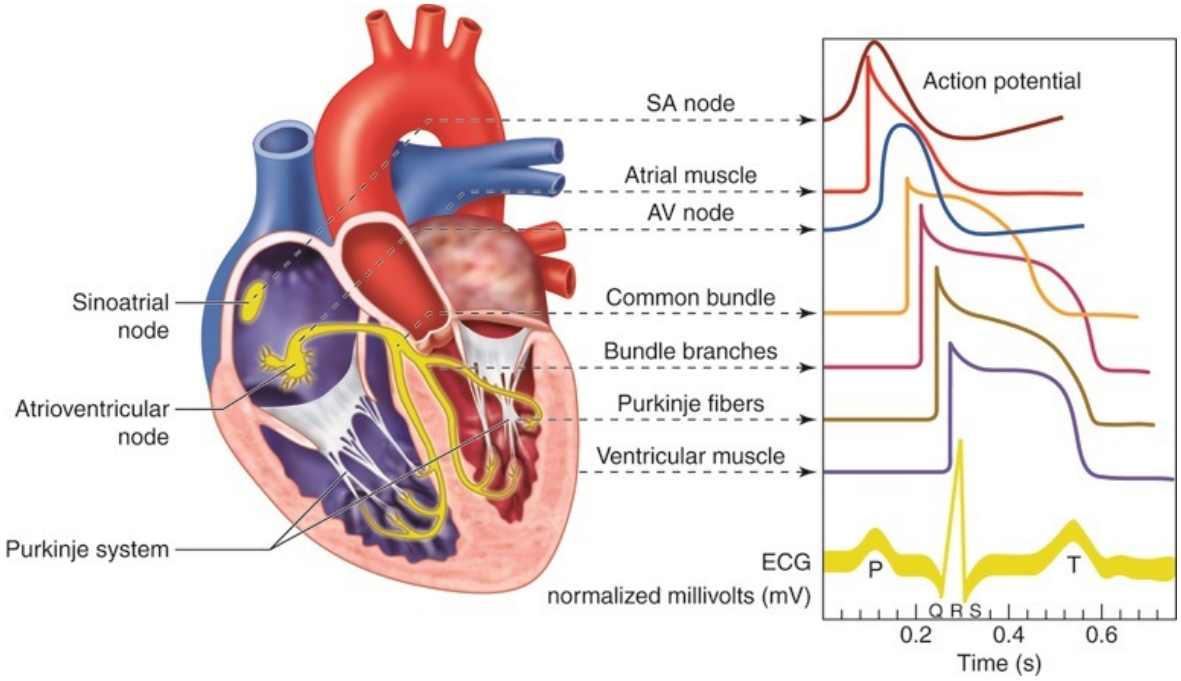
Human Physiology
Laboratory Manual



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Fifth Edition

TABLE OF CONTENTS

GENERAL SAFETY PROCEDURES

1. In the event of a medical emergency, use the classroom phone to dial 9-911.

2. In the event of a blackout, do not move. Emergency lights should come on. If not, use your phone as a flashlight to help yourself and others out of the room.

3. In the event of a fire, immediately leave the room. The last person to leave the room should make sure there is no left in the room and close the door behind them. Pull the fire alarm. Assemble in the quad.

4. In the event of an earthquake, duck under the lab benches. When the shaking stops, immediately leave the room. The last person to leave the room should make sure there is no left in the room. Close the door behind you as you leave. Assemble in the quad.

5. For other emergencies dial campus safety (714) 992-7777 or 27777 from a campus phone.

LABORATORY SAFETY PROCEDURES

1. If you have any health condition that might be affected by a particular lab exercise or might affect others, then discreetly inform your instructor.

2. Clothing should be appropriate for working in the lab and for the physical activities required during lab.

3. Do not touch any equipment unless you have been instructed on its use.

4. All equipment must be put away properly at the end of the lab.

5. Clean all glassware at the end of the lab.

6. Know where the eyewash station and emergency shower are located and how and when to use them.

7. Do not eat or drink during lab. Keep all food and drink off the lab benches.

8. Clean the benches at the end of each lab.

9. Listen to and follow instructions during.

10. If you are not sure, ask!

PROCEDURES FOR HANDLING BODILY FLUIDS

1. Do not handle anyone's bodily fluids except your own unless you are wearing gloves.

2. Cover all work surfaces with appropriate absorbent materials.

3. Clean any spill with diluted bleach (Be careful when using bleach.) or other appropriate disinfectant.

4. Place all contaminated materials in the proper containers.

5. Wipe off desks with bleach or other appropriate disinfectant at the end of the lab exercise.

Section I. The Scientific Basis of Physiology

METRIC SYSTEM REVIEW

PREFIXES:

giga	G	10^9	1,000,000,000
mega	M	10^6	1,000,000
kilo	k	10^3	1,000
centi	c	10^{-2}	.01
milli	m	10^{-3}	.001
micro	μ	10^{-6}	.000001
nano	n	10^{-9}	.000000001
pico	p	10^{-12}	.000000000001

LENGTH

The meter (m) is the standard unit of length. It is about 39 inches (slightly more than one yard.) An inch is about 2.5 centimeters (10^{-2}m).

* 1,000,000 μm = 1 meter
* 100 cm = 1 meter
* 1000 m = 1 kilometer

MASS (or weight):

The gram (g) is the standard unit of mass. It is about 1/30th of an ounce. One kilogram (kg) is about 2.2 pounds. On earth, weight and mass are equal, so the terms are used interchangeably.

* 1000 mg = 1 gram
* 1000 g = 1 kilogram

VOLUME

The liter (l) is the standard unit of volume. It is slightly more than one quart. One milliliter (ml) has the same volume as one cubic centimeter. **One milliliter of water weighs one gram**.

* 1000 milliliters = 1 liter
* 1 milliliter = 1 cubic centimeter (cm^3)

TEMPERATURE

Temperature is measured in degrees Celsius. The freezing point of water is 0^0 C, the boiling point of water is 100^0 C. Body temperature is about 37^0 C. Room temperature (72^0 F) is about 22^0 C.
A change of one degree Celsius is about the same as a change of 1.8^0 F

REVIEW PROBLEMS

10 cm is how many mm?
0.25 nm is how many mm?
1.5 kg is how many mg?
2 liters of water weighs how many kg?

Name_____

METRIC SYSTEM

You need to feel comfortable working with the metric system. You should be able to estimate everyday situations using metric units. This exercise is designed to get you used to thinking naturally in metric. Please fill in all of the blanks using appropriate amount and metric units. For many of these questions you will need to do a reasonable approximation.

Weight (mass)

1. A healthy newborn baby weighs about _____.
2. An average adult woman might weigh _____.
3. A can of soda weighs about _____.
4. When giving a transfusion, a unit of blood weighs about _____.
5. A regular dose aspirin pill weighs about _____.
6. One drop of water weighs about _____.

Length

1. About how long is this room? _____.
2. The length of a typical pencil is _____.
3. The average height of a man in the U.S. is about _____.
4. A quarter is about how thick? _____.
5. The average diameter of a human cell is about _____.

Volume

1. The volume of the laboratory room is about _____.
2. The total blood volume in the body is about _____.
3. The volume of your textbook is about _____.
4. The volume of a drop of water is about _____.
5. The volume of a can of soda is about _____.

Temperature

1. The temperature of this room is about _____.
2. A person with a high fever would have a temperature of about _____.
3. On a cold day in Fullerton, the outside temperature is about _____.

Name_____ Date _____

CHEMISTRY REVIEW

1. Convert the following numbers into scientific notation. (Don't worry about significant figures.)
A. 550000 = _____

B. 0.03 = _____

2. Which of the following equations has the correct significant figures?
A. 30.0 x 2 = 60.0
B. 0.050 + 0.00020 = 0.0502
C. 2.4 x 2 = 5

3. Name the following elements:
K _____ Cl _____

Ca _____ H _____

4. Give the symbol for the following elements:
Carbon _____ Sodium_____

Iron _____ Phosphorus_____

5. An atom has an atomic number of 6 and an atomic weight (mass) of 14.
How many of each of the subatomic particles listed does this uncharged atom have?
A. protons _____
B. neutrons _____
C. electrons _____

6. How many bonds does each of the following normally form?
Carbon _____ Hydrogen _____

Nitrogen_____ Oxygen _____

7. When dissolved in water, what is normal charge of each of the following ions?
Sodium_____ Calcium _____

Chloride_____ Potassium _____

8. What is the molecular weight of the following: (In biology we discount the weight of isotopes.)
carbon _____ carbon dioxide _____

water _____ calcium chloride _____

9. Which column of the periodic table is the most electronegative?

10. Name the type of chemical bond

in a molecule of O_2 _____

in a molecule of NaCl _____

in a molecule of water _____

between two molecules of water _____

11. Describe London dispersion force (van der Waals force).

12. What is a covalent bond?

13. Balance the following reaction:

___Fe + ___ O_2 ⇌ ___ Fe_2O_3

14. What does the symbol ⇌ mean?

15. Name the following:

PO_4^{3-} _____ NH_4^+ _____

OH^- _____ CH_4 _____

16. For each of the following, state whether it is a strongly acid, weak acid, neurtral, strongly alkaline (basic), weak alkaline (basic)

blood: pH 7.4 _____ urine: pH 6.2 _____

HCl: pH 0 _____ NaOH: pH 13 _____

17. What does the term “pH” mean?

18. What is the definition of a buffer (in chemistry)?

19. Calculate the molarity of the following solutions:

    9.0 g of HCl in 1 liter of water _____

    23 mg of Na in 1 ml of water _____

20. What is the molarity of the following solutions?

    18 mM glucose (millimoles) in 100 ml water (the MW of glucose is 180) _____

    10 mM NaCl in 10 ml water _____

THE SCIENTIFIC METHOD

Part I.
For each scenario, do the following:

A. Generate a hypothesis.

B. Describe how you would test the hypothesis including the experimental procedure, variables and controls.

C. What results would you expect in order to support or refute your hypothesis?

1. It has been known for centuries that alcohol consumption can lead to cirrhosis of the liver. Cirrhosis is a condition where liver lobules are replaced by scar tissue (fibrous connective tissue.) While it is easy to understand that alcohol is toxic to hepatocytes, no one really knows what causes the proliferation of fibroblasts that occurs in cirrhosis. One suggestion is that it is the presence of dying or dead hepatocytes that triggers fibroblast proliferation.

2. While there is no cure for the common cold, many people claim that there are ways to prevent getting a cold. Some of the more common prophylactics include taking high doses of vitamin C, zinc supplements, echinacea (a plant extract) and garlic extract. Each of these treatments has proponents who vouch for its efficacy. Likewise, many people claim that these treatments are not effective and if there is any benefit, it is only because of the placebo effect.

Part II.

Each year, in the U.S., there are about 150,000 cases of colon and rectal cancer diagnosed. Of these about 50,000 are fatal. A new drug is developed which will cut the number of colon and rectal cancer cases and fatalities by 80%. This would save about 40,000 lives per year. This drug, like all others, has some potentially serious side effects. Each year about 1% of people taking this drug will get seriously ill and about 10% of them (0.1% of those taking the drug) will die. In order to be effective, this drug must be given before any signs of colon or rectal cancer develop.

There are about 100,000,000 people in the U.S. above age 45, and so at higher risk of developing these cancers. Should the FDA approve this drug? If so, under what circumstance?

Turn in all of your completed work with your name at the top at the end of the lab today.

DIFFUSION

Diffusion is one of the most important concepts in physiology. Diffusion is defined as the random movement of particles that results in particles tending to go from areas of high concentration to areas of low concentration. Almost all physiological processes, including neural signaling, oxygen transport, and kidney function involve diffusion.

In this laboratory exercise, we will determine the rates of diffusion. We will measure how long it takes for NaOH to diffuse through an agarose gel. Agarose is a complex carbohydrate and which, when dissolved in water, will form a gel that is similar to cytosol and extracellular matrix. These agarose plates have been made with a pH indicator (phenolphthalein) which will turn pink when the NaOH comes in contact with it. This will allow us to see how far the NaOH has diffused.

