

## Cellular Respiration

### Water and pH

1. Organic compounds contain carbon and hydrogen. Inorganic compounds do not contain BOTH carbon and hydrogen.
2. Covalent bonds involve sharing of electrons. Ionic bonds involve transferring electrons. Covalent bonds are stronger than ionic bonds. (Hydrogen bonds are much weaker than either covalent or ionic bonds.)
3. H<sub>2</sub>O
4. Oxygen is unfair. It doesn't share well. It keeps electrons close for more time than hydrogen does.
5. Atoms of water are bonded covalently. These bonds are strong.
6. Done on diagram.

### Hydrogen Bonding Results in Water's EXTRAORDINARY PROPERTIES

1. Water's slightly charged oxygen and hydrogen are attracted to other charged particles such as sodium ions (Na<sup>+</sup>) and chloride ions (Cl<sup>-</sup>). Negatively charged oxygen is attracted to positively charged sodium and positively charged hydrogen is attracted to negatively charged chloride. This causes the particles of the solute (NaCl) to separate (dissolve).
2. A. In adhesion, water molecules bond with other neutral material. In cohesion, water molecules bond with each other. In both cases, weak hydrogen bonds are formed.  
B. Cohesion.  
C. Water molecules are hydrogen bonded to each other, like boxcars of a train. Water molecules also form hydrogen bonds with the xylem tubes of the plant. When water at the leaves is pulled away from the plant by transpiration, water molecules in the chain are pulled upward.
3. A. It gives them time to adjust to the change.
4. A. Heat from the body is transferred to water molecules. With enough heat energy, hydrogen bonds are broken and individual water molecules move quickly enough to change state. AS they move away they carry with them body heat.  
B. It would take less body heat for the water to vaporize and we would cool off more quickly.
5. A. When water freezes to form ice, it floats. This insulates the water below, which limits its cooling. Organisms that can survive cold water are protected from the water becoming even colder. Also, the insulation prevents the body of water from completely freezing, allowing life to continue living there even in cold condition.
6. The polar heads are attracted to water, but the non-polar heads avoid water. This causes the molecules to "self-assemble" so that the heads are near the watery environments and the tails are oriented toward each other.
7. The number of hydrogen ions (H<sup>+</sup>) equals the number of hydroxide ions (OH<sup>-</sup>).

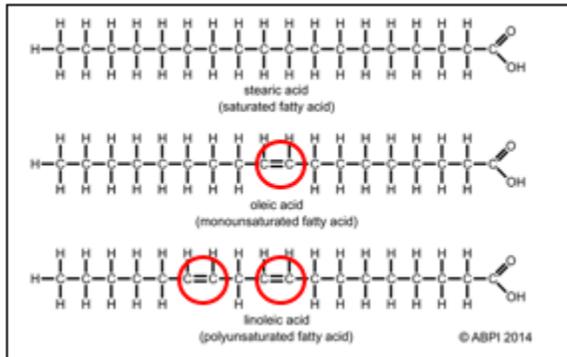
### B3. pH

1. A. The number of hydrogen ions (H<sup>+</sup>) equals the number of hydroxide ions (OH<sup>-</sup>).  
B. Hydrogen ions are in greater abundance than hydroxide ions.  
C. Hydrogen ions are fewer in number than hydroxide ions.
2. Note the pH.
3. A. 10x, B. 1000X, C. 10X, D. 100X, E. 100X.
4. pH would move out of the acceptable range. With the failure of the homeostatic mechanism, we would die.

# Biological Molecules

## Organic Molecules vs Inorganic Compounds

1. Methane is one carbon atom with four hydrogen atoms bonded to it.



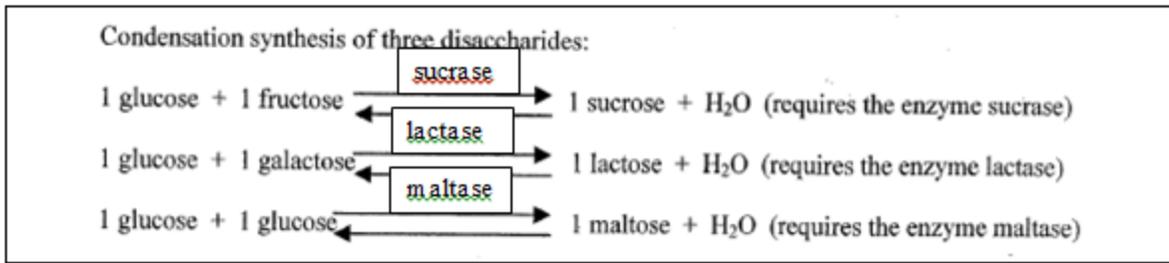
2. There are double bonds between carbon and oxygen but these do not affect the degree of saturation of the fatty acid.
3. The more double bonds, the less hydrogen atoms in the molecule.

## Functional Groups

1. More likely.
2. Look at the table.
3. Methyl
4. It contains hydrophobic functional groups so it doesn't mix with water. Oil is less dense than water so it floats.

## Carbohydrates

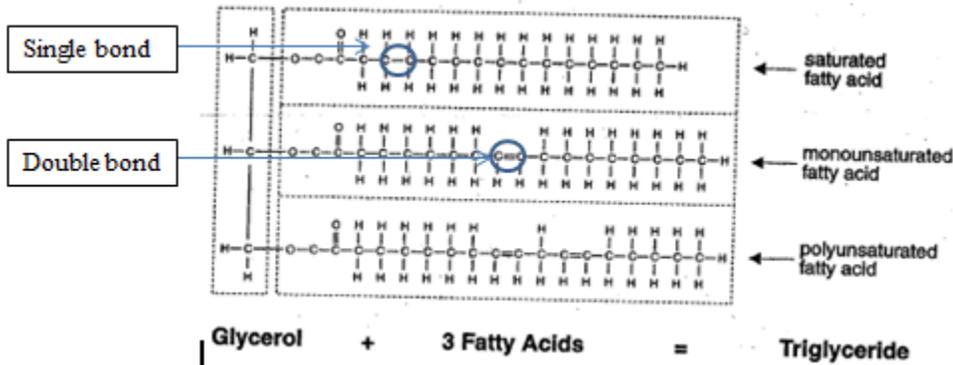
1. Mono = one, saccharide = sugar
2. It means they have six carbons.
3. They all have the same formula:  $C_6H_{12}O_6$ .
4. The location of the hydroxyl group attached to the first carbon is reversed with the hydrogen.
5. It has five sides.
6. Glucose is a building block of starch. Glucose is made by plants and used by all living things for energy. It is found in all living things. Fructose is found in fruit. Galactose is found in milk. Sugars are added to processed foods.
7. In cellular respiration the energy trapped in the bonds of glucose is transferred to ATP, a form of chemical energy that is useable by cells.
8. A hydroxyl group (one oxygen and one hydrogen) is removed from one glucose molecule and a hydrogen atom is removed from the other. The two sugar molecules are bonded and a water molecule is formed.
9. Because one two hydrogen atoms and one oxygen atom (a water molecule) are removed in the formation of the disaccharide.
10. Water. The process is called dehydration synthesis (a.k.a. condensation synthesis).
11. The reaction is reversible.
12. Enzymes. An enzyme specific for that reaction is also necessary.



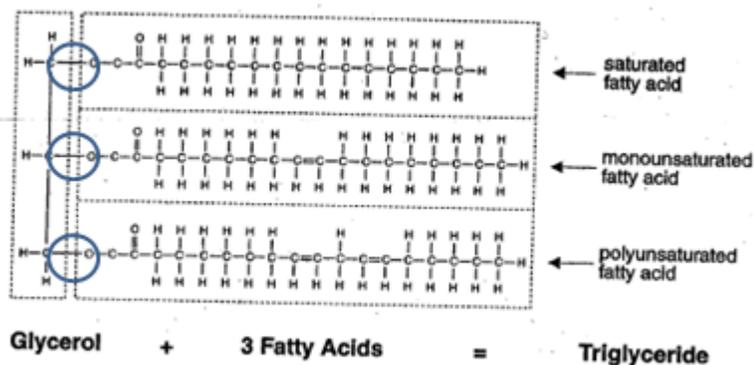
- A polymer is a molecule made of repeating subunits. Polysaccharides are made of repeating subunits of glucose.
- Glycogen.
- Starch is made of alpha glucose and the sugars orient themselves in the same direction when a bond is formed between them. Cellulose is made up of beta glucose and the sugars alternate orientations within the molecule.
- We have the genes (DNA) that code for the enzyme to digest starch (amylase). We do not have the genes that code for the enzyme to digest cellulose.

### Lipids

- Glycerol and fatty acids.
- Methyl (CH<sub>3</sub>)



- Butter. Butter contains more saturated fatty acids. Oil contains more unsaturated fatty acids.
- Because it is made up of glycerol and three fatty acids.

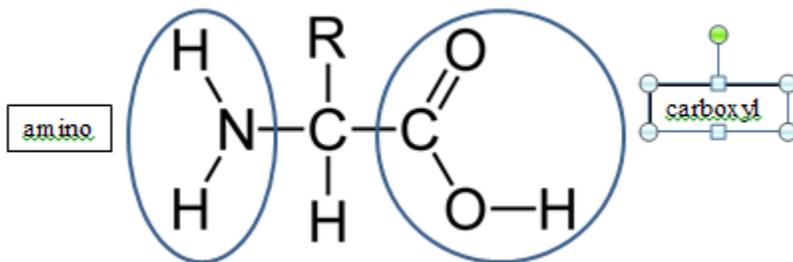


- Three.
- They are not made up of repeating subunits. They are made of two types of molecules: glycerol and fatty acids.
- To store energy and for cushioning and insulation.
- The phosphate group.
- The phosphate group is hydrophilic. The lipid tails are hydrophobic.
- They self-assemble into membranes because the hydrophilic heads associate with water and the hydrophobic tails associate with each other.

