by cells of follicular origin, whether they are a part of the follicle or the corpus luteum.

   Estrogen is the main hormone that promotes development of female secondary sex characteristics, such as accumulation of body fat under the skin, and the distribution of hair under the arms, on the legs, and in the pubic region. At puberty, secretion of estrogen stimulates growth of the uterus and vagina, and onset of the menstrual cycle. It also causes widening of the pelvic girdle.

3. **Progesterone**

   Progesterone is another important female sex hormone. It is produced only in the corpus luteum. It is necessary, along with estrogen, for the development of the breasts.

**TO SUMMARIZE:**

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH</td>
<td>from the anterior pituitary</td>
</tr>
<tr>
<td>FSH</td>
<td>from the anterior pituitary</td>
</tr>
<tr>
<td>Estrogen</td>
<td>from follicle and corpus luteum (in the ovary)</td>
</tr>
<tr>
<td>Progesterone</td>
<td>from corpus luteum (in the ovary)</td>
</tr>
</tbody>
</table>

For all of the cycles discussed we can assume that we are looking at the cycles of a ‘model’ female, that is, one whose cycles last exactly 28 days. In reality, there is great variation among cycle times, even from the same woman from month to month.
The Ovarian Cycle

This cycle is concerned with the physical changes that occur in an ovary over 28 days:

During days 1 to 13, the follicle is maturing in the ovary. On the 14th day, ovulation occurs. Day 1 to 14 are known as the **follicular phase**.

Days 15 to 28 are the **luteal phase**. It is during this time that the corpus luteum develops from the follicle, secretes hormones, and then degenerates.

The Menstrual Cycle

This cycle is concerned with the physical changes that occur in the endometrium (lining of the uterus) over 28 days. During days 1 to 5, the endometrium is sloughed off, resulting in the flow of menstrual fluid (mense) associated with **menstruation**. Rebuilding and thickening of the endometrium occurs during days 6 to 13. Remember that ovulation occurs on day 14. Days 14 to 28 see a much greater thickening of the endometrium, accompanied by the development of mucus-secreting glands in the uterus.

These two cycles occur at the same time. For example, during days 1 to 5, when the endometrium is degenerating, a new follicle is already starting to mature in the ovary (days 1-5 in the ovarian cycle). It is the ovarian cycle, with its accompanying hormonal changes, which controls the menstrual cycle. Therefore, in the next section, where we consider the cyclic hormonal changes that occur over the 28 days, we shall follow the phases of the ovarian cycle.

Hormonal Regulation

The female reproductive cycle is governed by cyclic changes in the amounts of the four hormones we looked at above. The level of any one hormone is determined by the relative levels of one or more of the other hormones. Look at the chart provided.

A. **Follicular Phase (Days 1 to 14)**

1. FSH and LH, secreted by the anterior pituitary, stimulate growth and development of a follicle in the ovary. Endometrium is sloughing during the first five days (menstruation).

2. The follicle produces estrogen, which stimulates the start of endometrial rebuilding.

3. Around days 8 to 10, there is a surge of estrogen secretion from the follicle. This causes a corresponding surge in LH and FSH production by the anterior pituitary (positive feedback). LH and FSH peak on day 14.

4. The peak of the LH level causes ovulation on day 14.
B. Luteal Phase (Days 15 to 28)

5. The corpus luteum begins to develop from the emptied follicle, under the influence of the still high (but decreasing) LH level.

6. Cells of the corpus luteum secrete estrogen, with the addition of progesterone. Estrogen plus progesterone greatly increase thickness and development of the endometrium. Mucus secreting glands develop.

7. Progesterone plus lower levels of estrogen inhibit LH and FSH secretion by the anterior pituitary (negative feedback – compare with step 3).

8. The corpus luteum begins to degenerate, probably as a result of reduced LH and FSH levels. The corpus luteum only degenerates if pregnancy does not occur.

9. Since the corpus luteum is the source of estrogen and progesterone, its degeneration results in a drop-off of the level of these two hormones.

C. Follicular Phase (Days 1 to 14)

10. Reduced levels of estrogen and progesterone result in the sloughing off of the endometrium. We are back again at menstruation of days 1 to 5.

11. Because the source of inhibition of LH and FSH production has decreased (ie. Estrogen and progesterone levels dropped-off), their levels start to increase once more. This causes a follicle to begin to develop once more.