Procedure:

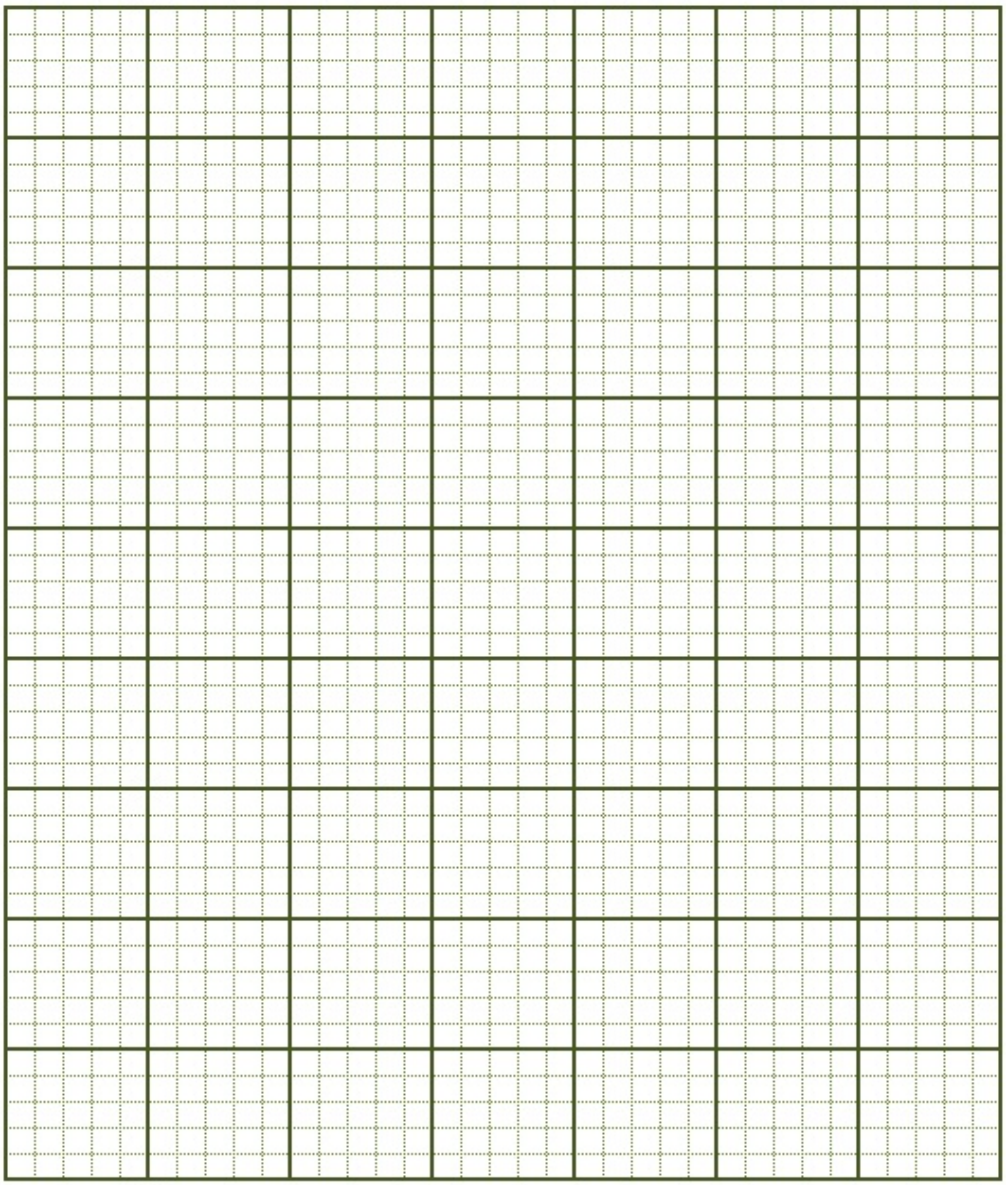
1. Read over the lab and generate a hypothesis as to what you expect your results to be. How far will the NaOH diffuse in 5 minutes? **Turn your hypothesis in before you begin. Explain why you chose this number.**

2. Take an agarose plate (1% agarose) and make 4 wells (holes) in the agarose. Using a pipette pump with a plastic straw and insert it straight down into the agarose. Induce suction in the pipette by turning the knob. Then gently lift the pipette. You should have a well with smooth sides.
3. Using a glass Pasteur pipette (long and thin) place one drop of dilute NaOH in each hole. Make sure the NaOH does not overflow the hole. Record the time.
4. At five minute intervals and for a total time of 30 minutes, measure how far the NaOH has diffused from the wells.
5. Calculate the average rates of diffusion for each 5 minute period in mm/min and μm/sec.
6. Graph the diffusion rate by graphing the total distance the NaOH diffused in 5 minute intervals. Don't forget to label the axes and the graph.

Results:

	5	10	15	20	25	30
average total distance diffused (mm/min)						
average distance diffused in each 5 min. interval						

GRAPH PAPER



Using the data gathered from the first 5 minute interval, and assuming the extracelluar matrix of loose fibrous connective tissue is similar in density to 1.0% agarose, how long would it take for a substance the size of NaOH to travel from a cap illary to a fibroblast (about 10 μm)?

Using the data gathered from the first 5 minute interval, how long would it take a substance the size of NaOH to diffuse across a synapse (about 3.5 nm)?

Questions:

1. Was your hypothesis supported? Explain why or why not.
2. What are the factors which affect the rate of diffusion?
3. Is the rate of diffusion constant over the 30 period of this experiment? (Remember, diffusion is occurring in two dimensions in our experiment.)
4. Under what circumstances is diffusion a useful method of transport in the body?
5. What other transport mechanisms does the body use and why?

Turn in all of your work including the answers to the questions above when you are done.

SURFACE AREA TO VOLUME RATIO

The effect of surface area to volume ratio is of profound importance to almost all physiological systems. Most physiological systems depend on movement of materials across a surface boundary, either a cellular membrane or tissue membrane. The amount of material that can cross the membrane is dependant on its surface area. Organisms use many mechanisms that ensure that the surface area is sufficient to carry out particular functions. Among these mechanisms are: villi, capillary beds, irregularly shaped cells, etc.

As the volume increases, the surface area also increases. However, as the size of an object increases, the surface area to volume ratio decreases. In this lab, we will determine the effect of increasing volume on the surface area to volume ratio and how that affects diffusion.

Procedure:

1. Read over the lab and generate a set of hypotheses.
2. Cut two cubes of gelatin with the following dimensions: 1 cm^3 (one cm on a side) and 8 cm^3 (2 cm on a side).
3. Calculate the surface area of each cube and its volume. Determine the surface area to volume ratio for each cube.
4. Immerse all the cubes at the same time in a dye solution.
5. Keep the cubes in the solution for 20 minutes. **Do not touch or move the container**.
6. Remove the cubes at the same time and quickly and gently rinse them off.
7. Cut the cube in half and measure how far they dye has diffused into the cube.
9. What proportion of the cube volume was dyed and undyed?

   For example if you started with a cube that was 2 cm on a side and the dye diffused 4mm, then undyed portion of the cube is 1.2cm x 1.2cm x 1.2 cm = 1.7cm^3. Since you started with a cube that was 8cm^3, the proportion of the cube that is undyed is 1.7/8 = 21%.

Questions:

1. How do the surface area to volume ratios relate to the proportions of the cubes that were dyed?
2. How does the rate of diffusion of the dye compare to that of the NaOH in the previous lab exercise?
3. What accounts for this difference?
4. Why are cells so small?
5. What are some methods that cells use to increase their surface area to volume ratios?
6. What are some methods that organs use to increase their surface area to volume ratios?

Turn in all of your completed work with your name at the top at the end of the lab today.

ENZYMATIC DIGESTION

In order to facilitate chemical reactions, the body uses enzymes to increase the rate of the reaction. There are thousands of different enzymes in the body. Some enzymes can be used in anabolic reactions in which large molecules are made by combining smaller ones. Other enzymes can be used in catabolic reactions in which small molecules are made by breaking down larger ones. There are many factors which affect enzyme activity. These include temperature, pH, substrate concentration, etc. In this laboratory exercise we will be studying the effects of these factors on some hydrolytic enzymes.

Our source of enzymes is ground-up pancreas (pancreatin). Since the pancreas produces a number of different enzymes, pancreatin contains many digestive enzymes. One of these is pancreatic amylase which hydrolyzes starch into glucose disaccharides (maltose). Another pancreatic enzyme we will be studying is pancreatic lipase. This enzyme hydrolyzes triglycerides into monoglycerides and fatty acids.

I. The effect of pH on enzyme activity

Enzymes are proteins. Therefore, their secondary, tertiary, and if they have one, their quaternary structures are affected by changes in pH in their environment. In this lab exercise we will determine the pH which will allow for the highest level of activity of pancreatic amylase.

Procedure:

1. Label 5 test tubes #1 - #5. Add 5ml of starch solution to each test tube.
2. Add 2 ml "Standard Buffer" to tube #1. This is your positive control.
3. Add the following buffers to tubes #2 - 5
   - 2 ml pH 4.0 buffer to tube #2
   - 2 ml pH 6.0 buffer to tube #3
   - 2 ml pH 8.0 buffer to tube #4
   - 2 ml "Standard buffer" to tube #5
4. Add 2 ml of pancreatin to tubes #1, # 2, #3 and #4. The fifth test tube will have 2 ml of water as a negative control. Mix the contents of the tubes by covering them with *Parafilm* and inverting them three times.
5. Place all of the tubes in a 37^{o} water bath for 30 minutes.
6. Boil about 250 ml of water in a 500 ml beaker.
7. Once the water has come to a boil, add 5 ml of Benedict's solution (Benedict's solution tests for maltose) to each test tube. Mix the contents of the tubes by inverting them three times.
8. Place the test tubes in the boiling water for 3 minutes.
9. Immediately at the 3 minute mark, note the color of each tube. The amount of digestion is indicated by the color

blue	none	orange	+++
green	+	red	++++
yellow	++		

Questions:

1. What is the optimal pH for amylase?
2. What happens to the enzyme at different pH's? (be specific)
3. How does the pH of the food you eat affect digestion? Explain. (Careful, this is a trick question.)
4. What is the purpose of having a positive control (tube 1) and the negative control (tube 5)?

II. The effects of temperature on enzyme activity

As temperature changes, so does enzyme activity. Lower temperatures reduce kinetic energy and therefore the rate of reaction. Higher temperatures increase kinetic energy, but ultimately can cause an enzyme to denature. In this lab exercise we will try to determine the optimal temperature for pancreatic amylase activity.

Procedure:

1. Label 4 test tubes A through D with a grease pen. Add 5ml of starch solution to each test tube.
2. Add 2 ml of "Standard Buffer" to each of the tubes. Mix the contents of the tubes by covering the tubes with *Parafilm* and inverting them three times.
3. Place tube A in ice water bath (record the temperature)
   B at room temperature (record the temperature)
   C in the 37° water bath
   D in hot water bath (about 75°C)
4. Allow the tubes to adjust to the temperature for at least one minute
5. Add 2 ml of amylase to each tube (without removing the tube from the baths) .
6. Incubate tubes for 30 minutes.
7. Boil about 250 ml of water in a 500 ml beaker.
8. Take the tubes out of the baths and immediately add 5 ml of Benedict's solution to each test tube. Mix the contents of the tubes by inverting them three times. (Do not use Parafilm on the tube that was in the hot water.)
9. Place the test tubes in the boiling water for 3 minutes.
10. Immediately at the 3 minute mark, note the color of each tube. The amount of digestion is indicated by the color

blue	none	orange	+++
green	+	red	++++
yellow	++		

Questions:

1. What is the optimal temperature for amylase?
2. In what ways does temperature affect enzyme activity? (be specific)

III. The effect of substrate on enzyme activity

In this lab exercise we will try to determine how the amount of substrate available to the enzyme can influence the amount of enzyme activity

Procedure:

1. Take 4 test tubes and number them 1-4 with a grease pen. Add 1 ml of cream which contains litmus (a pH indicator which turns pink at low pH) to tubes each tube.
2. Add 1 ml of water to each tube.
3. Prepare the four tubes as follows

Tube #1	2 ml water (negative control)
Tube #2	2 ml pancreatin
Tube #3	2 ml pancreatin and 0.25 ml bile
Tube #4	2 ml water and 0.25 ml bile

4. Mix the contents of each tube by covering it with Parafilm and inverting it a few times. Note the color of each tube.
5. Place the tubes in a 37^{o} water bath.
6. Record the changes in color of the solutions every 10 minutes for 30 minutes.