12. It compartmentalizes reactions within the cell and specific organelles. In other words, it keeps reactions separate and that allows the cell to control the rate of formation of products.
13. A. cholesterol, B. estrogen, and testosterone, C. cholesterol, D. cholesterol.
14. FIND OUT! "The Healthy Eating Plate encourages consumers to use **healthy oils**, and it does not set a maximum on the percentage of calories people should get each day from healthy sources of fat. In this way, the Healthy Eating Plate recommends the opposite of the low-fat message promoted for decades by the USDA." <http://www.hsph.harvard.edu/nutritionsource/healthy-eating-plate/>
15. They will not be able to emulsify fat effectively because the gall bladder is not there to squirt bile into the small intestine. The fat will not be digested efficiently, will slow the rate of movement of food through the digestive system, and may cause gas, discomfort, and constipation.

## Proteins

1. A. Collagen and keratin is skin, hair and nails. B. Actin and myosin fibers in muscle C. Transport proteins in cell membranes, D. Antibodies. They are also enzymes and some hormones.
2. Electron carriers in the mitochondria transport electrons and move hydrogen across the membrane. Channel proteins allow specific polar molecules to diffuse across the cell membrane. Transport proteins pump ions across a cell membrane against their concentration gradient. Enzymes catalyze reactions.
3. The speed up reactions by lowering the amount of energy required for a reaction to take place (activation energy).

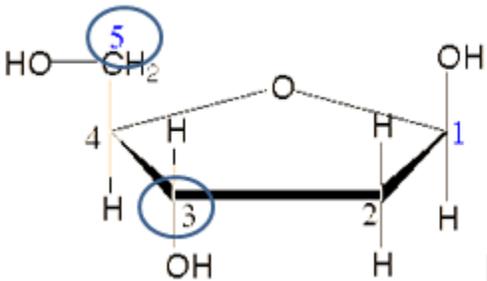


- 4.
5. With an "R". There are twenty variations in humans. That means there are twenty amino acids in humans.
6. You should circle the amino group,  $\text{NH}_2$ , and the carboxyl group,  $\text{COOH}$ .
7. A peptide bond.
8. Four peptide bonds were formed. Four water molecules were formed.
9. It would likely be corrupted. Possibly, an incorrect amino acid could replace the proper one. Another possibility is that the entire sequence, from the point of mutation on, could be incorrect. More on this in the DNA unit.
10. Hydrogen bonding.
11. More hydrogen bonding, ionic bonding, disulfide bonding.
12. Hemoglobin. It provides a place where oxygen or carbon dioxide can bond and shuttles these molecules between the lungs and body cells.

## Nucleic Acids

1. DNA provides the codes for all proteins and proteins control all reactions that keep us alive (enzymes). Proteins also are essential to life since they provide structure, are involved in cell signalling (hormones), transport necessary materials across cell membranes and more.
2. The nitrogen base.
3. DNA has one less oxygen molecule than RNA. DNA contains the nitrogenous base thymine, while RNA contains uracil.

4. DNA is a double helix (two sided molecule). RNA is a single helix (one sided molecule).
5. It has two sides of the molecule. This gives the molecule integrity, making it less likely to be broken.
6. The human genome is the complete set of nucleotide sequences for humans. It is the blueprint to build a person.
7. It allows us to pinpoint genes for specific diseases such as metabolic disorders. It also helps us to recognize mutated DNA. It will make new medical advances possible. See <https://www.genome.gov/27549135>
8. Complementary base pairing occurs when nucleotides that form the rung of the ladder bond with each other by hydrogen bonding. Adenine bonds with thymine. Cytosine bonds with guanine.
9. In DNA replication, the hydrogen bonds between bases are broken so that each side of the molecule is exposed and provides the template for the formation of a new molecule. More on this in the unit on DNA.
10. Yes. If a different amino acid is coded for the protein shape likely change. Each protein's shape is vital to its unique function.
11. The carbon. Each carbon has a number.



- 12.
13. Adenine or guanine should be circled in red and thymine or cytosine should be circled in green.
14. Two hydrogen bonds between adenine and thymine. Three hydrogen bonds between guanine and cytosine.
15. The two sides of the molecule are oriented in opposite directions. As a result, the 5' end of one chain is across from the 3' end of the other chain.
16. It contains ribose, not deoxyribose.
17. Adenine.
18. ATP has three phosphates. Energy that is transferable to other molecules is located in the bonds between the phosphates.
19. ATP is made during cellular respiration.
20. Energy goes with the phosphate that is transferred to another molecule.
21. Glucose, and ultimately the sun.

## Membranes and Transport

### B9 Membrane Structure and Function

1. Clockwise from the top left corner A. glycolipid, B. carbohydrate chain of glycoprotein, C. Protein of glycoprotein, D. cholesterol E. hydrophilic head of phospholipid F. integrated transmembrane protein G. hydrophobic tail of phospholipid.
2. Hydrophilic – near the water and the phosphate heads of the phospholipids. Hydrophobic – away from the water and near the fatty acid chains of the phospholipid tail
3. 3.a. receptor, b. recognition, c. channel, d. carrier, e. enzymatic
4. Some carbohydrate chains on cells are unique to the individual. The immune system recognizes foreign cells by certain chains. Certain / enough chains must be matched to reduce the chances of tissue rejection. Even so, immunosuppressive drugs are necessary.

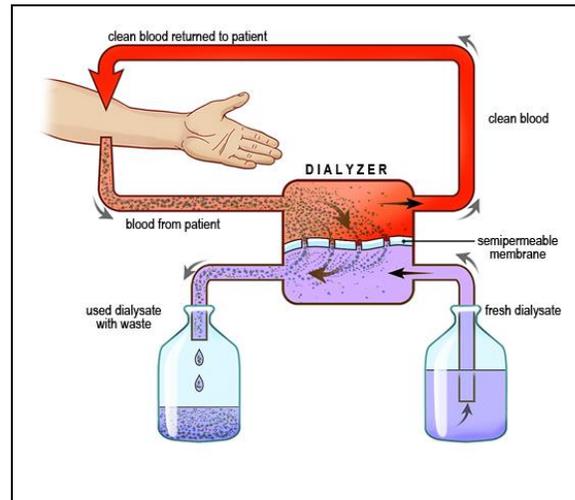
- The blood types are a way of identifying certain carbohydrate chains on the surface of red blood cell proteins. Human blood types and transfusion compatibility are determined by the glycocalyx.
- Meat is animal matter. Animal cells contain cholesterol in their membranes. Cholesterol is metabolized by the liver. Excess cholesterol may not be easily metabolized, especially if there is a metabolic disorder.

### B9 Permeability of the Plasma Membrane

- Oxygen, carbon dioxide, water
- Through channel proteins and transport proteins
- Through aquaporins.

Kidney dialysis question: As the blood passes by the Semipermeable membrane, each molecule that is small enough will diffuse across, down its own concentration gradient. Because there are no nitrogenous wastes in the solution, they will leave the blood.

- Put a tea bag in water. The tea diffuses away from the tea bag, down its concentration gradient.
- Particles can move up a concentration gradient. Some materials pass freely, others require assistance. Diffusion, osmosis, and active transport occur across the membrane.



### B9 – Transport Mechanisms

- No.
- Each of the two colors of food coloring diffuses along its own concentration gradient.
- The warmer particles have more kinetic energy and therefore spread more quickly.
- The one on the right.
- Smaller particles will travel farther before having a collision and being diverted from their path.
- Carbon dioxide and oxygen, small non-polar molecules.
- Diffusion.
- Solute – black dots, solvent – white dots, solution – both combined.

### Osmosis Demonstration 1 and 2

- Hypertonic. The sugar solution is hypertonic because it contains more dissolved solutes per unit volume than the water.
- The dialysis membrane is impermeable to sugar.
- Water moves in by osmosis, which dilutes the sugar solution.
- The level after two hours should be higher.
- It has been diluted by the water that moved in.
- These cells do best in a solution isotonic to the cell cytoplasm.
- They use their contractile vacuoles to pump out water. This is analogous to continuously bailing a boat with a leak.
- The cells do best in a solution that is hypotonic to the cells.
- Turgor pressure occurs when the plant cell cytoplasm is hypertonic to the surrounding environment. In such a case, water flows in and pressure against the cell wall increases. This helps plants stand upright.
- Watering with salt water kills plants because it creates an environment that is hypertonic to the cells. This draws water out of the cells to the point where life sustaining chemical reactions cannot take place in the cells.

11. Blue / black
12. Green
13. Starch will stay inside (it will be black inside). Glucose test strips will give a positive result outside the bag.
14. The semipermeable membrane of the dialysis bag had pores large enough to allow glucose out and iodine to diffuse in, but not large enough to allow starch to diffuse out.

#### Facilitated Diffusion

1. Insulin is the chemical signal that binds to the glucose gates and prompts them to open to allow glucose in.

#### Active Transport

1. Images should be detailed and include ATP.
2. When the potassium is returned, it resets the pump to its original conformation so that more sodium can be pumped out.
3. Channel carrier: down a concentration gradient. Pump carrier: up a concentration gradient.

#### Exocytosis and Endocytosis

Form of Endocytosis	Energy used?	Type of particle	Size of particle
Phagocytosis	Yes	Other cells, large food particles	Very large – millions of molecules.
Pinocytosis	Yes	Liquid or very small particles. Includes dissolved ions.	Small ions, molecules
Receptor- mediated endocytosis	Yes	Vitamin, peptide hormone, lipoprotein	Large molecules

## Enzymes

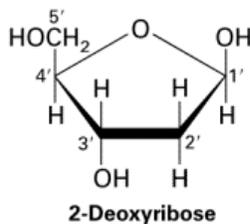
### B11

1.  $lactose \xrightarrow{lactase} glucose + galactose$
2. Examples include glycolysis, Krebs cycle and others.
3. Equilibrium
4. Because the product is always being removed, the reaction is driven in the direction of starch production
5. The hormone insulin is produced which triggers cells to allow glucose to enter cells from the bloodstream where it is available for use in cellular respiration
6. The enzyme lowers the activation energy of the reaction, which is the energy needed for the reaction to occur. It does NOT change the amount of free energy of the substrate or product.
7. By adding heat. This is not acceptable in living systems because it could cause protein denaturation
8. The lock and key theory states that each enzyme is like a lock in which only one substrate fits perfectly into the active site. The induced fit theory is that the enzyme undergoes a slight change in shape when the substrate is in the active site and this shape change creates the product.
9. Due to protein denaturation (losing or changing its 3-dimensional shape due to change in H bonds)
10. pH of 5. Not very fast.
11. There can be no reaction when there are no reactants
12. Saturation occurs when all of the enzymes active sites are occupied. Adding more substrate past this point does not increase the rate of reaction.