Pregnancy

If fertilization were to occur, the zygote (fertilized egg) would travel down the oviduct into the uterus, where it would embed itself in the endometrium. This process is called implantation. Cells of the zygote then secrete a hormone known as Human Chorionic Gonadotropin, or HCG. HCG causes the corpus luteum to be maintained, and to continue producing estrogen and progesterone. This is important, because then the endometrium is prevented from sloughing off, and in fact is developed even further under stimulation from estrogen and progesterone. Thus, menstruation does not occur in a pregnant woman.

HCG is very similar in structure to the hormone LH. For this reason it can inhibit LH and FSH production by the anterior pituitary, through negative feedback. This ensures that no more follicles mature while the woman is pregnant (recall from step 1 that LH and FSH stimulate follicle production).

Once the placenta develops, it takes over production of both HCG and progesterone and estrogen. The placenta is the structure across which exchange of nutrients and wastes between the blood of the mother and the fetus takes place. It is formed from both fetal and maternal tissue.
Confirm Your Understanding

1. Name the four major hormones of the female reproductive system and the source of each of these hormones.

2. Which hormone is the most important for promoting the development of the secondary sex characteristics?
   
   Name three characteristics that estrogen produces.

3. What are the two phases of the ovarian cycle and the days they occur on?

4. What occurs between the two phases and what triggers it?

5. When menstruation occurs during days 1-5 what is happening in the ovarian cycle?

6. What effect does estrogen have on the endometrium during the follicular phase?

7. During the luteal phase, why does the corpus luteum usually begin to degenerate?
8. When the corpus luteum degenerates, which two hormone levels decrease?

9. What does HCG mean and where does it come from?

10. What effect does HCG have on female reproduction?

11. How does the placenta develop and what does it do?
Human Reproduction

When there is a low level of _____________ and _____________ hormones, the lining of the endometrium is lost. The first day of bleeding is day (28, 1, 5 – pick a number) ______ of the next cycle. In response to the low level of these hormones, the ________________ releases the hormone ________________ which starts the follicle developing. As the follicle and the ________________ contained in it mature the hormone _________ is released which starts the ________________ developing a rich blood supply. When estrogen levels are high, ________________ and ________________ are released. ________________ is responsible for ovulation as well as changing the ruptured ________________ into the ________________, which acts as an endocrine gland, producing ________________ and ________________ (the pregnancy hormone). These maintain the ________________.

The high levels of these two hormones cause a decrease in the hormone ________________. Without this hormone, the ________________ cannot be maintained and degenerates, stopping the release of its hormones.

Pregnancy

If implantation occurs, the ________________ must be maintained and the ________________ cannot be allowed to degenerate. To stop this the inner membrane, the ________________ releases the hormone _____, which maintains the ________________ so it can continue to produce ________________. After _____ months, the ________________ is developed enough to secrete its own ________________ and ________________.

In males, ________________ causes the production of sperm and inhibin in the ________________ and the hormone ________________ causes the production of ________________ by the ________________.
**Sexual Reproduction Test**

Males have three glands, namely ______________________, ______________________ and the ______________________ which produce _____________.

The purpose of this secretion is to ____________________________ _____________. The male gamete has ____________ chromosomes and was produced by the process of ______________________. The sperm are made in the testes in tube-like structures called the ______________________. The hormone ____________ is responsible for their production as well as the maturation of the egg in the female. Male secondary sex characteristics are caused by the hormone called ______________________ produced by the ______________________. The hormone ____________ maintains the male hormone secretion. Males have a scrotum because _____________________________.

The average girl’s menstrual cycle repeats every _________ days. Ovulation occurs around day _____________. The hormone that is released from the developing follicle is called ______________________, which thickens the lining of the ______________________.

After ovulation, the ______________________ then releases of pregnancy hormone ______________________, as well as estrogen, whose main function is to ____________________________ ____________________________.

The lining is lost if ______________________ does not occur in the uterus.

If a girl becomes pregnant the hormone ____________ is released from the ______________________ layer to maintain the ______________________.