Questions:

1. Why did some of the solutions change color faster than others?
2. How does bile affect the substrate concentration?
3. What would happen if you left the solutions in the incubator for 2 hours?

CELL MEMBRANES

In the following two laboratory exercises, we will study some properties of cell membranes and some factors that affect the movement of particles across membranes. The membrane we will study is the erythrocyte plasma membrane. Since all cell membranes have essentially the same structure and basic properties, the information we get from these exercises can be generalized to all membranes.

INTRODUCTION

I. OSMOSIS

Osmosis is often defined as the diffusion of water across a semi-permeable membrane. A semi-permeable membrane is one which allows some molecules to cross it, but not others. The most common example of a semi-permeable membrane is a cell membrane. It allows water to freely diffuse across it, but it does not allow most other materials to cross the membrane.

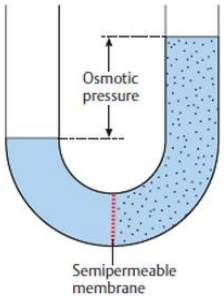
II. TONICITY

The tonicity of a solution is the concentration of particles in that solution. Solutions with more dissolved particles are **hypertonic**. Solutions with fewer dissolved particles are **hypotonic**. Two solutions with an equal number of dissolved particles are **isotonic**. Since water can diffuse freely across most cell membranes, the net flow of water is determined by the tonicity of the solutions on either side of the membrane. Osmosis is dependant on the tonicity of the solutions separated by a semi-permeable membrane. Water will osmose from hypotonic solutions into hypertonic solutions. If two isotonic solutions are separated by a semi-permeable membrane, there will be no net diffusion of water. If a cell is in a hypertonic solution, water will tend to osmose out of the cell and the cell will crenate (shrivel). If a cell is in a hypotonic solution, water will osmose into the cell and the cell will swell and it may ultimately lyse (break). We can therefore use the crenation or lysis of cells to determine the tonicity of a particular solution.

The measurement of the number of particles in solution is called the osmolarity of the solution. For example one mole of glucose (180g) dissolved in one liter of water will produce a one molar solution. This solution has an osmolality of one osmolar (1 Osm). A one molar solution of sodium chloride (58.5g/mole) will dissociate into one mole of sodium and one mole of chloride. Therefore, a one molar solution of NaCl will be a 2 Osm solution.

III OSMOTIC PRESSURE

The differences in tonicity between two solutions separated by a semi-permeable membrane created a force which causes the water to move. This force is called osmotic pressure. In the illustration below, we can see how osmotic pressure has pushed the fluid on the right up the tube against the force of gravity. The greater the tonicity difference, the greater the osmotic pressure.



Questions:

1. Is the membrane which makes up the rough endoplasmic reticulum a semi-permiable membrane? Explain why or why not.
2. What can happen to cells in your body if you drink too much water?
3. What is the osmolarity of the following solutions?
    A. 400 mM sucrose
    B. 400 mM calcium carbonate ($CaCO_3$)
    C. 400 mM magnesium chloride ($MgCl_2$)
4. What would happen if we put pressure on the right side of the tube above?

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Measurement of the Tonicity of Cells and Intercellular Fluid

We can determine if a solution is isotonic, hypotonic, or isotonic by placing erythrocytes into that solution. If the solution is isotonic, then the erythrocytes will appear normal under the microscope. If the solution is hypertonic, then the cells will crenate.

When erythrocytes are placed in a slightly hypotonic solution, the erythrocytes swell. In a very hypotonic solution, the cells will lyse. Since blood is a suspension of cells, once the erythrocytes are lysed, there is no longer a suspension of cells, and therefore the solution goes from being opaque to a clear red.

In this lab activity we will determine:
1. the osmolarity of the intracellular fluid in milliosmoles.
2. the effects of putting cells into solutions of varying tonicity

Procedure:
1. Place two milliliters of one solution listed below into a test tube.
2. Add one drop of sheep blood to the solution and mix gently. Immediately remove one drop of the blood solution from the test tube and observe under the microscope.
3. Repeat these steps for the other solutions in the table below and fill in the information in the table.
4. For each solution, calculate the molarity and osmolarity of the solution.
5. By looking at the solution and the microscopic appearance of the cells, determine whether each solution is hypertonic, isotonic, or hypotonic to intracellular fluid.

Solution	**Molarity**	**Osmolarity**	**microscopic appearance of RBC**	**appearance of solution in test tube**
physiological saline	(control)			
35 g/l NaCl				
8.5 g/l NaCl				
4.5 g/l NaCl				
90 g/l glucose				
54 g/l glucose				
18 g/l glucose				

Questions:
1. What is the purpose of using the physiological saline?
2. Which solutions were isotonic?
3. What is the approximate tonicity of intracellular fluid?
4. What is the approximate tonicity of blood and other extracellular fluids?

II. Diffusion: The effects of size

Small particles can diffuse across a cell membrane through transient pores in the phospholipid bilayer, while larger ones can not. As particles enter a cell, the osmolarity of that cell will increase and cause water to enter the cell. As water osmoses into a cell it will cause the plasma membrane to expand and eventually the cell will lyse.

Procedure:

1. Generate a hypothesis as to the size of the membrane pores. (Hint: Use information you learned in the lecture about membrane transport.)
2. Place two drops of sheep blood into two milliliters of each of the solutions below.
3. Immediately mix the solution.
4. Time how long it takes for the solution to become transparent. This can be done by holding the tube against a printed page and determining how long it takes until you can read the type.
5. If the solution clears within 60 seconds, repeat the experiment 3 times to calculate an average time for each solution to become transparent.
6. If the solution does not clear in 60 seconds, set it aside and look at it at 10 minute intervals for the 30 minutes.

	Molar Mass
0.3 M Ethylene glycol	62
0.3 M Propylene glycol	76
0.3 M Glycerol	92
0.3 M Glucose	180

Questions:

1. What is the size of the transient membrane pores?
2. What other factors, besides size, affects diffusion through the membrane?

III. Diffusion: The effects of lipid solubility

The greater the lipid solubility of a substance, the faster it will diffuse across a membrane. In this portion of the lab we will determine the rate of diffusion of molecules with different lipid solubilities. (Note that these molecules are also of different sizes, and that might also have an effect on your results.) As in the previous experiment, as molecules enter a cell, the cell's osmolarity increases, and the cell lyses.

Procedure:

1. Generate a hypothesis as to the effects of lipid solubility on membrane diffusion. Include a justification for your hypothesis.
2. Place two drops of sheep blood into two milliliters of each of the solutions below.
3. Immediately mix the solution.
4. Time how long it takes for the solution to become transparent. This can be done by holding the tube against a printed page and determining how long it takes until you can read the type.
5. Repeat this three times and calculate the average time for the solution to become transparent.
6. Repeat steps 2 - 5 for the next solution.

	Concentration	Formula	Molar Mass
Methyl alcohol (methanol)	0.3 M	CH_3 - OH	32
Ethyl alcohol (ethanol)	0.3 M	CH_3 - CH_2 - OH	46
Propyl alcohol (propanol)	0.3 M	CH_3 - CH_2 - CH_2 - OH	60
Butyl alcohol (butanol)	0.3 M	CH_3 - CH_2 - CH_2 - CH_2 - OH	74

Questions:

1. How does molar mass affect diffusion?
2. How does lipid solubility affect diffusion?

THE CELL CYCLE

The life cycle of cells involve a number of stages. When a cell is dividing, it is going through a series of steps to replicate its chromosomes and create two nuclei. This process is called mitosis. Cells that are non-dividing are in a state called G_0. Neurons, for example, almost never divide. Those non-dividing cells are in a state called G_0. Some cell types, like hepatocytes, are normally in G_0, but can occasionally be triggered to divide. Other cell types, like intestinal epithelial cells, never enter G_0.

When a cell divides, it goes through a number of stages, some of which can be seen through a microscope. We will be looking at slides of either onion root tips or whitefish embryos. These cells are constantly dividing. Before you begin, make sure that you know what events are occurring at each stage. Then, using the microscope slides of either, identify the different and draw stages of the cell cycle. Make sure to label each stage and the label the parts of the cells you drawing. Only include structures that are visible under the microscope. Turn in your drawings and answers to the questions at the end of today's lab.

Interphase
- G_1
- S
- G_2

Prophase
Metaphase
Anaphase
Telophase
Cytokinesis

Questions:
1. What other cell types, besides the two mentioned above, are always in the G_0 phase in an adult?
2. In what phase do organelles replicate?
3. Are there differences in how cells in the G_1, S, and G_2 phases appear under the microscope?
4. During which phase of the cell cycle are these cells beginning cytokinesis?
5. Which phase of the cell cycle is typically the shortest? How can you determine this?
6. Which phase of the cell cycle is typically the longest? Why does this phase need to be long?

GENETICS PROBLEMS

1. Achondroplasia (dwarfism) is an autosomal dominant disorder. A dwarf man has three children with a normal woman. One is a dwarf and the other two are of normal stature. What is the genotype of the man?

2. Lactase deficiency is an autosomal recessive condition. A woman who is lactose intolerant marries a man who has two normal lactase alleles. What is the probability that they will have a child who is lactose intolerant?

3. A woman with type A blood has a child with type O blood. The woman's husband has type B blood. Is it possible that the child is his? Explain.

4. Duchenne muscular dystrophy is a sex linked recessive trait. A woman who is a carrier marries a man who is normal. If they have a boy, what is the probability that he will have muscular dystrophy? If they have a girl, what is the probability that she will have muscular dystrophy?

5. Cystic fibrosis is a recessive autosomal disease. It occurs when the protein that actively transports chloride out of a cell is defective. The result is that the cells become hypertonic and all fluid secretions become very viscous. The lungs and other organs become blocked with a thick mucus which eventually is fatal. A couple, both of whom are heterozygous for CF, have a child who has CF. The couple wants to have another child. What is the probability that their second child will also have CF?

6. The enzyme galactase, which allows people to metabolize the monosaccharide galactose, is coded for by a single gene. Those that are homozygous for the abnormal galactase allele die during infancy. People who are heterozygous can metabolize galactase just as efficiently as those with two functional alleles. However, these people produce only half as much enzyme as those who are homozygous for the normal galactase gene. This suggests that the normal galactase allele is

A. dominant
B. recessive
C. codominant
D. incomplete dominant
E. an epigenetic trait

7. Polydactyly (having 6 fingers) is dominant over 5 fingers. Why are there so few 6 fingered people?

8. Eye color is most likely what type of trait?

A. dominant/recessive
B. codominant
C. polygenic
D. incomplete dominant
E. multiple allelic

9. In a survey of 100 people, about 3/4 of them have a second toe that is shorter than the big toe and about 1/4 have a second toe that is longer than the big toe. (There is no difference between men and women.) This suggests that the gene for a short second toe is

A. dominant
B. recessive
C. incomplete dominant
D. sex linked
E. there is not enough information to answer the question.

10. Some conditions (like alcoholism) tend to run in families. How might you be able to tell if a particular trait is a genetic trait or a non-genetic trait that is passed from parent to child?

Section II. Physiological Testing and Diagnosis

The purpose of these laboratory exercises is to provide you with insight into the processes of physiological testing and diagnosis and to allow you to gain a better understanding of physiological concepts.

1. Personal Health History

The purpose of a health history is to try to get as much information about a patient as possible. Health care providers need to know about a patient's current health, health concerns, as well as information about past medical conditions, since all these factors will affect diagnosis and treatment, and possibly predict a medical emergency.

In addition, undiagnosed conditions may be detected as a result of reviewing the health history. For example, a patient who feels healthy may have high blood pressure and not be aware of it.

2. Family Health History

A family medical history is a record of health information about a person and his or her close relatives. Families have many factors in common, including their genes, environment, and lifestyle. Together, these factors can give clues to medical conditions that may run in a family. By noticing patterns of disorders among relatives, healthcare providers can determine whether an individual, other family members, or future generations may be at an increased risk of developing a particular condition.

A family medical history can identify people with a higher than average chance of having a disorder, such as heart disease, high blood pressure, certain cancers, and diabetes. These complex disorders are influenced by a combination of genetic factors, environmental conditions, and lifestyle choices.