13. Once Lucy and Ethel (the 'enzymes') are wrapping chocolates (the 'substrates') as fast as they can, it doesn't matter how many more chocolates you add, the number of wrapped chocolates remains the same because they can't go any faster. The 'active sites' (Lucy and Ethel's hands) are already full of chocolates.
14. Because the reaction is already happening without the enzyme present
15. Substrate
16. With competitive inhibition the inhibitor binds to the active site of an enzyme so that the substrate cannot bind there. Conversely, with non-competitive inhibition the inhibitor binds to the enzyme at a site which is not the active site but this binding causes a conformational change (shape change) in the enzyme so that the substrate no longer fits in the active site.
17. All the tryptophan will be used up, even the one in the active site. There will be no tryptophan to bind to enzyme 1 and inhibition will stop. The tryptophan pathway will begin to catalyze the synthesis of tryptophan.
18. When there is a low concentration of product G'

## Nucleic Acids

1. Phosphate, pentose sugar (deoxyribose or ribose), base (purine)



- 2.
3. On your own
4. TACTAGGTGCGCA
5. The complete set of chromosomes in a species, or an individual organism.
6. The **Human Genome Project** (HGP) was an international scientific research **project** with the goal of determining the sequence of chemical base pairs which make up **human DNA**, and of identifying and mapping all of the genes of the **human genome** from both a physical and functional standpoint.
7. Serious unfavorable mutations are not passed on because they kill the organism before it reaches reproductive ability.
8. In preparation for cell division. Cell division occurs to repair wounds, repair worn out cells, or for growth.
9. Multiple Ori sites mean that the two sides of the DNA molecule will be separated more quickly. This makes it possible to add new nucleotides at multiple locations, which makes overall replication much faster than if the molecule unzipped at one end and proceeded to unzip toward the other end.
10. DNA polymerase adds new nucleotides in a 5' to 3' direction. The new strand grows in a 5' to 3' direction.
11. Along the leading strand, an RNA primer is bonded to the DNA strand at the 3' end. DNA polymerase adds DNA nucleotides to the primer, continuously, in a 5' to 3' direction of the new strand. Afterward, the RNA primer is replaced by "replacement DNA".
12. Along the lagging strand, DNA is added discontinuously because new nucleotides can only be added in a 5' to 3' direction of the new strand, but the replication bubble is opening in the opposite direction. Multiple RNA primers are needed. An RNA primer is laid down and a short fragment of DNA (Okazaki fragment) is added to it by DNA polymerase. When the replication fork opens up further, another primer is laid down and another Okazaki fragment is laid down. Replacement DNA takes the place of RNA primers.

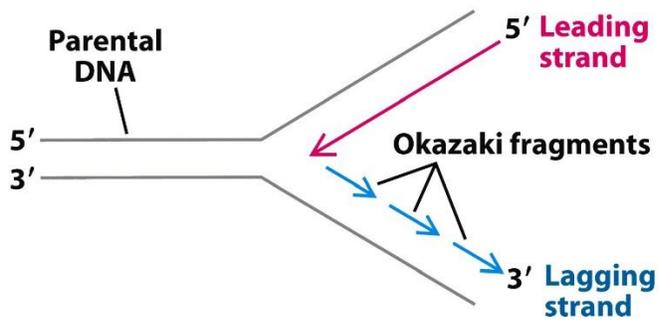
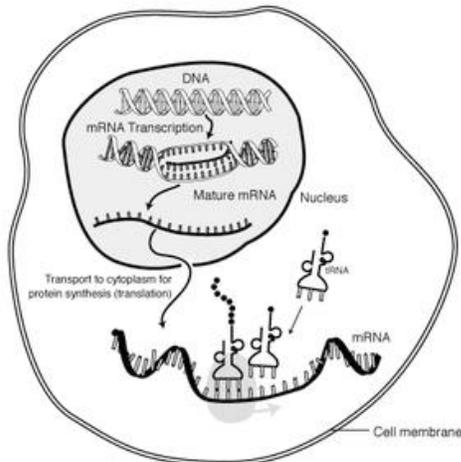


Figure 28.9  
Biochemistry, Seventh Edition  
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- Ligase forms phosphodiester bonds between the new DNA nucleotides and the parent nucleotides. It joins the sugar and the phosphate of nucleotides as they are added.

### Protein Synthesis

- Nucleus=vault, ribosome=chef/workbench, transcription=copying the recipe to paper, translation=reading the recipe by the chef, DNA=recipe book, mRNA=copy of the recipe, tRNA=chef's helpers that bring ingredients, polypeptide chain=undecorated cookie, code=recipe, codon=complementary copy of the recipe, anti-codon= (no analogy), amino acid=ingredient. Missing: page in the recipe book= gene



- 
- 
- It has the same sequence of bases except that the mRNA strand has uracil where the DNA sense strand has thymine.
- No. No, the resulting sequence of amino acids would be different. Prove it to yourself.
- 5' to 3'.
- There is more than one code for each amino acid.
- It signals the ribosome to start reading the mRNA at that point. It is a "start here" signal.
- The termination of translation. It signals the ribosome to stop reading the mRNA. The polypeptide is complete.
- ☺
- Release factor binds to the stop codon, causing a water molecule to be added to the end of the chain and separation from the last tRNA occurs
- ☺
- Journal Quiz Question – you will have to come up with this yourself
- Journal Quiz Question
- The following can affect which protein is produced:
  - The sequence of DNA
  - Differential processing of mRNA

- Changes to mRNA before leaving the nucleus
- Changes to the polypeptide to make it functional

The following can affect the rate at which proteins are produced:

- Whether nuclear pores are open or closed
- Life expectancy of the mRNA
- End product inhibition

15. *E. coli* bacteria

16. Journal quiz question. Word list: regulator, repressor, enzymes, structural genes operator, promotor RNA polymerase, allosteric, transcribe, translate.

17. Do the research.

DN A	T	A	C		G	G	G		C	T	C		T	A	G		C	G	A		G	A	T		A	T	T
mR NA	A	U	G		C	C	C		G	A	G		A	U	C		G	C	U		C	U	A		U	A	A
a.a.	MET				PRO				GLU				ISO				ALA				LEU				stop		

18.

DN A	T	A	C		<u>C</u>	G	G		C	T	C		T	A	G		C	G	<u>G</u>		G	A	T		A	T	T
mR NA	A	U	G		<u>G</u>	C	C		G	A	G		A	U	C		G	C	<u>C</u>		C	U	A		U	A	A
a.a.	MET				ALA				GLU				ISO				ALA				LEU				stop		

19.

20. A mutation may result in the stop codon, in which case an incomplete polypeptide will result (nonsense mutation). A mutation may code for a different amino acid if a single base is different, as in #18 (missense mutation). A mutation may result in a sequence that codes for the same amino acid (silent mutation).

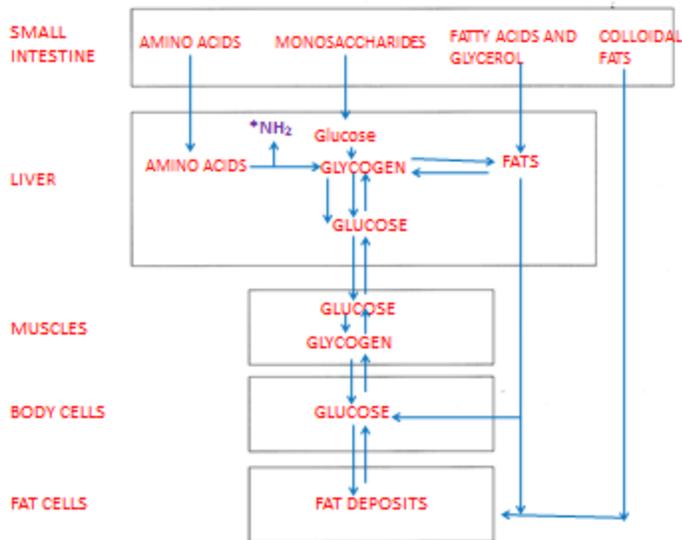
DN A	T	A	C		G	G	G		G	C	T		C	T	A		G	C	G		A	G	A		T	A	T
mR NA	A	U	G		<u>C</u>	<u>C</u>	<u>C</u>		C	G	A		G	A	U		C	G	C		U	C	U		A	U	A
a.a.	MET				PRO				ARG				ASP				ARG				SER				ISO		

21.