The purpose of the menstrual cycle is to ____________________________ ____________________________ ____________________________.
TEST 5 REVIEW

1. Explain external respiration. (5)

2. Explain the mechanics of breathing. (7)

3. A person suffered a major blood loss. Use –ve feedback loops used by the respiratory and excretory systems only to help keep the person alive. (8)

4. What is the function of the pleural membranes? (3)

5. Compare the composition of glomerular filtrate with that of blood plasma. (5)

6. Explain the role of the following in the excretory system: efferent arteriole, microvilli, counter-current exchange mechanism, ascending loop, bladder. (5)

7. Using a feedback loop, explain why a person produces a larger volume of urine after drinking two liters of water. (4)

8. Explain how the kidney controls blood pressure, O₂ levels in the blood, and blood pH. (6)

9. Alcohol appears to inhibit the secretion of ADH. Predict the results (with an explanation) of alcohol intake on the following:
   a) solute concentration of the blood plasma (2)
   b) urine production (2)

*10. Assume that a bacterial infection results in large perforations in the glomerulus of a patient.
   a) How will the glomerular filtrate in the diseased person compare to the filtrate of a healthy person? (2)
   b) What effect will this have on ADH levels circulating in the bloodstream and why? (2)
   c) A person with this disease will have edema of body tissues. Using your knowledge of kidney function and blood tonicity, explain the mechanism accounting for this swelling. (3)

11. After a severe drop in blood pressure, how will the following respond to maintain homeostasis?
   a) urine production (1)
   b) autonomic nervous system (1)
   c) kidney (1)
12. Label the following structures on a typical kidney. (6)
List THREE ways that blood in the renal vein is different from that in the renal artery. (3)

13. The female reproductive system is carefully regulated by hormones produced by the brain and some of the sex organs. Explain the effect the following would have on the reproductive system.
   a) A failure of the corpus luteum to degenerate 10 days after ovulation. (2)
   b) A lack of FSH production during the first 15 days of the menstrual cycle. (2)

14. List in the correct order, the structures through which human sperm pass as they travel from the testis until they leave the body. What is the purpose of semen? (4)

15. Relate the effect of the following birth control methods to the physiology of human reproduction.
   a) birth control pills (1)
   b) IUD (1)
   c) vasectomy (1)

16. Describe the effects of estrogen production in the female body and how estrogen affects the menstrual cycle. (5)

17. Describe the internal physiological changes that cause the erection of the penis. (2)

18. State the function of the following in sperm: acrosome, midpiece, tail (3)

19. Describe the hormonal changes and the effects they have in a female as a result of implantation of the embryo. (5)

20. State the function of FSH and LH in men and women. (4)
* 21. The following table shows the amounts of substances present in human blood plasma, glomerular filtrate, and urine. All are measured in g/100mL of fluid.

<table>
<thead>
<tr>
<th>Component</th>
<th>Plasma</th>
<th>Filtrate</th>
<th>Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>0.10</td>
<td>0.10</td>
<td>0</td>
</tr>
<tr>
<td>Amino acids</td>
<td>0.05</td>
<td>0.05</td>
<td>0</td>
</tr>
<tr>
<td>Proteins</td>
<td>8</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Inorganic salts</td>
<td>0.72</td>
<td>0.72</td>
<td>1.53</td>
</tr>
<tr>
<td>Urea</td>
<td>0.03</td>
<td>0.03</td>
<td>2.00</td>
</tr>
<tr>
<td>Uric acid</td>
<td>0.004</td>
<td>0.004</td>
<td>0.05</td>
</tr>
</tbody>
</table>

a) Account for the difference in the levels of proteins in the plasma and filtrate. (2)
b) The concentration of inorganic salts and urea in urine is much greater than that present in the filtrate. Explain why this is so. (2)

* 22. Use the following chart to identify each person.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Hb (g/100mL)</th>
<th>O₂ in arteriole Blood/100mL</th>
<th>O₂ in venous Blood/100mL</th>
<th>Cardiac Output (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Normal</td>
<td>15</td>
<td>19</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>B Hypoxia</td>
<td>15</td>
<td>15</td>
<td>12</td>
<td>6.6</td>
</tr>
<tr>
<td>C Hypoxia</td>
<td>8</td>
<td>9.5</td>
<td>6.5</td>
<td>7</td>
</tr>
<tr>
<td>D Hypoxia</td>
<td>16</td>
<td>20</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>E Hypoxia</td>
<td>15</td>
<td>19</td>
<td>18</td>
<td>no info.</td>
</tr>
</tbody>
</table>

Provide two lines of evidence using the chart above to support your answer.

a) Which subject in the above chart is suffering from a dietary iron deficiency? (2)
b) Which subject is suffering from heart failure and poor blood circulation? (2)
c) Which subject has recently climbed a mountain where the air is thin and atmospheric O₂ is low? (2)
d) Which subject is suffering from a poison that prevents her cells from using oxygen? (2)
e) Subject B has increased breathing. Briefly describe the physiological mechanism that is responsible for the increased breathing. (3)