While a family medical history provides information about the risk of specific health concerns, having relatives with a medical condition does not mean that an individual will definitely develop that condition. On the other hand, a person with no family history of a disorder may still be at risk of developing that disorder. Some of these risks can also be identified in a good patient history.

Knowing one's family medical history allows a person to take steps to reduce his or her risk. For people at an increased risk of certain cancers, healthcare professionals may recommend more frequent **screening** (such as mammography or colonoscopy) starting at an earlier age.

3. Current Health Assessment

After completing all of the laboratory activities, you should have a fairly good means to assess your overall health. This assessment is not the same as, nor does it replace, having a professional medical exam. Using the results of your diagnostic tests, write up an overall health assessment which should include areas of concern about your health or lifestyle, potentially diagnosed illnesses, and prospects for future health.

Because personal and family medical history, by their natures, include information which you may not feel comfortable sharing, feel free to omit any portion of it or change any values for the purposes of these exercises. Likewise, you may omit or change any results of physiological tests you do in class if you want to keep them private. You will be graded on your ability to interpret data, not on the values you generate.

How to write up the clinical lab reports.

With the exception of the Results sections which are to be hand written in class, the lab reports should be typed at home.

For each laboratory activity or set of activities, you will need to write up the each of the following:

I. Brief title and description of the activity.
For example: "Measuring arterial blood pressure using a sphygmomanometer"

II. Purpose:
What is the goal of this activity? Is this a diagnostic test? If so, for what specific diseases or conditions is it testing? Is it demonstrating a physiological principle? If so, for what physiological concept are we testing?

III. Results:
Results should be hand written in pen during the lab. It's OK if it is a little messy. If you make a mistake, you may not erase; simply draw a line through your mistake. An inexplicable result is not necessarily a mistake! You should repeat the activity again to see if that result is consistent.

Example:
Emily measured my blood pressure three times:
118/71, 135/74, ~~111~~ 113/70

My average blood pressure was:
122/72

I was not sure about the second measurement, so I decided to have Michael measure my blood pressure and these results were:

117/75, 121/77, 119/76

My average blood pressure the second time was:
119/76

IV. Discussion and Conclusion:
This is the most important part of your write-up and usually the longest part. First, you need to explain your data and then you should draw appropriate conclusions from those data. In addition, you should explain if there is a problem with your data, including what makes you think there is a problem, where or how you think (in retrospect) the problem might have occured, and how the problem affects your interpretation of the data.

Example:

When Emily measured my blood pressure, the results were not consistent. The second measurement seemed very high. Because Emily had never used a sphygmomanometer before, I decided to ask Michael, who is an LVN and experienced at using a sphygmomanometer to take my blood pressure.

The results of these measurements was an average blood pressure of 119/76. We expect some variation from one measurement to the next simply because of when we hear the Korotkoff sound relative to the constantly moving needle on the dial, but Michael's data were fairly consistent.

The average blood pressure in the U.S. is 120/80, and at first glance my data show that my blood pressure is very close to average. This would suggest that I do not have hypertension - blood pressure above 140/90. I also don't have hypotension because I never feel dizzy or faint. However, for someone my age (19) and weight (123 lbs), this blood pressure is in fact a little high. Average blood pressure includes both men and women at all adult ages. Therefore, my numbers should be somewhat below average.

The reason for these results could be that I was a little tense at having to repeat this test. Having to stay late in lab to repeat this test when everyone else was leaving may have increased my blood pressure due to an increase in sympathetic stimulation of the cardiovascular system. This would have caused increased strength of ventricular contraction and may also have increased arteriole vasoconstriction. Both of these factors would have elevated my blood pressure.

It may also be that I have a slightly elevated blood pressure. While it is not a concern right now, it is something that I need to monitor in the future. My father has hypertension, and I may have inherited a predisposition to it.

V. Questions:

Often there are questions at the end of an activity. These questions should be restated in your write-up and then answered.

Medical History

_____ _____ _____
Name (Last) First M.I.

Date of Birth _____ Sex: ___ M ___ F

Weight _____lbs. _____kg. Height ____ft____in. _____cm.

Marital Status _____ Number of children ___ Ages/Sexes _____

Occupation_____

Number of units you are taking this semester_____

Are you currently under a doctor's care for any condition? ☐ yes ☐ no
If yes, explain_____

Are you currently taking any prescription medication? ☐ yes ☐ no
If yes, explain_____

Do you exercise regularly? ☐ yes ☐ no

Do you eat properly? ☐ yes ☐ no

Do you feel you are under a lot of stress? ☐ yes ☐ no

How would you describe your overall health? ☐ excellent ☐ good ☐ fair ☐ poor

Do you have any specific medical concerns or problems? _____

_____

Family Medical History

Do you or any of your close relatives (siblings, parents, parents' siblings, grandparents) have/had any of the following (check all that apply)

	you	relative (specify)	description
Alcohol addiction	☐	_____	_____
Allergies	☐	_____	_____
Arthritis	☐	_____	_____
Asthma	☐	_____	_____
Autoimmune disease	☐	_____	_____
Cancer	☐	_____	_____
Clotting disorders	☐	_____	_____
Frequent Colds	☐	_____	_____
Constipation	☐	_____	_____
Diabetes	☐	_____	_____
Diarrhea	☐	_____	_____
Dizziness	☐	_____	_____
Drug addiction	☐	_____	_____
Fatigue	☐	_____	_____
Headaches	☐	_____	_____
Hearing problems	☐	_____	_____
Heart disease	☐	_____	_____
Hepatitis	☐	_____	_____
High blood pressure	☐	_____	_____
Frequent indigestion	☐	_____	_____
Infectious disease	☐	_____	_____
Kidney disease	☐	_____	_____
Liver disease	☐	_____	_____
Lung disease	☐	_____	_____
Menstrual problems	☐	_____	_____
Mental illness	☐	_____	_____
Migraines	☐	_____	_____
Pains	☐	_____	_____
Skin problems	☐	_____	_____
Tuberculosis	☐	_____	_____
Thyroid problems	☐	_____	_____
Urinary problems	☐	_____	_____
Vision problems	☐	_____	_____
Other	☐	_____	_____

Physical Examination Results

Fitness

Caridovascular fitness: Schneider Test score _____

Balance_____

Agility and Dynamic Balance _____

Strength upper limbs: number of pushups in 60 sec. _____

lower limbs: broad jump_____cm standing from crossed leg position____

Flexibility _____

Body Mass Index _____

% body fat _____

BMR (Cal/day) _____

Estimated Cal/day _____

Actual average Calories used/day _____

Average Calories eaten/day _____

Reflexes

tendon reflexes	☐ normal	☐ abnormal (explain)_____
visual reflexes	☐ normal	☐ abnormal (explain)_____
Babinski reflex	☐ normal	☐ abnormal (explain)_____
Hoffmann reflex	☐ normal	☐ abnormal (explain)_____

Senses

Two point touch: right ____ cm (fingertip) ____ cm (palm) ____ cm (forearm) ____ cm (back)

left ____ cm (fingertip) ____ cm (palm) ____ cm (forearm) ____ cm (back)

Vision:

Corrected	right 20/_____	left 20/_____
Uncorrected	right 20/_____	left 20/_____
Pinhole	right 20/_____	left 20/_____
Astigmatism	right _____	left _____
Near point	**right** _____	**left** _____
Peripheral vision	**right** _____	**left** _____

Stereoscopic vision _____

Color vision ☐ **normal** ☐ **abnormal (explain)**_____

Taste: Taste threshold _____

Skittle flavors you can taste without using the sense of smell _____

Hearing:

right ear ____ db (250 Hz) ____ db (1000 Hz) ____ db (4000 Hz) ____db (8000 Hz)

left ear ____ db (250 Hz) ____ db (1000 Hz) ____ db (4000 Hz) ____db (8000 Hz)

Rinne Test _____

Muscular System

Response time: alert _____ distracted _____

Grip strength: maximum _____ time to 50% _____ motivated _____

Fatigue time: grip _____ repetitive motion _____

Cardiovascular System

Heart: ECG ☐ normal ☐ abnormal (explain)_____

Heart rate resting _____ exercise _____

lying _____ feet elevated _____ (initial) _____ (later)

Speed of blood flow _____ cm/sec

Heart sounds ☐ normal ☐ abnormal (explain)_____

Blood pressure:

resting ____/_____ sitting ____/_____ laying

exercise ____/_____

Blood: Hematocrit _____

WBC count

- neutrophils _____
- lymphocytes _____
- monocytes _____
- eosinophils _____
- basophils _____

Blood type _____

Fasting plasma glucose _____

Respiration

Spriometry: vital capacity _____

forced expiratory volume _____

% of average _____

FEV after exercise _____

Blood oxygen: rest ____ exercise _____ holding breath _____

Lung sounds: ☐ normal ☐ abnormal (explain)_____

G.I. Tract Sounds: ☐ normal ☐ abnormal (explain)_____

Urinalysis

	control	experimental (specify)
volume	_____	_____
color	_____	_____
clarity	_____	_____
specific gravity	_____	_____
blood	_____	_____
glucose	_____	_____
protein	_____	_____
urobilogen	_____	_____
ketones	_____	_____
pH	_____	_____

Microscopic Analysis _____

_____

Overall Health Assessment:

Using the data from the personal medical history, family medical history, results of the diagnostic tests done in class, nutrition and activity assessment, describe your overall health. What are some areas of current concern? What might be of concern as you get older? How might you improve your life-style?

FITNESS

There are many aspects to physical fitness. These include: cardiovascular endurance, balance and coordination, muscular strength & endurance and flexibility. The ideal is to be fit in all of these categories, so that a marathon runner is not necessarily more fit than a sprinter. In today's lab, we will do a brief assessment of each of these categories.

I. Cardiovascular Fitness

One of the simplest and most effective measures of cardiovascular fitness is the Schneider Test. This series of tests compares your heart rate at rest and after exercise. This gives us insight into the efficiency of the cardiovascular system to transport oxygen to the tissues.

Procedure:

1. Sit quietly for 3 minutes and measure your heart rate pulse in bpm (beats per minute).
2. Step up two stairs at a time, right foot first, then bring up the left foot and place it next to your right. Step down with the left foot and then bring the right foot down to the floor next to it. **Caution:** Hold the handrail in case you lose your balance.
3. Repeat this exercise five times, allowing only three seconds total time for each repetition.
4. Immediately after completion of the fifth repetition, measure your heart rate.
5. Continue to measure your heart rate for the next two minutes. Record your heart rate at 30 second intervals and graph the results.
6. Calculate your scores from the tables and calculate your overall fitness score.

Resting heart rate (bpm)	Score
< 70	3
71-80	2
81-90	1
91-100	0
101-110	-1
> 110	seek medical help

Difference between normal and immediate post-exercise heart rates

Resting heart rate (bpm)	Change in heart rate (bpm)				
	0-10	11-20	21-30	31-40	>40
<70	3	3	2	1	0
71-80	3	2	1	0	-1
81-90	3	2	1	-1	-2
91-100	2	1	0	-2	-3
101-110	1	0	-1	-3	-3

Time for heart rate to return to resting rate (sec)

Time	score
0 - 30	3
31 - 60	2
61 - 90	1
91 - 120	0
> 120	-1

Overall Fitness score

8 - 9	Excellent
7	Good
5 - 6	Fair
<5	Poor

II. Balance

Static balance is the ability to maintain one's position. This ability is due to coordination among the postural muscles. As people get older, their static balance ability often decreases which can lead to falls.

Procedure:

1. Stand on one foot for 60 seconds without touching your other foot on the ground.
2. Repeat with your other foot. (You have a dominant and nondominant leg, so one side should be a little easier than the other.)
3. If you find this easy, repeat while standing on your toes.

III. Agility and Dynamic Balance

Dynamic balance is the ability to move without falling. Increased dynamic balance often comes with training.

Procedure:

Run the T course touching all cones. 10 m to the first cone and 5 m to the right, turn around and 10 m to the next cone, return to the middle cone, then back to the start.

How fast were you able to run? Did you slip and fall?

IV. Muscular Strength

Many people confuse muscular strength with fitness. In fact, muscular strength is probably the least predictive of overall health. We do not have the time to do many strength tests, so we will just do one upper body test and one lower body test.