22. In a frameshift mutation will cause all the amino acids after the addition or deletion to be incorrect (#21).

# Digestion

1. DNA, nucleic acid, nucleotides, all food groups, 2. Starch, carbohydrates, alpha glucose, 1,4, 3. Fat, lipids, glycerol and 3 fatty acids, 2,5,6,7,8 4. Cholesterol, lipids, ring structure, 6 5. Cellulose, carbohydrates, beta glucose, 1,3,4,8 6. Glycogen, carbohydrates, alpha glucose, 6 7. Protein, protein, amino acids, 2,5,6,7,8 8. Monosaccharides, carbohydrates, carbon hydrogen oxygen, 1,2,3,4 9. Disaccharide, carbohydrates, monosaccharides, 1,2,3,4 10. Phospholipid, lipids, glycerol, 2 fatty acids, phosphate group
2. Answers are on the page.
3. 1. G, 2. E, 3. B, 4. H, 5. D, 6. A, 7. F, 8. C, 9. I, 10. J
4. The mouth (salivary glands) does not produce enzymes to digest fat and protein. Meat is made of fat and protein. The salivary glands do produce amylase, which breaks the rice down into maltose.
5. The low pH is the first line of defense against pathogens on the food. It denatures the bacterial enzymes, destroying the bacteria.
6. The pH of the stomach is very low, but needs to be raised to slightly alkaline for food digestion to take place in the small intestine. More immediately, the first part of the small intestine, the duodenum, does not have as much mucous to protect it from low pH conditions.
7. Cardiac – controls entrance of food into the stomach and prevents reflux of food back into the esophagus. Pyloric – controls exiting of food from the stomach and allows only small amounts of food to leave at a time.
8. It must be stored in its inactive form in the glands of the stomach wall. If it was not, it would digest the walls of the stomach, which are made of protein.
9. Color
10. See textbook
11. Duodenum – contains mostly undigested food. It is the location where food mixes with secretions from the liver, gall bladder, and pancreas. Jejunum – contains partly digested food. Absorbs digested food. Ileum – Absorbs digested food. Secretes digestive enzymes responsible for the final stages of protein and carbohydrate digestion.
12. It contains many digestive enzymes. It is long, so food spends enough time there to be digested.
13. Label the diagram
14. A. Glucose, fructose, galactose, amino acids, glycerol, fatty acids, nucleotides. B. Into the lacteal.
15. Mesenteric artery → portal vein → liver → hepatic vein
16. The blood leaving the small intestine is rich in nutrients. The blood is directed into the liver, rather than into general circulation so that the nutrients can be processed. (The liver is the processing centre.)
17. STOMACH – pepsinogen, PANCREAS – amylase, maltase, sucrase, lactase, lipase, trypsinogen, peptidases, nucleases, bicarbonate, LIVER – bile, bicarbonate.
18. Wastes are stored, water is reabsorbed, bacteria like *E. coli* breakdown wastes and make nutrients.
19. Label
20. Colorize
21. Hormones are gastrin, cholecystikinin, secretin. Enzymes are pepsinogen, amylase, trypsin, lipase, sucrose, maltase, lactase, nucleases, peptidases. Other secretions are bile, sodium bicarbonate, hydrochloric acid.
22. Gastrin → pepsinogen. Cholecystikinin → bile, pancreatic secretions. Secretin → sodium bicarbonate, bile.



But do you understand it?

### Self check

1. Yes. These conditions resemble those in the small intestine.
2. No. Wrong enzyme for the substrate. To get digestion, amylase could be replaced with pepsin or trypsin or egg white could be replaced by starch.
3. No. The temperature is wrong.
4. No. Wrong pH and too hot.
5. Yes. This resembles conditions in the small intestine.
6. No. Wrong pH.
7. No. Wrong pH. Peptidases complete protein digestion by breaking down polypeptides into amino acids in the small intestine. Ph must be more alkaline for peptidases to work.
8. Yes. Conditions resemble those in the stomach.
9. No. Wrong substrate for the enzyme. To get digestion, either starch should be replaced by protein, or the trypsin should be replaced by amylase.
10. No. There is no enzyme present to digest the egg white.

## Circulatory System

C3

1. D, A, B, E, C
2. See side margin
3. See side margin
4. It has to create enough force to send the blood to all parts of the body. The right ventricle only has to create enough force to get the blood to the lungs.
5. a. myocardium, b. endocardium, c. pericardium, d. pericardial sac, e. coronary arteries, f. coronary veins, g. septum, h. atria, i. ventricles, j. valves, k. atrioventricular valves, l. cordae

Structure	Function
1 Aorta	Carries $\text{O}_2$ rich blood away from heart to body
2 Superior vena cava	Brings $\text{CO}_2$ rich blood to the heart from the head and arms
3 Right pulmonary artery	Bring $\text{O}_2$ rich blood to the right lung
4 Right Pulmonary veins	Bring $\text{O}_2$ rich blood from lung to left atrium
5 Right atrium	Receives $\text{CO}_2$ rich blood from body and sends to R. ventricle
6 AV valve (tricuspid)	Prevents backflow of blood from ventricle to atrium
7 Right ventricle	Sends blood to lungs
8 Inferior vena cava	Brings $\text{CO}_2$ rich blood from the lower body
9 Left pulmonary artery	Takes $\text{CO}_2$ rich blood to the left lung
10 Left pulmonary veins	Bring $\text{O}_2$ rich blood from left lung to Left atrium
11 Left atrium	Receives $\text{O}_2$ rich blood from lung
12 AV valve (bicuspid)	Prevents blood from flowing from ventricle to atrium
13 Semilunar valve (Can you find the other one?)	Prevents blood from flowing back into ventricles.
14 Left ventricle	Sends blood to the body.
15 Aorta	Same as above

tendinae, m. tricuspid valve, n. bicuspid valve, o. semilunar valves

6. The blood on the right side (deoxygenated) does not mix with the blood on the left side (oxygenated).
7. Sometimes coronary arteries in the heart get blocked by fat deposits. This prevents oxygen from getting to the heart muscle and parts of it die. Result: the heart doesn't beat very well and may result in a heart attack. Bypass surgery uses blood vessels from other parts of the body to divert blood around the blockage to the oxygen starved parts of the heart.

C4

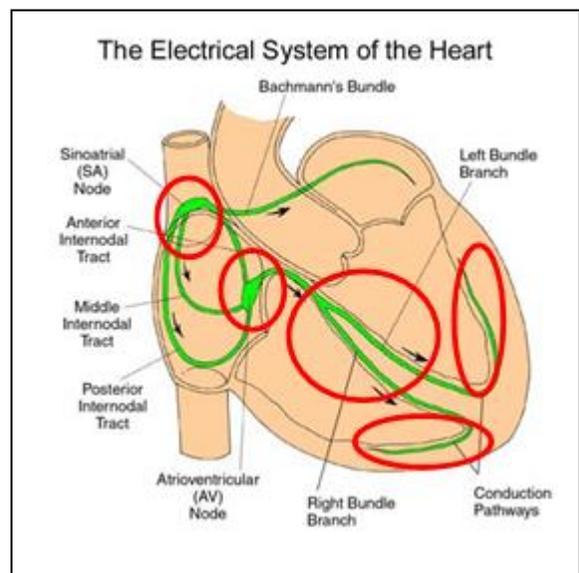
1. Second diagram: Ventricles contract. Blood is pumped out of the heart. Blood from the right ventricle goes into the pulmonary artery. Blood from the left ventricle goes into the aorta.  
Third diagram: Blood flows passively into the atria and ventricles.
2. The valves prevent blood from back flowing.
3. According to the diagram above, it spends more time relaxing. The atria only contract for .1 second but it relaxes for .7s. The ventricles contract for .3s and relax for .5s.
4. The atria and ventricles should not contract simultaneously. If they did, blood would not flow efficiently. The atria would be working against the ventricles.

Key Points:

5. Atria contract (atrial systole) → blood flows to ventricles → ventricles contract (ventricular systole) → blood flows to arteries.
  - a. Blood flows from the right ventricle to the pulmonary arteries.
  - b. Blood flows from the left ventricle to the pulmonary arteries.Atria and ventricles relax (diastole).
  - c. Blood flows passively into the atria and ventricles due to the push from blood behind it.
6. A sphygmomanometer. It applies pressure on the brachial artery to the point where no blood flows through it. As the pressure is gradually released, blood pressure eventually overcomes the cuff pressure. This is the ventricular systolic pressure. As pressure is continued to be released, a point is reached where blood flow is no longer heard. At this point diastolic pressure has been reached.
7. Hypertension – high blood pressure  
Hypotension – low blood pressure  
Causes are covered on page 19 of this booklet.
8. p. 19: Exercise
9. p. 19 If it is caused by disease (atherosclerosis, arteriosclerosis, heredity, smoking, stress, diet (ex. Salt in diet), viscous – thick – blood, too much blood in the system as with blood doping.

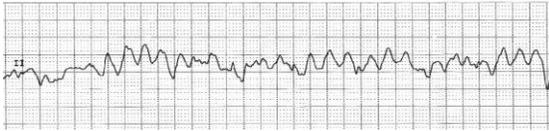
#### C4 – The Heart's Electrical System

1. see side margin
2. Beat faster
3. Exercising vigorously.
4. When we are active, muscles need more ATP. Cellular respiration takes place at a faster rate. More oxygen is necessary for this. Thus, the heart must deliver the oxygen more quickly.
5. Movie



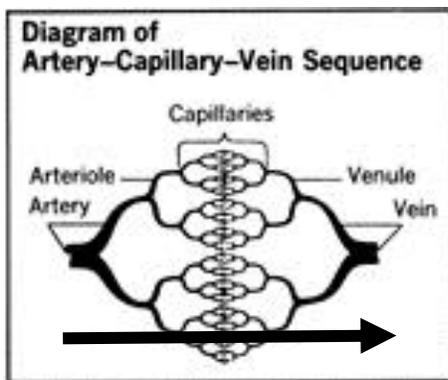
Wave	What are the atria and ventricles doing?
P	Atria - contracting Ventricles - relaxing
QRS	Atria - relaxing Ventricles - contracting
T	Atria and ventricles relaxing

- 6.
7. **Ventricular fibrillation** is the uncoordinated contraction of the heart muscle of the ventricles. They quiver instead. This can lead to asystole and is a medical emergency. It may be treated by **defibrillation**, a therapeutic dose of electrical energy to the heart with a device called a defibrillator.



- 8.
9. Their natural pacemaker has been damaged and does not function to create a coordinated heart rhythm.