Procedure:

Upper limb: How many push-ups can you do in 60 seconds?

Lower limb: Standing broad jump.

How far can you jump from a standing position? (Best of 3 tries.)

V. Flexibility

As people age, they lose elastic fibers and therefore flexibility. This can often lead to lead to injuries such as strains and sprains. We will measure how much flexibility you have in your upper and lower limbs.

Procedure:

Stretch until it begins to hurt, not beyond. (This should be done after the cardiovascular test so that you are warmed up.)

Upper limb: To what angle can you raise each arm?

Abdomen: How far forward can you reach while sitting on the floor with your feet in front of you?

Hips: How far can you spread your legs?

VI. Strength and Balance

This simple test has been shown to be a very good predictor of susceptibility to cardiovascular disease. The ability to successfully carry out this activity is determined by body weight, strength, balance, and flexibility.

Procedure:

Sit cross-legged on the floor. Stand up without using your hands to help you push off the floor.

VII. Body Mass Index

Body mass index (BMI), is a measure of the relationship between the weight of a person and height. It is often used as a measure of obesity, though it is not appropriate for diagnosing individuals. Some people may have a high BMI but low fat levels (athletes) while others may have a low BMI but have high fat levels. Given the ease of calculating BMI, it is often used instead of direct body fat measurement.

Adult BMI Chart

BMI	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Height	**Weight** in Pounds																
4′10	91	96	100	105	110	115	119	124	129	134	138	143	148	153	158	162	167
4′11	94	99	104	109	114	119	124	128	133	138	143	148	153	158	163	168	173
5′	97	102	107	112	118	123	128	133	138	143	148	153	158	163	168	174	179
5′1″	100	106	111	116	122	127	132	137	143	148	153	158	164	169	174	180	185
5′2″	104	109	115	120	126	131	136	142	147	153	158	164	169	175	180	186	191
5′3″	107	113	118	124	130	135	141	146	152	158	163	169	175	180	186	191	197
5′4″	110	116	122	128	134	140	145	151	157	163	169	174	180	186	192	197	204
5′5″	114	120	126	132	138	144	150	156	162	168	174	180	186	192	198	204	210
5′6″	118	124	130	136	142	148	155	161	167	173	179	186	192	198	204	210	216
5′7″	121	127	134	140	146	153	159	166	172	178	185	191	198	204	211	217	223
5′8″	125	131	138	144	151	158	164	171	177	184	190	197	203	210	216	223	230
5′9	128	135	142	149	155	162	169	176	182	189	196	203	209	216	223	230	236
5′10″	132	139	146	153	160	167	174	181	188	195	202	209	216	222	229	236	243
5′11″	136	143	150	157	165	172	179	186	193	200	208	215	222	229	236	243	250
6′	140	147	154	162	169	177	184	191	199	206	213	221	228	235	242	250	258
6′1″	144	151	159	166	174	182	189	197	204	212	219	227	235	242	250	257	265
6′2″	148	155	163	171	179	186	194	202	210	218	225	233	241	249	256	264	272
6′3″	152	160	168	176	184	192	200	208	216	224	232	240	248	256	264	272	279
	Healthy Weight						Overweight					Obese					

SOURCE: US Department of Health and Human Services, National Institutes of Health, National Health, Lund, and Blood Institute, The Clinical Guidelines on the Identification, Evaluation and Treatment of Overweight and Obesity in Adults: Evidence Report, September 1998 [NIH pub. No.98-4083].

VIII. Percent body fat

The most reliable way to measure percentage of body fat is to immerse a person in water and determine their density. While it might be fun to do this in class, it is not practical. Another method for measuring body fat is measuring skin fold thickness. It measures the amount of fat in the hypodermis by pinching the skin in various locations around the body and measuring its thickness. This method is also not very practical in a classroom situation. The method we will use is not as accurate, but does give adequate results. It involves measuring the electrical resistance of the body. Electricity does not flow well through fat, so we can measure approximately how much fat is in the body by measuring the resistance to the flow of electricity using the electronic fat meters.

A portion of the fat in your body is essential fat, also known as structural fat. This fat is not used for metabolism, but used as a structural component of the body. For example, the fat on the sole of the foot, around the kidneys, etc. is structural. One should never get to the point where the body is so starved that it is using this fat. Being "underfat" risks reaching that point.

The normal percentage of body fat increases with age. However, this increase is relatively small. People tend to become overweight as they age because their eating habits do not change as they get older; de spite the fact that most people's activity level decreases with age.

Women

Essential fat: 10-13%

Age	Underfat	Healthy Range	Overweight	Obese
13-17 yrs	Under 15%	16-30%	31-36%	Over 36%
20-40 yrs	Under 21%	21-33%	33-39%	Over 39%
41-60 yrs	Under 23%	23-35%	35-40%	Over 40%
61-79 yrs	Under 24%	24-36%	36-42%	Over 42%

Men

Essential fat: 2-5%

Age	Underfat	Healthy Range	Overweight	Obese
15-40 yrs	Under 8%	8-19%	19-25%	Over 25%
41-60 yrs	Under 11%	11-22%	22-27%	Over 27%
61-79 yrs	Under 13%	13-25%	25-30%	Over 30%

IX. Metabolic Rate

Metabolic rate is the overall level of chemical reactions in the body. The simplest way to measure metabolic rate is to measure the number of calories a person uses in a day. This is done by putting a person in a sealed room and measuring the amount of oxygen used. A person's metabolic rate is going to vary depending on the amount and type of activity, the size of a person, the temperature of the environment, etc.

Calculating Lean Body Mass

LBM is lean body mass. It is your weight in kilograms minus the weight of your body fat. For example, if you weigh 75 kg and have percent body fat of 20% then you have 15 kg of fat. Your lean body mass is therefore 75 - 15 = 60 kg.

Basal Metabolic Rate (BMR)

This is a more useful measure of chemical activity in the body. BMR is measured at rest and compensates for a persons size. A person's BMR is determined by a variety of hormones. BMR's of healthy people do not vary very much from person to person. (Being obese because of a "hormonal problem" is extremely rare.) The formula for estimating your BMR is:

BMR = 370 + (21.6 x LBM)

Since fat cells are not very metabolically active, they use very little energy. Therefore, we can eliminate them from our calculation of BMR.

Knowing your BMR, you can estimate your daily Caloric needs by multiplying by an activity factor.

Daily Calorie requirement

Activity Factor	Category	Definition
1.2	Sedentary	Little or no exercise (most college students).
1.375	Lightly Active	Light exercise or sports 1-3 days a week or a job where you stand all day.
1.55	Moderately Active	Moderate exercise or sports 3-5 days a week or a job where you walk all day.
1.725	Very Active	Hard exercise or sports 6-7 days a week.
1.9	Extremely Active	Hard daily exercise or sports or extremely physical job (very few people fall into this category).

Example: A woman who weighs 65 kg and has 25% body fat. Her lean body mass is 48.75 kg.
Her BMR would be 370 + (21.6 x 48.75) = 1423 Calories. The daily calorie requirement for this woman, assuming she is a student who does not exercise regularly is 1.2 x 1423 = 1708 Calories.

1. Calculate each of the following: BMI, % body fat, BMR
Estimated total Calories you need per day

2. Are there any factors which might cause any of the numbers calculated above to be inaccurate? If so, what are they?

REFLEXES

A reflex is defined as a simple involuntary behavior caused by a specific stimulus. There are hundreds of different types of reflexes. We can categorize neural reflexes as belonging to a number of different categories. In some ways these categories are arbitrary since all neural reflexes are quite similar.

Innate vs. learned reflexes: Innate reflexes, like sneezing, are those that are not learned. Learned reflexes are ones that are acquired through repetition, such as having your blood pressure go up every time you hear the words "physiology exam."
Visceral vs. somatic reflexes: Visceral reflexes are ones which affect the organs, like pupil dilation. Somatic reflexes are those that affect the skeletal muscles.
Cranial vs. spinal reflexes: Cranial reflexes are those that involve the cranial nerves whereas spinal reflexes involve the spinal nerves.

Endocrine reflexes: These are simple endocrine responses (the release of specific hormones) which are caused by specific stimuli. In some cases, endocrine reflexes work along with neural reflexes.

Many reflexes are so common that most people do not think of them as reflexes, such as: sneezing, coughing, and urinating. Testing reflexes is an important diagnostic tool to assess the health of the nervous system. A thorough neurological exam will consist of testing dozens of reflexes. An exaggerated reflex suggests damage to the central nervous system, such as an injury or stroke. An inhibited or absent reflex suggests damage to the peripheral nervous system, perhaps to due severing or pinching a nerve, or peripheral neuropathy, or it may be due to a problem with the muscle. Testing the patellar tendon reflex is a very common in routine physical exams, even though it is useless on its own. In order to get any useful information about the nature and extend of a neurological problem, many reflex tests must be done.

I. Tendon reflexes

Reflexes are constantly used to maintain posture. As a tendon is stretched, the muscle will contract reflexively to maintain a constant force.

A. Patellar tendon reflex
Procedure:
1. Sit on the edge of the lab table with your feet dangling.
2. Have your partner tap on your patellar tendon with a rubber mallet.
3. Record how many cm your foot moved.
4. Repeat with the other knee.
5. Repeat steps 1 - 4 but this time while counting backwards from 100 by 7's (100, 93, 86 etc.)
6. Do 20 squats (more if you are in very good shape) and repeat steps 1 - 4.

B. Achilles tendon reflex
Procedure:
1. Kneel on a chair
2. Have your lab partner tap on your Achilles tendon with a rubber mallet.
3. Record how many cm the toes moved.
4. Repeat with the other foot

C. Biceps reflex

Procedure:

1. Extend your hand out and have your lab partner hold up your hand at the wrist.
2. Have your lab partner tap your biceps tendon (at the radial tuberosity) with a rubber mallet
3. Did you or your partner feel the movement?
4. Repeat with the other forearm.

II. Visual Reflexes

A. Pupillary reflex

This test is used as a very quick measure for brain injury. Bleeding (subdural hematoma) or swelling (cerebral edema) puts pressure on the oculomotor nerve. This causes the pupils to become fixed (non changing) and dilated.

Procedure:

1. In a dark room, shine a light into your partner's eye.
2. Repeat with the other eye.

B. Nystagmus

This test is used routinely, especially in children, to gauge their visual acuity.

Procedure:

1. Spin the optokinetoscope slowly and observe your partners eye movements.
2. Repeat, but this time, spin it faster.

III. Other reflexes

A. Babinski reflex

This reflex is used to test the integrity of the connection between the brain and the spinal cord. In a negative Babinski response (normal) the toes curl. In a positive Babinski response, the toes curl outward. Positive Babinski responses are found in cases where the spinal cord or brain is damaged, multiple sclerosis, and in children under 1 year of age.

Procedure:

1. Quickly run the pointed metal end of the reflex hammer along the lateral side of the foot going from the heel to the toes.
2. Repeat on the other foot.

B. Hoffmann's reflex

This reflex tests whether there is damage to the primary motor neurons which go from the brain to the spinal cord.

Procedure:

1. Flick the terminal phalanx of the middle finger. If the thumb flexes, it is a positive response.
2. Repeat on the other hand.

C. Dive reflex

The dive reflex is found in most mammals. It is used to decrease oxygen demand when diving so you can stay under water a little longer.

Procedure:

1. Put on a pulse-ox meter and let it reach a steady pulse rate.
2. Stick your face in cold water for 30 seconds.
3. Have your lab partner record changes in the pulse rate.

D. Pupillary-skin reflex

Some reflexes, such as this one, make no sense, but they are fun to do.

In a dark room, gently scratch the back of the neck 3 cm lateral to the midline and observe the pupil. Repeat on the other side.

Questions:

1. How does counting backwards affect reflexes?
2. How does exercise affect reflexes?
3. Why is the Achilles tendon reflex the easiest tendon reflex to see?
4. Why was the biceps tendon reflex harder to see than the other tendon reflexes?
5. Why do infants exhibit a positive Babinski response?
6. How might the nystagmus reflex be used to test the visual acuity of infants or non-verbal adults?