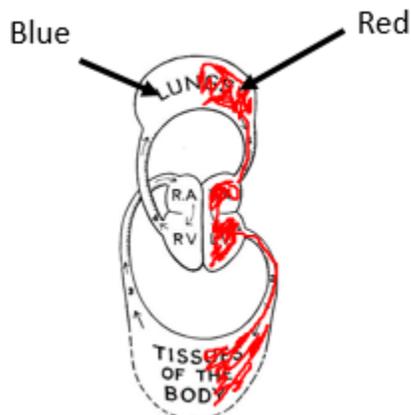
### C5 Blood Vessels



- 1.
2. At the capillaries.

	Structure / thickness	Valves?	Toward or away from heart?
Artery	Elastic layer, muscular, thick	No	Away
Arteriole	Contractile,	No	Away
Capillary	Very thin; one cell thick	No	Away and toward
Venule	Thin walled	No	Toward
Vein	Thin walled	Yes	Toward

3.



- 4.
5. 1. Right atrium, 2. Right ventricle, 3. Pulmonary artery, 4. Capillaries of the lung, 5. Pulmonary vein, 6. Left atrium, 7. Left ventricle, 8. Aorta, 9. Capillaries of the body tissues, 10. Vena cava.

## C5 –Major Blood Vessels

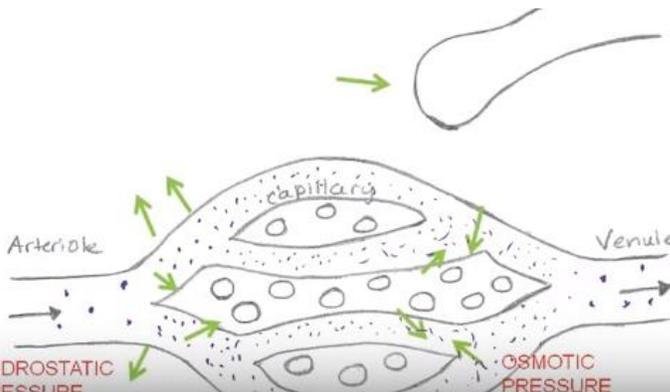
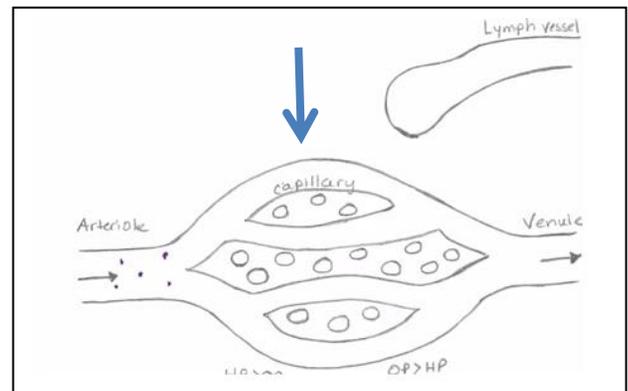
1. See video
2. The hepatic portal vein shunts blood to the liver rather than directing it back into general circulation. Unlike most other veins, it connects two organs to one another. Why? Review digestion/
3. It drops. This occurs because the total cross sectional area of vessels increases.
4. Because there are so many of them.
5. There is no pump pushing it forward. The pressure to move blood back toward the heart is provided by the blood behind it.

## C5 – Capillary Phenomena - Shunting

1. Muscles, brain, digestive system.
2. Brain.
3. There is a limited amount of blood – not enough to fill all the capillary beds at the same time. When you eat, capillary beds are open since nutrients are being absorbed into the blood and require a fresh supply of oxygen and glucose for active transport. When you use your muscles, capillary beds there are open to bring necessary oxygen and glucose and take away waste carbon dioxide. If you try to use both areas simultaneously, neither one will get enough oxygen and glucose and the cells will suffer. Also, wastes will not be carried away at the rate they are produced.
4. Shunting.
5. They would be open and filled with blood.

## C5 – Capillary Phenomena – Capillary Fluid Exchange

1. Hydrostatic pressure (blood pressure).
2. Osmotic pressure
3. In the middle
4. It enters a lymph vessel and then is deposited into the circulatory system.
5. Fluid would accumulate at the tissues causing Edema. The blood would also become more viscous.

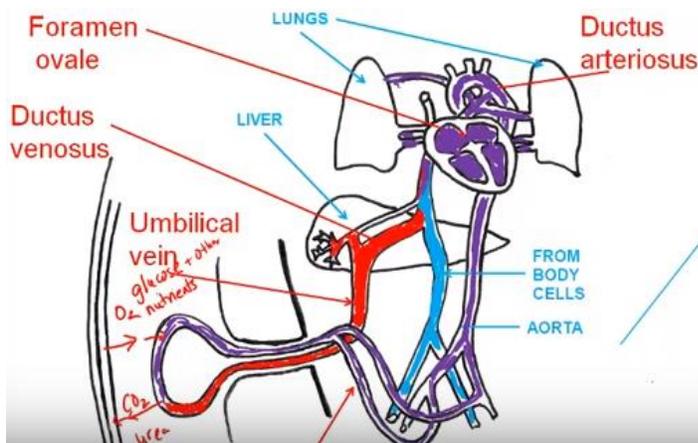


- 6.
7. \*Journal quiz question

## C5 - Fetal Circulation

1. At the placenta. This is where nutrients and oxygen diffuse from the mother's capillaries into the fetal capillaries. From there nutrients enter the umbilical vein.
2. They diffuse from one capillary to another.

3. In class.



4.

Structure	Purpose
FORAMEN OVALE	Diverts blood from the lungs into general circulation.
DUCTUS ARTERIOSUS	Diverts blood from the lungs into general circulation.
PLACENTA	Allows carbon dioxide and urea to diffuse from the fetal blood.
UMBILICAL VEINS	Allow oxygenated, nutrient rich blood to return to the heart.

5.

6. Pulmonary vein (carries oxygen), hepatic portal vein (carries nutrients).

7. Same as number 6

8. Journal quiz question.

#### C4 Homeostatic Mechanisms that Control Blood Pressure

1. See video

2. Arterioles – lumen decreases. Heart rate – faster. Force – stronger. Cardiac output – increases.

3. Arterials – lumen increases. Heart rate – slower. Force – less. Cardiac output – decreases.

4. Increased sympathetic activity causes sympathetic impulses to increase, resulting in increased heart rate, lumen of blood vessels to decrease.

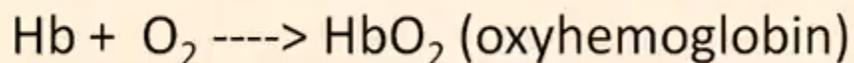
5. Journal quiz question.

#### C6 – Blood Cells

1. Components of plasma: water, plasma proteins, inorganic salts, nutrients, lipids, dissolved gases, nitrogenous wastes.

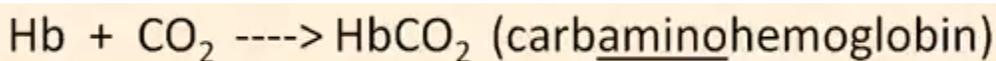
2. Oxygen and carbon dioxide bond to hemoglobin, which is on the surface of red blood cells.

3. HbO<sub>2</sub>. It is hemoglobin with oxygen bound to it.



4.

5. HbCO<sub>2</sub>. It is hemoglobin with carbon dioxide bound to it.



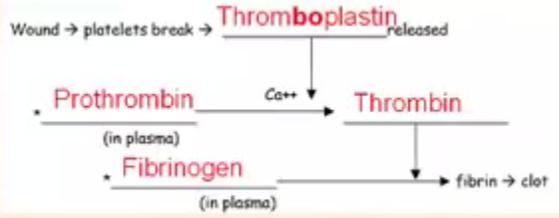
6.

7. HbCO. It is carbon monoxide bound to hemoglobin. Carbon monoxide forms strong bonds with hemoglobin. This means it doesn't release from hemoglobin. The result is that oxygen cannot bind to hemoglobin.

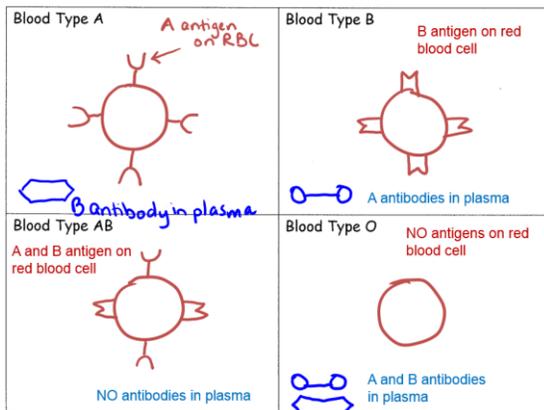
8. Erythropoietin.

9. More erythropoietin.

10. Athletes preparing for a competition donate blood to their own blood bank. Their bodies make more red blood cells. Just before the competition the donated red blood cells are transfused back into the athlete. This gives him / her an unusually high number of red blood cells. This gives the athlete the advantage of greater oxygen carrying capacity. It also raises blood viscosity and pressure to dangerous levels.
11. They defend the body against pathogens and foreign particles.
12. They engulf pathogens.
13. Gangrene – neutrophils, tuberculosis – monocytes, bee sting – eosinophils, cold or flu – lymphocytes.



- 14.
15. Thromboplastin
16. Prothrombin, fibrin
17. Fibrin
18. The blood would not clot as effectively.
19. The blood would not clot as effectively.



- 20.
21. Donor antigens on the surface of the red blood cells must contact recipient antibodies in the plasma. If the incorrect blood types were mixed, antibodies would attack antigens and cause clumping of red blood cells.
22. The donor cells enter the recipient bloodstream and are immediately surrounded by antibodies causing immediate clumping at the site of transfusion. The donated plasma would be diluted by the recipient plasma. While some donor plasma would contact recipient RBC's the clumping would be minimal.