Fill in the following table and include this page with your reflex lab writeup:

	variable	receptor	control center	effector	positive feedback, negative feedback, or neither	reflex? Y or N
scenario 1						
scenario 2						
scenario 3						
scenario 3						
scenario 4						
scenario 5						
scenario 6						

Scenario 1: When intense physical activity increases the level of CO_2 in the blood to the dangerous levels, the carotid bodies in the carotid arteries sense the change in CO_2 and send a message to the medulla oblongata. The brain responds by stimulating the chest muscles and diaphragm to increase lung ventilation. This lowers the blood CO_2 level.

Scenario 2: When a baby starts suckling at the breast of its mother, the nerve endings in the nipple detect the suckling and send impulses to the hypothalamus. The hypothalamus releases a hormone (oxytocin) that stimulates milk secretion from the mammary glands. The release of milk causes more suckling at the breast and the cycle goes on until the baby is full.

Scenario 3: After a meal, nutrients are absorbed by the small intestine and the concentration of those nutrients in the blood rises. High glucose level is detected by the ß-cells of pancreas, which respond by releasing a chemical messenger, insulin. Insulin signals the liver to take up glucose and store it. As the result, the blood glucose concentration is returned back to the normal level.

Scenario 4: When a blood vessel is damaged, collagen is exposed. This stimulates platelets to attach to the site of damage and start releasing signaling chemicals (platelet activating factors). These chemicals attract more platelets to the area and stick to each other. These new platelets recruit even more platelets to stick to each other. The platelets continue to pile up and release chemicals until a platelet plug is formed large enough to seal the damaged area.

Scenario 5: Your instructor is telling the class information that will be on the next exam. Your hippocampus processes that information and allows you store that information in the cingulate gyrus of the brain. On the exam you retrieve that information and answer the question correctly. You then pass the class and go on to many more years of school and answering many more questions correctly.

Scenario 6: When a person is walking normally, the hamstrings stretch slightly. Proprioceptors in the muscle sense the stretch and send the information to the spinal cord. The spinal cord then signals the muscle to contract slightly to prevent the muscle from over stretching which allows you to continue to walk normally.

SENSORY PHYSIOLOGY

I. Skin Receptors

There are many types of sensory receptors in the skin: touch, pressure, pain, heat, cold, etc. In these laboratory exercises we will analyze the distribution and properties of some of those receptors.

A. Two point touch discrimination

This test not only allows us to determine the size of receptive fields in different regions of the body, but it can also serve as an important diagnostic test. Peripheral neuropathies may decrease sensitivity to touch and therefore may reduce one's two point touch discrimination. Stroke or other brain damage affecting the post-central gyrus may also reduce one's ability to sense touch.

Procedure:

With your eyes closed, have your lab partner touch you with either one or two points of the two-point caliper. Start at about 1 cm and go up or down from there until you get consistent results.

Test the following areas:

a. fingertip
b. palm
c. anterior forearm: measure separately both along the length of the forearm and along the width
d. lower back (be careful not to cross the midline when measuring)

Questions:

1. How does this relate to receptive fields?
2. How does this relate to the pattern of dermatomes?
3. How does this relate to the post-central gyrus?

B. Localization of touch

One of the reasons we have discrete receptive fields for touch is to be able to localize where on the skin the sensation was felt. Anything that interferes with sensory signals, such as neuropathies, stroke, decreased blood flow to the brain or skin, etc. will also affect one's ability to localize sensation.

Procedure:

With your eyes closed, have your lab partner touch you with a marker. Using a different colored marker, try to touch the same spot. Measure the distance between the two marks.

Test the following areas:

a. fingertip
b. palm
c. anterior forearm

Question:

What causes this phenomenon?

C. Temperature receptor distribution

There are both hot and cold receptors in the skin. In this activity, we will determine the location and relative number of those receptors.

Procedure:

1. Using the stamp pad, mark the anterior (ventral) forearm and make a similar stamp in your lab book.
2. Close your eyes and have your lab partner randomly select a hot, cold, or room temperature rod and touch a square.
3. For each point mark down whether you felt the probe as hot, cold, or room temperature.
4. Repeat until you have mapped about a dozen squares.
5. Compare what you felt with the actual probe temperatures.

Questions:

1. Are there more hot or cold receptors?
2. Why aren't receptors evenly distributed?
3. What happens if you touch a hot receptor with a cold probe? Why?

D. Sensory adaptation

For many senses, the ability to sense change is more important than the ability to perceive constant stimuli. Some receptors are fast adapting and others slow adapting. In this activity we will test the ability of two types of receptors to adapt to constant stimuli.

Temperature receptor adaptation

Procedure:

1. Fill one container with ice water, one with room temperature water and one with 45^0 C water.
2. Place one hand in the cold water and the other in the hot water for 2 minutes
3. Place both hands in the room temperature water.
4. How does each hand feel?

Questions:

1. Are temperature receptors tonic or phasic?
2. Are touch receptors in the skin tonic or phasic?
3. Why is the advantage of having some receptors tonic and others phasic?

E. Referred pain

Many sensations, like visceral pain, can not be localized well. We often perceive those sensations as coming from regions other than where they originate. For example, ice cream headache or "brain freeze" is due to cold sensation in the mouth and throat. We do not understand how referred pain works, but it is clinically significant because it can often lead to misdiagnosis.

Procedure:

Place your elbow in ice water for 1 minute. Describe the location and sensations in your hand.

Question:

What nerve is conducting this sensation?

II. Vision

A. Visual acuity

It is estimated that more than 70% of the population has problems with visual acuity, the ability to see objects clearly. One of the most common causes of lower visual acuity is myopia. Myopia is due to an elongated eyeball which causes near-sightedness, the inability to see far objects clearly. Visual acuity is routinely measured by using a Snellen chart. The results are given in numbers such as 20/75. That means that this individual can read at 20 feet what someone with no visual problems can read at 75 feet. Likewise if you have 20/15 vision, your vision is better that the average person with no visual problems because they have to be 15 feet from the Snellen chart in order to see what you can see at 20 feet.

Procedure:

1. Stand 20 feet from the Snellen chart
2. Cover one eye with the eye occluder and starting at the top row read the letters.
3. If you wear glasses or contacts, do this test both with and without them.
4. The last line you can read correctly with only one or two errors represents your visual acuity.
5. Look through the pinholes in the eye occluder. and repeat the eye test.
6. Repeat steps 1 - 6 with the other eye.

Questions:

1. What problems does this test diagnose?
2. What is the purpose of the pinhole test?
3. How can you distinguish among the different visual problems?

B. Astigmatism

Astigmatism occurs when the eye cannot focus evenly in all directions. For example, vertical lines may appear blurry, but horizontal lines do not. About 30% of the population has some astigmatism. This is usually caused by a congenital defect in the curvature of the cornea. Since the cornea is the main focuser of light coming into the eye, any alteration in the roundness of the cornea will affect visual acuity.

Procedure:

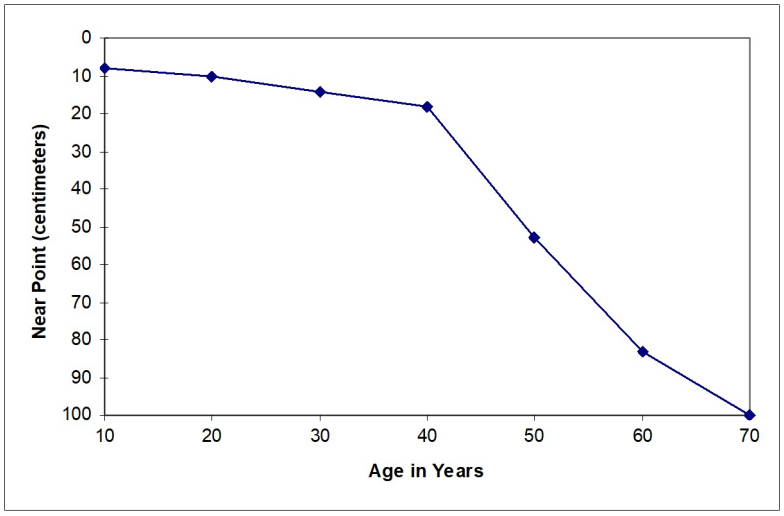
1. Stand 10 feet from the astigmatism chart cover one eye.
2. If you wear glasses or contacts, do this test both with and without them.
3. If you have a problem seeing the lines from this distance, move closer.
4. Do any of the lines appear darker than the others? If so, you have astigmatism.
5. Repeat with the other eye.

Question:

How does one treat astigmatism?

C. Near point

Near point is how close an object can be and still remain in focus. A near point of greater than 25 cm. is considered a problem. Sometimes this far-sightedness is caused by a shortened eyeball. This is known as hyperopia. A much more common cause of far-sightedness is presbyopia. Presbyopia occurs as people age. Their lenses lose elasticity and eventually can no longer focus on near objects. The chart below shows the changes in near point with age. Everyone, except for some people with severe myopia will need reading glasses by the time they are in their late 40's or early 50's.



Procedure:

1. Hold a meter stick to your cheek just below the eye with one hand.
2. With your other hand, hold a pin vertically at the far end of the meter stick.
3. Slowly run the pin along the meter stick toward your eye until the pin becomes blurred. Measure that distance.
4. Repeat with the other eye.
5. Record the near point for each eye.

D. Peripheral vision

Some visual problems result in loss of central vision and others in a loss of peripheral vision. The above tests are for central vision. This test is for peripheral vision. Normal peripheral vision is about 90^0 laterally and 35^0 medially, although at these extremes it is very difficult to distinguish colors and shapes.

Procedure:

1. Hold the peripheral vision apparatus to your nose while you look over the top.
2. Have your partner slowly move the letters forward. When you can first see the letters is the farthest extent of your visual field.
3. Continue until you can read the letters clearly.
4. Repeat with the other eye.
5. Record the angle for the first appearance of the letters and when they become clear.

Questions:

1. What visual problems might result in a loss of peripheral vision?
2. What visual problems might result in good peripheral vision but no central vision?

E. Blind spot

The blind spot located where the optic nerve exits the retina. It is an area in the visual field with no photoreceptors. The blind spot is not noticed because the brain fills in the image. If there is damage to the retina, other blind spots may be present and likewise not noticed unless specifically tested for.

Procedure:

1. Close your left eye and put your nose almost on the page so that your right eye is over the cross.
2. Slowly lift your head while looking at the cross. At some point the dot will disappear.
3. Measure the distance between your eye and the paper.
4. Turn the book upside down and repeat with the other eye.
5. Record the blind spot distance for each eye.

F. Color blindness

There are a number of different types of color perception deficiencies. Almost all of them are X-linked, and therefore are much more common in men than women. The most common types of color deficiencies involve red and green cones. The types of color blindness and their approximate frequency in the population are given below:

"Red weakness"	1% of males - Under poor light might mistake red for yellow. (see a red traffic light in the rain as a yellow light)
"Green weakness"	5% of males - Might mistake green for yellow. (see a light green apple as a yellow apple)
"Red blindness"	1% of males - No ability to see red. (red traffic light appears to be out)
"Green blindness"	1% of males - Cannot see green. (Red and green traffic lights look the same)

Fewer than 0.5% of women have color deficiencies.
About 1 in one million males have total color blindness; they see the world in black and white.

Procedure:
Go through the color blindness book with your lab partner. Can you see the numbers and designs?
What types of color blindness are being tested?

G. Stereoscopic vision

When both eyes work together, they allow you to see stereoscopically so that objects appear in three dimensions. If one eye does not see as well as the other, it will hinder one's ability to see stereoscopically. In extreme cases, such as amblyopia, one eye does not work at all and one has no stereoscopic vision.

Procedure:
Using the stereoscopic vision, determine the minimum level of your stereoscopic vision.

H. Optical illusions

Optical illusions, while fun, also illustrate some important properties of the visual system. One way to classify optical illusions is dividing them into two categories, sensory illusions and cognitive illusions.

Sensory illusions are due to the physiological properties of photoreceptors. Receptor fatigue, bleaching of photoreceptors, inhibition are all examples of sensory neuron properties. Cognitive illusions are due to the way the brain processes information. Because the brain has to compensate for movement, the blind spot, variation in lighting, etc., how you perceive the world is not how the world actually appears.

Procedure:
Look at the optical illusions and determine which are sensory illusions and which are cognitive illusions.
Try to determine how the nervous system's function causes each illusion.