	Recipient Blood Groups (Plasma)			
	A (B antibodies)	B (A antibodies)	AB (no antibodies)	O (A & B antibodies)
Donor Blood Groups (RBC antigens)	A (-) no clumping	(+) clumping	(-)	(+)
B	(+)	(-)	(-)	(+)
AB	(+)	(+)	(-)	(+)
O	(-)	(-)	(-)	(-)

- 23.
24. Try it!
25. Find out!
26. First pregnancy produces normal fetus. The fetus was Rh+. Mother developed Rh antibodies after labour, when her blood and fetal blood made contact. Second pregnancy produces miscarriage. Fetus was Rh+. Mom's body already has antibodies from the first pregnancy. These attack the fetus's red blood cells. Third pregnancy

produced a normal fetus because the fetus was also Rh negative and has no Rh antigens on the surface of its red blood cells.

## Excretory System

1. Deamination occurs when the amino group (NH<sub>2</sub>) is removed from the amino acids. The amino group is converted to nitrogenous compounds which are removed by the kidneys. It occurs because amino acids cannot be stored and must be converted to glucose, fatty acids, or glycerol.
2. Colorize.
3. AFFERENT means “incoming”. The afferent arteriole brings blood INTO the glomerulus of the nephron. EFFERENT means “outgoing”. The efferent arteriole carries blood OUT OF the glomerulus of the nephron.
4. PROXIMAL means “close to”. The proximal tubule is close to the Bowman’s capsule. DISTAL MEANS “far from”. The distal tubule is far from the Bowman’s capsule.
5. The heart’s left ventricle (blood pressure).
6. The space between the cells in the wall of the capillaries of the glomerulus. The wall acts as a sieve.
7. Water is pushed out of the capillaries at the glomerulus so the blood leaving via the efferent arteriole has a lot less water and only materials that were not able to fit through the capillaries (proteins, blood cells, some water). Removal of water concentrates the blood.
8. So many materials that leave the blood must be returned because the body needs them. This is done by active transport, which requires energy (ATP).
9. They go back into the blood via the peritubular capillaries. These are capillaries that surround the nephron tubules (proximal, loop of Henle, distal, collecting duct). These capillaries are often not shown on diagrams.
- 10.

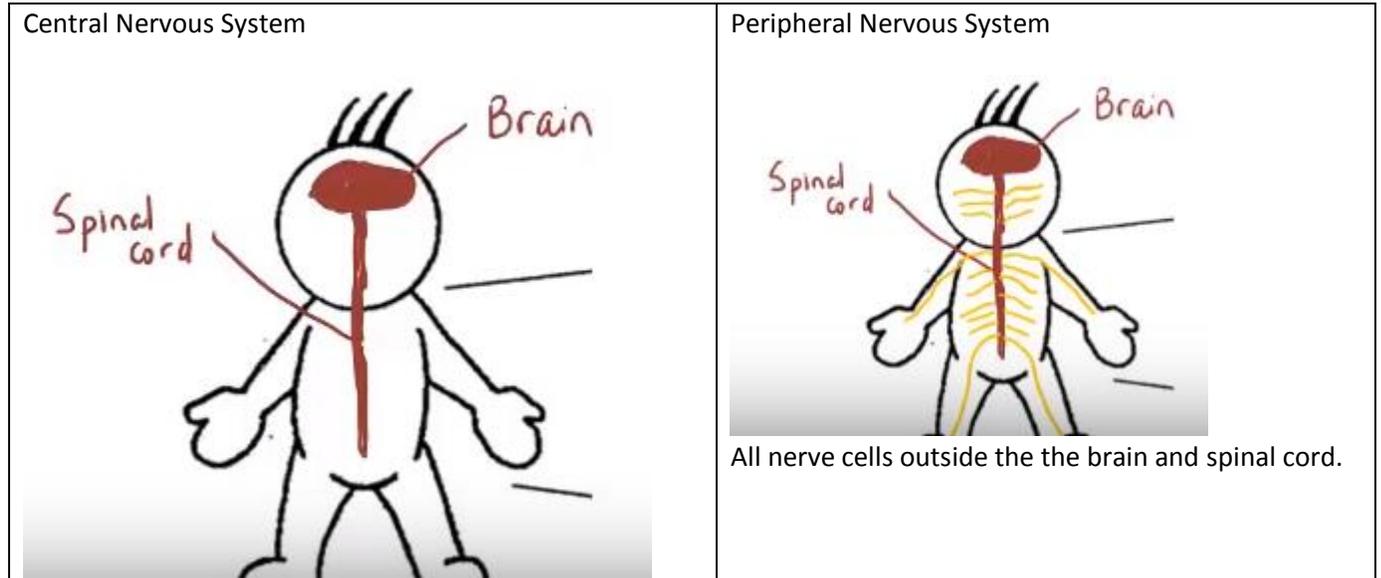
Descending	Ascending
Permeable to water	Impermeable to water
Takes in sodium by diffusion	Pumps out sodium
More dilute filtrate	Highly concentrated filtrate

11. C. Water has been removed from the tubules.
12. C. Water has been removed. Other solutes in the filtrate were also removed from the proximal tubule, so almost all that is left to be concentrated is waste.
13. A. This is filtrate that still contains a fair amount of water.  
Journal quiz question.
14. Summary. At the ascending limb sodium is pumped out but water stays behind. This produced a high solute concentration between the two limbs of the loop of Henle. Since the descending limb is permeable to water, it is drawn out by osmosis and returns to the blood. As filtrate moves down the descending limb (away from the cortex toward the medulla), and water is removed, the filtrate becomes more concentrated. As the filtrate continues up the ascending limb, sodium is pumped out this reduces the solute concentration. Water and sodium are removed, but the fluid that enters the distal tubule is concentrated with nitrogenous waste.
15. When blood is slightly too alkaline, less hydrogen ions and ammonia are moved into the distal tubule and less sodium and bicarbonate ions are returned to the blood. Keeping more hydrogen ions in the blood and returning fewer bicarbonate ions (HCO<sub>3</sub>) to blood will offset the alkalinity.
16. a. glomerulus, b. Bowman’s capsule, c. proximal tubule, d. distal tubule, e. collecting duct, f. to renal pelvis and bladder, g. ascending limb, h. base of loop of Henle, i. descending limb.
17. When blood volume drops, blood pressure drops. This causes the juxtaglomerular apparatus (JGA) of the nephrons to secrete more of the enzyme renin into the blood. IN the blood, renin promotes the formation of the hormone angiotensin II. An increase of angiotensin II signals the adrenal cortex to produce more of the

hormone aldosterone. Aldosterone stimulates the distal tubule and collecting ducts to absorb more sodium and water back into the blood. Water follows. This results in an increase in blood volume and pressure. A decrease in blood volume also causes cardiac stretch receptors to be less stimulated. This causes the atria to secrete less atrionatriuretic hormone, which also stimulates more renin secretion, leading to increased blood pressure, as above.

## Nervous System

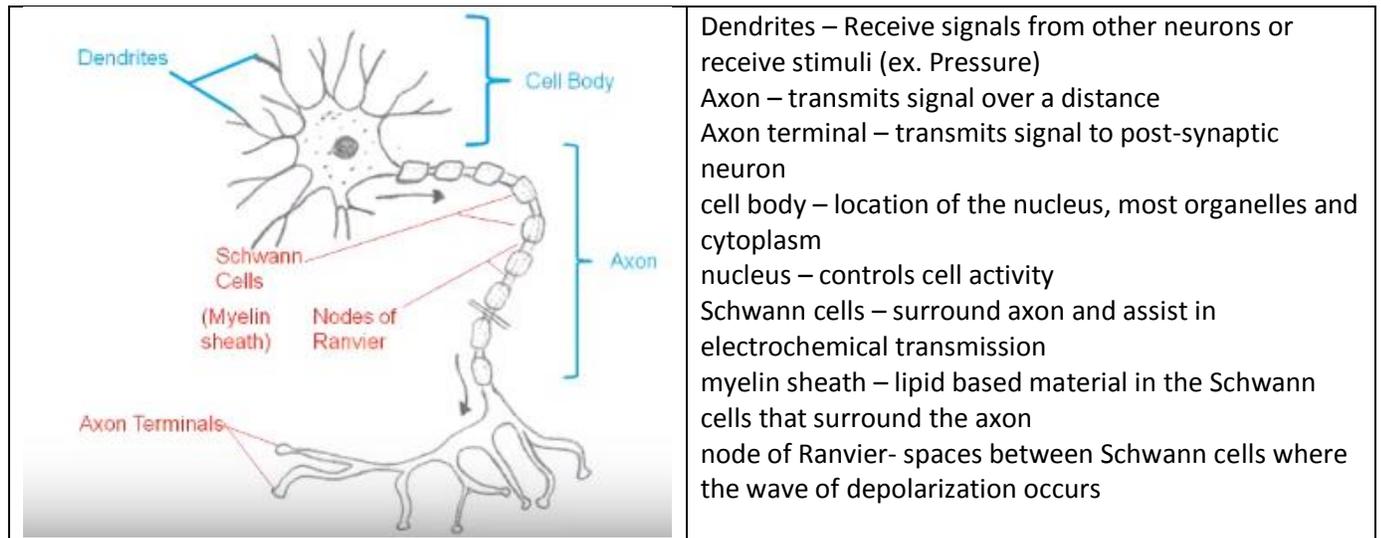
1.



2. Brain, spinal cord

3. All nerves outside the central nervous system. Example: optic nerve.

4.



5. Dendrites are cytoplasmic extensions of the cell body that receive signals from other neurons or are stimulated by external stimuli (ex. Pain, pressure, light)

6. They can either grow more dendrites to better interface with other neurons.

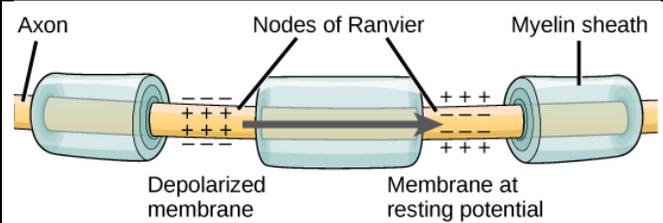
7. Schwann cells improve electrochemical transmission by producing the myelin sheath, which insulates the neurons of the peripheral nervous system for faster impulse transmission.

8. This is caused by the fatty myelin.

9. They are unmyelinated.

10. Locations where there is no Schwann cells / myelin.

11. Depolarization only takes place at the nodes of Ranvier, where myelin is absent. The presence of myelin results in faster impulse transmission because depolarization does not have to take place there. Depolarization at one node of Ranvier initiates depolarization at the next, without depolarization in the axon in between the two nodes.



12. The direction of the wave of depolarization. (The direction the electrical signal travels.)

### Types of Neurons

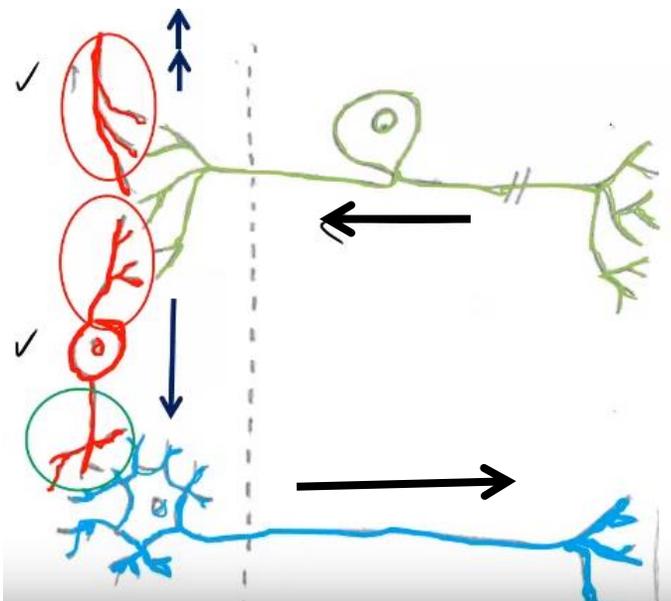
1.

Type of Neuron	Structure (Include axon and dendrite length)	Location and Function
Sensory	long dendrites, short axons.	Mostly peripheral nervous system. Cell body is outside the central nervous system but axon terminal is inside. Many sensory neurons bundled together result in ganglia. Relay signals toward the central nervous system.
Interneuron	short dendrites, long or short axons	Central nervous system. They form connections between neurons.
Motor	short dendrites, long axons	Mostly peripheral nervous system. Cell body lies inside the spinal cord, but axon in part of the peripheral nervous system. Relays signals to muscles.

2. Sensory
3. Interneuron
4. Heat, pressure, touch, cold, pain, light, vibrations, chemicals

### Neuron Arrangement

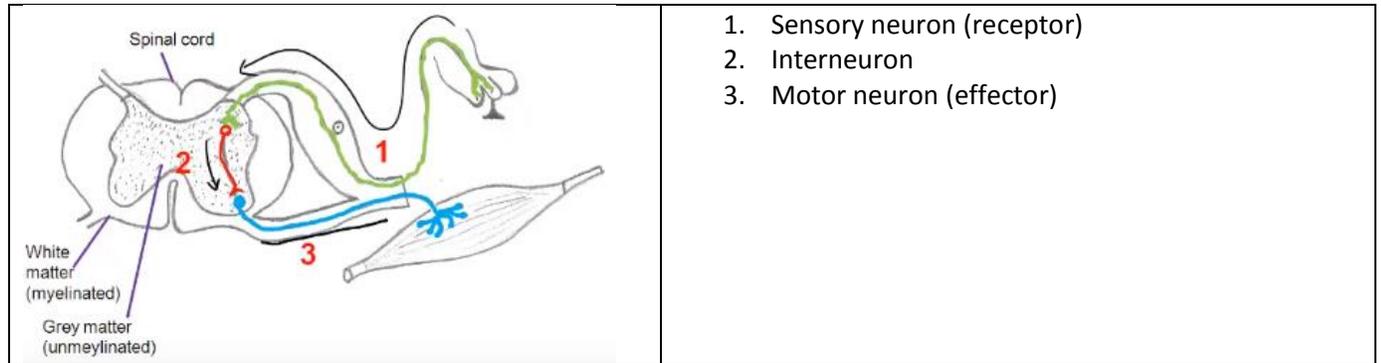
1.



2. A ganglion is the part of the nerve that bulges where cell bodies of sensory neurons are located. It is #8 in the picture.

## Reflex Arc

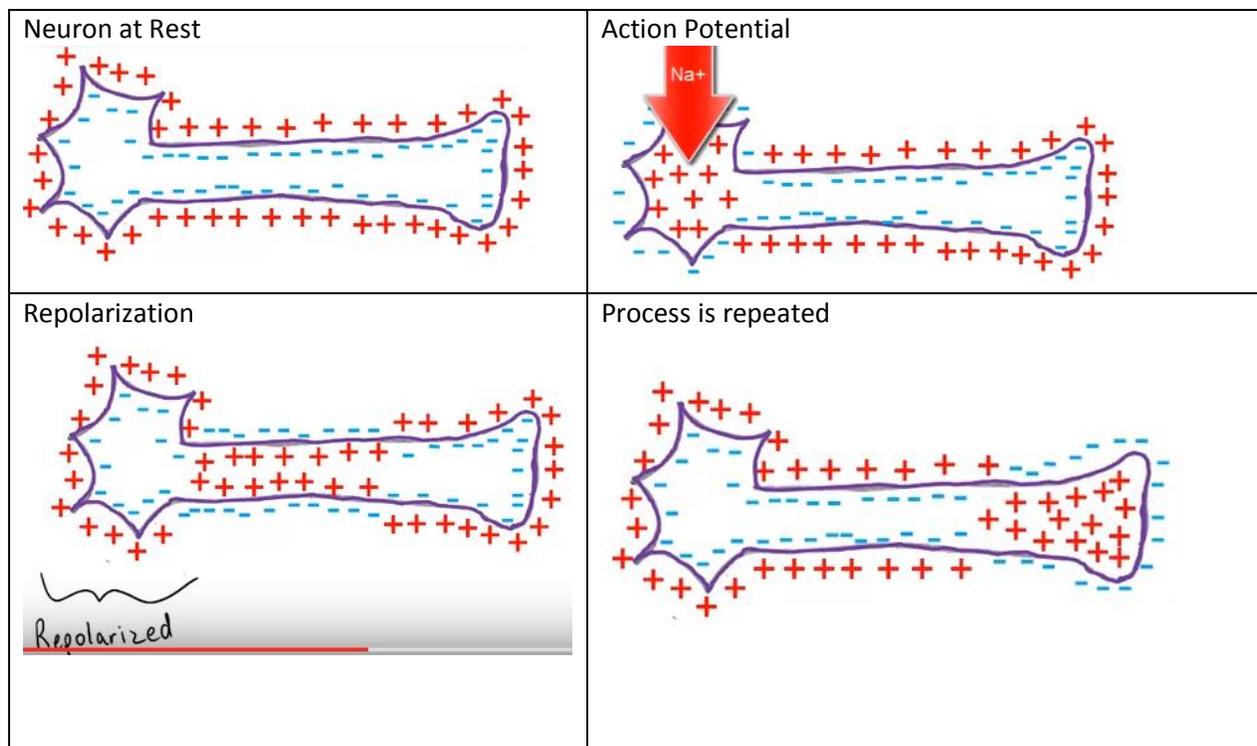
1.



2. The receptor receives the stimulus and a wave of depolarization travels up the sensory neuron. The impulse is transferred to the interneuron, which then transfers it to the motor neuron relaying it into the muscle (effector).
3. The brain is not involved.
4. You feel pain when the brain becomes involved. The sensory neuron would interface with another interneuron, which carries the impulse up to the brain, where pain is sensed.
5. Tack pokes finger, sensory neuron fires, 2 interneurons fire, motor neuron fires, (arm pulls away), brain receives information, you feel pain.

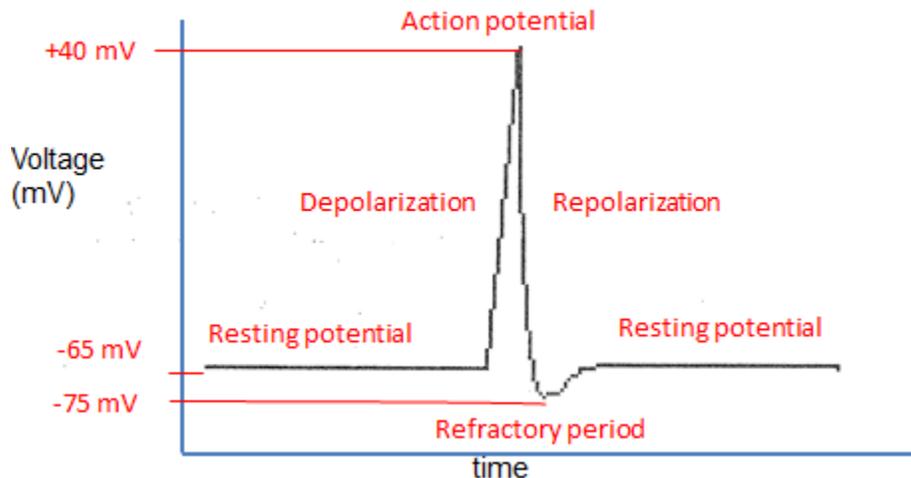
## Nerve Impulse Transmission

1.



2. A net positive charge (3 Na<sup>+</sup> out / 2K<sup>+</sup> in) out leaves large negatively charged particles inside the neuron, resulting in a net negative charge inside. Outside, the flood of positively charged sodium ions results in a net positive charge because there are more positive ions than negative ions.