III. TASTE and SMELL

Even though the sense of taste is used every day, its physiological importance is often underappreciated. Taste not only serves to make our food palatable. Many medications dull the sense of taste and therefore lead to a loss of appetite and eventually malnutrition. The sense of taste also serves to protect us from potential toxins in our food since most toxins have a bitter taste. Also, if we are low on certain nutrients, we have cravings for foods that contain those nutrients.

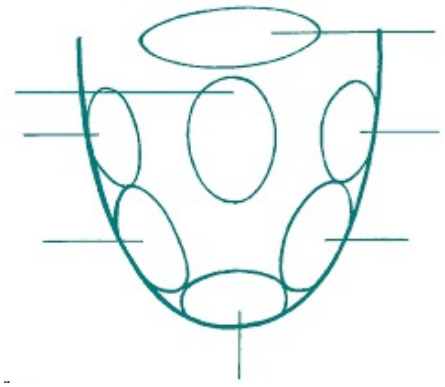
A. Distribution of taste receptors

There are five known taste receptors: salt, bitter, sweet, sour, and umami (meat flavor). There are many other tastes as well, but their receptors have not been identified. Most chemoreceptors can respond to more than one taste. For example one type of chemoreceptor is very sensitive to salt and somewhat sensitive to sweet and sour. (Very handy for Chinese food.) The distribution of the different types of chemoreceptors is not uniform. There are regions of the tongue that have very few taste buds, while other regions have many taste buds that contain chemoreceptors which are especially sensitive to one particular taste.

In this exercise, you will map the tongue and determine where on the tongue you are most sensitive to particular tastes.

Procedure:

1. Stick out your tongue.
2. Dry your tongue with a KimWipe
3. Have your lab partner wet a cotton swab with one of the taste solutions.
4. Dab the swab on a specific regions of the tongue.
5. Do you taste the solution? If so, map it on the tongue.
6. Repeat with the next region.
7. Rinse your mouth with water and repeat steps 1 - 6 with another taste solution.
8. Draw a map similar to the one below. Label which regions of the tongue are sensitive to which tastes.



B. Relationship between taste and smell

What we consider the sense of taste is actually a combination of senses including taste, texture, temperature, and perhaps most important, smell. In this exercise, we will determine the effects of smell on the sensation of taste.

Procedure:

1. Close your eyes and pinch your nose closed.
2. Have your lab partner give you a Skittle and chew it for 5 seconds.
3. What flavor was that Skittle?
4. Continue chewing the Skittle for a little while longer. Can you taste it now?
5. Repeat using the same or other flavor Skittles.
6. Record the accuracy of your guesses.

Questions:

1. What flavors we re you able to taste?
2. What is different about chewing for more than 5 seconds?

Procedure

1. Repeat the above, but this time instead of pinching your nose closed, have your lab partner dip a cotton swab in a fragrant oil and put it under your nose as you are chewing. Repeat with other oils and Skittle flavors.
2. Record the accuracy of your guesses.

Questions:

1. What flavors can you sense?
2. Do some fragrances interfere more than others with taste?

IV. HEARING

More than 25 million Americans suffer from hearing loss. Hearing loss can be classified as either conduction deafness or nerve deafness. Conduction deafness is due to problems in the outer or middle ear resulting in a loss of vibration. This is very common and is often temporary and treatable. Causes of conduction deafness include middle ear infections, ruptured ear drum, build up of wax or osteoarthritis of the middle ear bones.

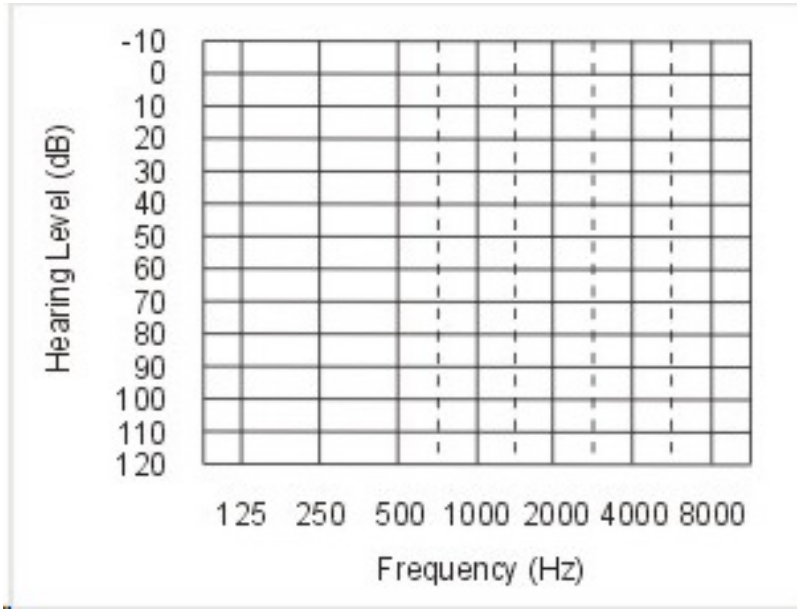
Nerve deafness is usually due to damage to the hair cells in the cochlea. One common cause is exposure to loud sounds which damages the hair cells. Another common cause is the deterioration of the hair cells with age.

A. Audiometry

Audiometry is a simple and useful hearing test to determine the thresholds for hearing at different frequencies. The loudness of a sound is measured in decibels (dB). A normal speaking voice is between 20 and 50 dB. Traffic noise is about 90 dB. A loud rock concert may be 120 dB. The human ear is capable of hearing sound frequencies between 100 and 10,000 Hertz, (Hz = cycles/sec.) As people age, they typically lose the ability to hear sounds at the very low range and the very high range.

Procedure

Because of time limitations, you will only determine the loudness threshold in dB for the following frequencies: 250, 1000, 4,000 and 8,000. Map out your hearing using blue pencil for the left ear and red for the right.



B. Rinne test

This test is used to distinguish between nerve deafness and conduction deafness.

Procedure

1. Plug one ear with cotton and test the other ear.
2. Strike a tuning fork and hold the end to the mastoid process of the temporal bone. Can you hear the sound?
3. Move the tuning fork to in front of the ear. Is the sound louder?
4. Repeat steps 2 - 3 with the ear that is plugged with cotton.
5. Repeat steps 1 - 4 with the other ear.
6. Record whether you could hear the sound better in the plugged ear vs. the unplugged ear.

Questions:

1. What does the cotton plug simulate?
2. Why is the tip of the tuning fork placed on the mastoid process?

C. Sound localization

The brain is able to localize sound by comparing the time difference between sound entering the right and left ear. Even though this time difference is tiny, we are able to use it to great effect.

Procedure:

1. Sit in a quiet room and close your eyes.
2. Have your lab partner strike a tuning fork at various regions surrounding the head.
3. Try to localize that sound.
4. Repeat a number of times and map your auditory field.

Questions:

1. Where in your auditory field could you not localize sound well?
2. What effect would deafness produce?
3. What effect would partial deafness produce?

V. EQUILIBRIUM

The vestibular system is directly associated with eye movement, balance, and for reasons no one understands, the stomach.

A. Nystagmus

Nystagmus is the rapid movement of the eyeball.

Procedure

1. Sit in a revolving chair and close your eyes.
2. Tilt your head forward.
3. Rotate about 10 times. (If you are prone to motion sickness, you may rotate less.)
4. Have your lab partner look at your eyes. Record which way are they moving relative to the direction of spin.

MUSCLE PHYSIOLOGY

I. Grip Strength and Electromyogram (EMG) Activity

Introduction

A motor unit is composed of a motor neuron and all the muscle fibers that are innervated by that motor neuron. In a persistent muscle contraction, like a clench, multiple motor units are firing repetitively throughout the contraction of the muscle. The strength of a muscle contraction is related to the number of motor units in the muscle that are activated. The electromyogram (EMG) recorded during the muscle contraction is seen as a burst of spike-like signals, and the duration of the burst is about equal to the duration of the muscle contraction. The strength of a striated muscle contraction is directly proportional to the amount of electrical activity in the muscle.

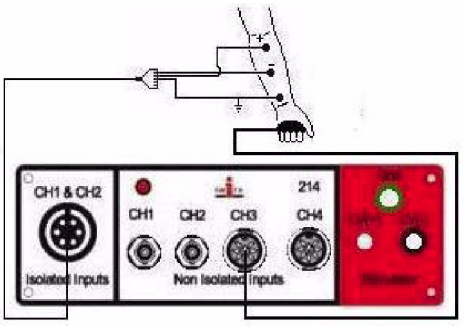
EMG is a useful tool for diagnosing problems with the nervous system and myopathies, diseases of muscle. If the EMG shows smaller spikes than expected, it suggests fewer muscle fibers are contracting, or the action potentials are not normal.

In this activity, you will use a hand dynamometer to measure a strength as the EMG activity of the forearm muscles used to generate the grip are recorded. Recordings of prolonged grip strength and forearm EMG activity will also be made to determine the rate of fatigue in the forearm.

Procedure:

1. Remove all jewelry from the wrist of your dominant hand.
2. Use an alcohol swab to clean the regions where the electrodes will be placed. One area is near the wrist, the second is in the middle of the forearm, and the third area is about 2 inches from the elbow. Let the areas dry before attaching the electrodes.
3. Remove the plastic disks from a disposable electrodes and apply them to the specified areas.
4. Attach three color-coded electrode cables

• the red lead is attached to the electrode near the elbow.
• the black lead is attached to the electrode in the middle of the forearm.
• the green lead (the ground) is attached to the electrode on the wrist.



A. EMG Intensity and Force

The purpose of this exercise is to determine the relationship between the intensity of EMG activity and the force of a muscle contraction. The EMG is due to the electrical activity of skeletal muscle. The greater the number of muscle fibers contracting, the greater the EMG signal.

Procedure

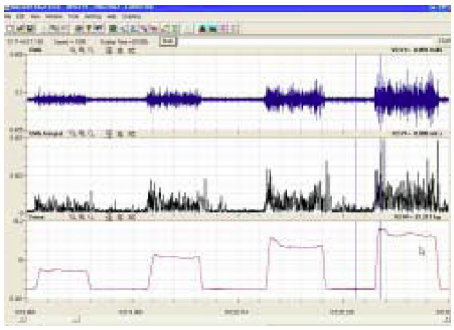
1. Sit quietly with your dominant forearm resting on the table top .
2. Clench your fist around the hand dynamometer four times, each clench should be two seconds long followed by two seconds of relaxation. Each clench should be stronger than the previous one.
3. Click the **AutoScale** buttons for the **EMG** (CH 1), **EMG Integral** (CH 2), and **Force** (CH3) channels. The recording should be similar to the first figure below.

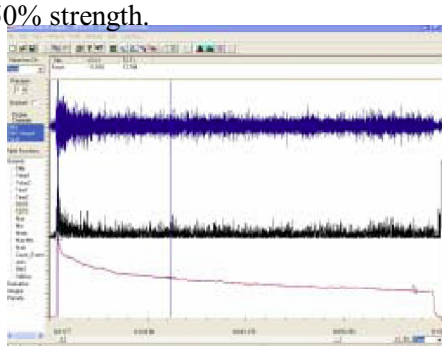
B. EMG Intensity and Fatigue

The purpose of this exercise is to see the effects of fatigue on EMG activity in the forearm. With prolonged contraction, the strength of the contraction can not be maintained.

Procedure

1. Sit quietly with your dominant forearm on the table top.
2. Click the **Start** button on the LabScribe **Main** window to begin recording. Record a baseline for a few seconds,
3. Clench the hand dynamometer as tight and as long as possible in an attempt to fatigue the muscles of the forearm.Click the **AutoScale** buttons on all three recording channels. Record the start time. Record the maximum force.
4. Continue to record the fatigue of the subject's forearm until the force of the muscle contraction drops below 50% of the maximum. Record how long it took for the muscle to fatigue
5. When the subject is at 50% strength, encourage the subject to exert more force. Record how much more force was generated. Record how long it takes to get back to 50% strength.





Questions:

1. Do muscle fibers have a refractory period like nerve fibers?
2. Does the amplitude of the EMG signal and the force of contraction increase because a finite number of fibers are firing more often, or because more fibers are recruited to fire as the intensity of signals in the motor neurons increases, or a combination of these two?
3. Compare your data with others. Does the strength of the forearm relate to the time it takes to fatigue?
4. Why does fatigue occur faster in the second part of the exercise? (Hint: What is causing fatigue?)