- When one section of the membrane depolarizes, the sodium gates on the adjacent membrane open to initiate depolarization there.
- It prevents it from moving backward because during this time there are insufficient potassium ions on the outside to reset the sodium potassium pump. (It takes time for them to diffuse out through potassium channels.)
- 



- Depolarization occurs when sodium channels open and allow sodium to flow in. Potassium channels open to allow potassium to flow out.

### Three Neuron Phenomena – A. Saltatory Conduction

- B. It has Schwann cells which are myelin. Myelin insulates the cell and prevents ion movement across the membrane. The impulse therefore only occurs at the nodes of Ranvier and skips the myelinated region.
- Myelinated neurons conduct more quickly (200 m/s) than unmyelinated neurons (1 m/s).
- This would take up too much space in the limited volume skull and spinal cord. There would be less neurons and less possibility for interconnections, reducing processing (thinking) ability.
- Journal quiz question.

### B. All or None

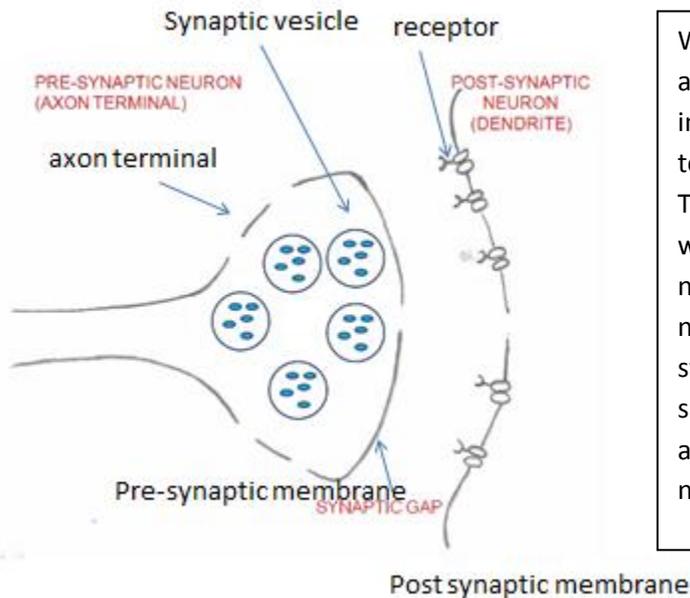
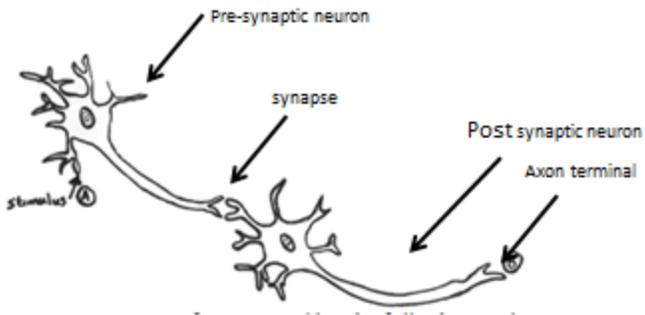
- The amount of stimulus to initiate the wave of depolarization is not the same for all people. Those with a high threshold for pain may require more stimulus for the wave of depolarization to be initiated.
- A strong pin poke would cause more waves of depolarization in the same amount of time than a weak pin poke.
- The stimulus over a larger surface area (the slap) would cause more neurons to be involved than an equally strong stimulus over a smaller surface area (poke).

### C. Hypernegativity

- Quadriceps and hamstrings. Abdominal muscles and back muscles.
- Hypernegativity ensures that muscles are not working against each other.
- NO movement would occur.
- A greater than normal stimulus.

### Synaptic Transmission

-



When a wave of depolarization reaches the axon terminal, calcium gates open. Calcium interacts with contractile proteins attached to both the vesicles and the membrane. This pulls vesicles toward the membrane where they fuse and release neurotransmitter into the synapse. The neurotransmitter diffuses across the synapse and binds with the receptor on the sodium gates, signalling the gates to open and allow sodium into the post synaptic neuron.

2.

3. When the wave of depolarization reaches the axon terminal, calcium gates open and allow calcium into the neuron. It interacts with the contractile proteins and pulls the vesicles to the membrane.

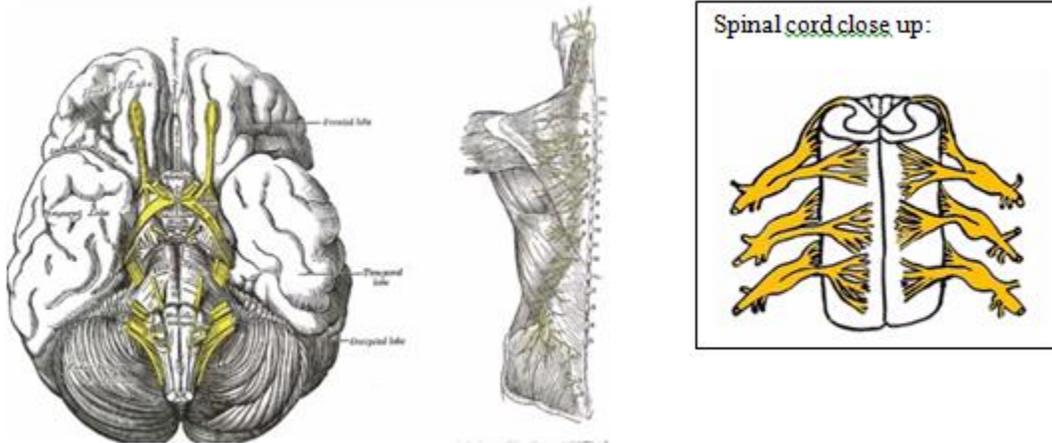
The vesicles fuse with the membrane, releasing neurotransmitter. The neurotransmitter diffuses across the synaptic cleft and binds with the receptor on the post synaptic neuron.

The receptor on the post synaptic neuron is associated with a sodium gate, which opens and allows sodium in. This initiates a wave of depolarization.

4. Animation. Did you view it? You should. It's good.
5. Neurotransmitters are broken down by enzymes. Acetylcholine is broken down by acetylcholinesterase (ACh-ase).
6. Neurotransmitters may diffuse away and into the blood stream, eventually to be excreted by the kidneys. A second way they clear the synapse is re-uptake. In re-uptake, neurotransmitters re-enter the vesicles.
7. If they were not cleared, the sodium gates would remain open and another wave of depolarization could not take place.
8. Because only the axon terminals have neurotransmitters and only the dendrites have receptors.
9. Watch the animation. Understand, but don't memorize.

## Organization of the Nervous System

1. Brain and spinal cord should be red. Nerves should be yellow.



2. Central nervous system is the brain and spinal cord, located in the skull and spine, respectively. Function: Processing area where sensory information is received and interpreted. Also where motor activity originates.

### External Brain

1. Frontal lobe – Executive functioning (seat of personality, conscious thought); major motor areas  
Parietal lobe – major sensory area  
Occipital lobe – major visual sensory area  
Temporal lobe – major auditory sensory area; visual and auditory memory stored here; perceptual judgement  
Cerebellum – coordinated movement  
Medulla oblongata - vital centres for breathing, heart rate, etc. located here.
2. A. occipital lobe damaged B. temporal lobe damaged C. frontal (pre-frontal) lobe damaged.
3. Cortical homunculus – represents the extent to which sensory information is generated from various parts of the body.
4. The corpus callosum is a band of nerve fibers joining the right and left hemispheres of the brain. It allows the two sides of the brain to communicate with each other.
5. Likely, it is a combination of nature (genes) and nurture (environment and experience).

### Internal Brain

1. D
2. A
3. E
4. C
5. B
6. Meninges are the membranes covering the brain and spinal cord.
7. It causes swelling and puts pressure on the brain and spinal cord, which are very soft and delicate and can easily be damaged.
8. The hypothalamus, part of the nervous system, is made of nerve tissue, but makes hormone-like substances which are transferred to the pituitary by a portal vein. The pituitary gland, part of the endocrine system, contains some nerve tissue. The pituitary is the “aster gland” since it releases hormones which affect other glands and their hormonal activity. The hypothalamus is the “master of the master gland”. These two

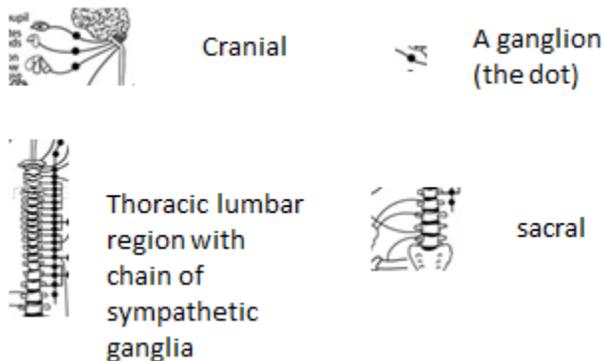
structures together form an interface of the two communication systems of the body: the nervous system and the endocrine system.

## Spinal Cord

1. White matter is made of myelinated neurons (with Schwann cells). Grey matter has no myelin.
2. This occurs because some of the tracts of interneurons carrying sensory and motor impulses up and down the spinal cord have been injured. Others have not.
3. The dorsal root contains sensory neurons, including the cell body, which forms a bulge called a ganglion. The ventral root contains motor neurons

## Autonomic Nervous System

1. Sensory somatic: dorsal and ventral root, mixed nerve. Autonomic: sympathetic ganglion, neurons connecting the ganglia, and part of the mixed nerves.
2. Just do it. It's already labelled.
- 3.



4. Short – sympathetic. Long – parasympathetic
5. Spinal cord – sympathetic organs – parasympathetic
6. A. sympathetic B. preparing to fight or run. Pupils dilate, heart speeds up, bronchi dilate
7. Parasympathetic – pupils constrict, heart slows to normal, bronchi constrict to normal, digestive activities begin again, bladder contracts.
8. Sympathetic prepares us for danger. Parasympathetic returns things to normal.
9. A. adrenaline B. adrenal gland C. acetylcholine