II. Response Time

Response time is the sum of the time it takes to transmit and process neural signals and stimulate muscle contraction. In this activity we will measure how long it take for you to respond to a falling meter stick?

Procedure:

1. Have your partner hold a meter stick while you place your thumb and forefinger about 5 cm apart along the 0 of the meter stick.
2. At random intervals the stick should be dropped and you try to catch it between your fingers.
3. The distance the stick fell can be used to determine the reaction time by using the following formula:

$$\text{time(sec.)} = \sqrt{\frac{\text{distance (cm)}}{490}}$$

5. Repeat this 5 times and calculate your average response time.
6. Repeat the experiment, but this time have your partner converse with you and ask you questions like "What is your favorite movie?" or "How would changing monetary policy affect GDP growth?"

Question:

How does thinking about something else affect your response time? What does this tell you about driving and talking on a cell phone?

III. Muscle Length-Tension Relationship

This activity measures the force your triceps brachii muscle can generate when it is almost fully extended and when it is partly contracted.

Procedure:

1. Have your lab partner hold a bathroom scale on the wall.
2. Push as hard as you can on the scale with the palm of your hand while your elbow slightly bent (150^0). Record the force you generated (weight on the scale.) Be sure to push with your arm not with your body leaning forward!
3. Repeat the process with your elbow at a 120^o and a 90^o angle.

Question:

Why does the force change with the length of the muscle?

IV. Effect of Altering Muscle Tone

Procedure:

1. Stand sideways along a wall with your feet about 12 inches from the wall.
2. Press against the wall with your forearm as hard as you can for 60 seconds. (It will be hard to sustain the force, but try.)
3. After 60 seconds, immediately step away from the wall and relax your arm.

Question:

What is happening and <u>why</u>?

V. Fatigue

Even the simplest and easiest of activities will result in fatigue if done often enough. This type of activity has little physiological effect on the muscle, so why can we not continue it for long periods of time? It is thought that this type of fatigue is due to the effects of the CNS and is called central fatigue.

Procedure:

1. Squeeze a rubber bulb at a moderate pace (1 - 2 squeezes per second).
2. Count off how many squeezes you are doing until you cannot squeeze any more.
3. Have your lab partner record the number of squeezes at 10 second intervals.
4. Graph the results.

Question:

How does this differ from what we did in the EMG and Fatigue exercise?

VI. Muscle Elasticity

Muscles, tendons and ligaments all have elastic fibers. These fibers allow your muscular system to go back to its original length after stretching. This elastic recoil also provides energy for movement by storing the energy of movement in the elastic fibers and then releasing later.

Procedure:

1. Mark your eye height using tape on a wall. Measure that height and add an additional 7%. (If your eye level is 150 cm, then 7% is 10.5 cm.)
2. Place a piece of masking tape on the wall at a height of your eye level plus the 7%.
3. Begin hopping at a comfortable pace so that at the top of the hop your eyes are level with the tape. Continue hopping for 30 seconds (or one minute if you have the stamina.).
4. Record your pace.
5. Have your lab partner have you hop at half your normal pace.

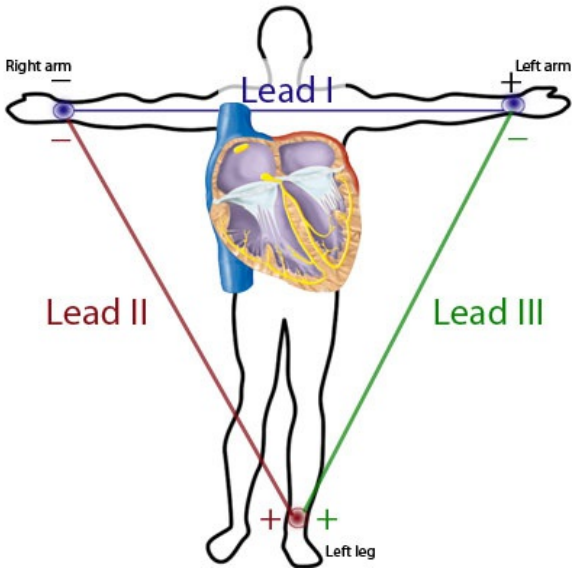
Question:

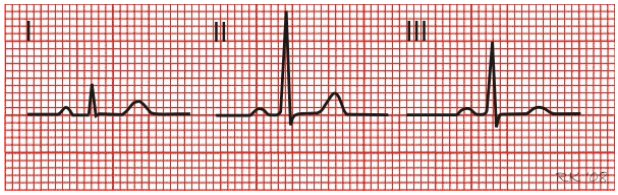
Is hopping at half the pace easier or harder? Why?

ELECTROCARDIOGRAM

One of the most important diagnostic tools is the electrocardiogram (ECG or EKG). An ECG measures the electrical activity of the heart by using electrodes attached to the surface of the skin. ECGs can be used to measure the rate and regularity of heartbeats, the size and position of the chambers, and the presence of any damage to the heart.

An ECG works by comparing the electrical activity in different regions of the skin and therefore providing different "views" of the heart. In a clinical setting, three electrodes (leads) and a ground electrode are placed on the extremities (wrists and ankles) and six electrodes are placed on the chest. For obvious reasons, we will only be using the limb electrodes in class. These three electrodes form a triangle (Einthoven's triangle) around the heart. The electrical activity is then compared among the different electrodes. For example, lead I compares the electrical activity as seen in the left arm versus the right wrist. Notice that the ECG from lead I is the smallest of the three. That is because there is less electrical difference between the two wrists than between the wrist and ankle.





Procedure

1. Remove all jewelry from the wrists and ankles.
2. Use an alcohol swab to clean and scrub a region with little or no hair, on the inside of the right wrist, left wrist and right ankle. Let the area dry.
3. Attach the electrodes to those areas.
4. Sit quietly with your hands on your lap.
5. Record the ECG for six seconds.

Questions:

Is the ECG normal? If not, what might be the problem?

ELECTROCARDIOGRAM AND PERIPHERAL CIRCULATION

In this experiment, you will record an ECG and the pulse wave in the finger of a subject simultaneously. This exercise will demonstrate the time delay that occurs between the electrical events in the heart and mechanical events in the circulatory system. This will allow us to measure the speed at which blood flows through the arteries.

Procedure

1. Remove all jewelry from the wrists and ankles.
2. Use an alcohol swab to clean and scrub a region with little or no hair, on the inside of the subject's right wrist, left wrist and right ankle. Let the area dry.
3. Remove the ECG electrodes from its plastic shield and apply the electrodes to the scrubbed areas.

- the **red** (+1) lead is attached to the right wrist,
- the **black** (-1) lead is connected to the left wrist,
- the **green** (C or ground) lead is connected to the right leg.

4. Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the middle finger, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place. Make sure the plethysmograph is snug but not so tight as to limit the circulation.
5. Sit quietly with your hands on your lap. If you move any muscles in the arms or upper body, electromyograms (EMGs) from the muscles will appear on the ECG recording as noise.
6. Click on the **Record** button, located on the upper right side of the LabScribe **Main** window. The signal should begin scrolling across the screen.
7. Click on the **AutoScale** button at the upper margin of the **ECG**, **Pulse**, and **Pulse Integral** channels. If the signal on either the **ECG** or the **Pulse** channel is upside down when compared to trace in the figure, click on the downward arrow to the left of the channel title and select the **Invert** function.
8. If the pulse signal is small or noisy, adjust the tension on the strap holding the pulse plethysmograph to the finger.
9. Record for 30 seconds then click **Stop** to halt recording.
10. Note the time interval between the QRS wave and the pulse.

Questions:

1. What factors affect the speed of blood flow?
2. How does the speed of blood flow change in arteries, arterioles, capillaries, and veins?

BLOOD PRESSURE

Monitoring blood pressure is an essential part of any physical examination. Adequate blood pressure is essential to maintain the blood supply and perfusion to all of the organs of the body. If pressure drops below a critical point, the hypotension causes the patient goes into circulatory shock as the patient becomes ischemic. Extreme hypertension can cause arteries to rupture, and long term hypertension causes the heart to work harder to overcome arterial resistance and increases the risk of heart attacks.

What is "normal" blood pressure? "Normal" or "acceptable" blood pressure varies with age, state of health and clinical situation. At birth, a typical blood pressure is 80/50 mmHg. It rises steadily throughout childhood, so that in a young adult it might be 120/80 mmHg. As we get older, blood pressure continues to rise, Blood pressure is lower in late pregnancy and during sleep. Another important factor in determining "normal" blood pressure is a phenomenon called "white coat hypertension." It is very common for people to be a little nervous when their blood pressure is measured, and that often results in higher readings. From this, you can see that a systolic pressure of 150mmHg for an elderly man or 90 mmHg for a pregnant woman may be quite normal. To judge whether any particular reading is too high or too low, we must compare the reading with previous reading for that patient.

I. Rough estimates of blood pressure without using any equipment.

It is not possible to derive a numerical value for blood pressure without some equipment, but a crude assessment of the circulation can still be obtained. If you can feel a radial pulse, the systolic blood pressure is usually at least 80 mmHg. That means that the tissues are still being perfused. The strength of the pulse also gives a clue as to pressure. Capillary refill time is another simple test of circulatory adequacy. To test this, press firmly on the skin with your thumb; release your thumb and see how long it takes for blood to return. A refill time of greater than 2 seconds suggests an inadequate circulation. This may be due to hypotension or edema.

II. Measuring blood pressure with a sphygmomanometer.

When the cuff of a sphygmomanometer is pumped- up, the pressure compresses the brachial artery causing the artery to collapse. As the pressure is slowly released, the brachial artery opens only during systole but it is still compressed during diastole. This causes a turbulent blood flow, which cause vibrations against the artery walls. These vibrations are heard as noises are called Korotkoff sounds. The blood flow through the brachial artery increases steadily, until the pressure of the sphygmomanometer cuff falls below the diastolic pressure. This is the point where the blood flow through the artery is smooth again.

The sounds heard while measuring blood pressure (Korotkoff sounds) have 5 phases:

1. initial 'tapping' sound (cuff pressure = systolic pressure)
2. sounds increase in intensity
3. sounds at maximum intensity
4. sounds become muffled
5. sounds disappear (cuff pressure = diastolic pressure)

Procedure:

1. You should be seated and have rested for 5 minutes.
2. You should not have smoked or ingested caffeine within 30 minutes before measurements.
3. Place the cuff snugly around the arm. Make sure the arrows indicating the brachial artery and the tubes exiting the cuff are lined up appropriately.
4. Place the stethoscope on the elbow and hold it in place firmly so that it doesn't move.

5. Close the knurled knob above the bulb and inflate until the pressure reaches about 140 - 160 mmHg.
6. Slightly loosen the knob so that the pressure begins to drop.
7. Listen for the Korotkoff sounds and record the pressure when you first hear the sound and when the sound disappears.
8. Wait about two minutes and repeat.

III. Body position heart rate and blood pressure
Procedure:
1. Lie down and relax for about one minute.
2. Measure the blood pressure and, at the same time, heart rate using the pulse/ox meter.
3. While monitoring the pulse rate, elevate the legs. What happens to the heart rate in the first 5 seconds? What happens to the heart rate in the second 5 seconds?
4. Stand up. What happens to the blood pressure?

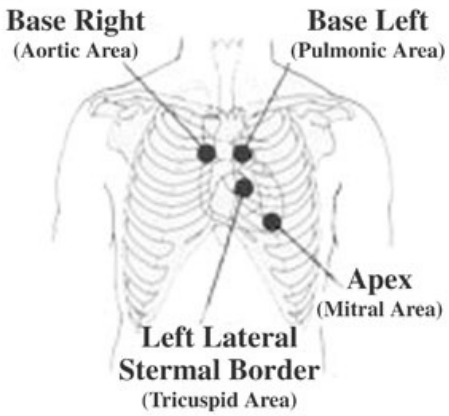
IV. Blood pressure after exercise
Procedure:
1. Exercise until a heart rate of about 150 beats per minute is reached.
2. Immediately after the exercise, use an automated blood pressure monitor to measure the blood pressure.
3. Write your resting and exercise blood pressure on the board for comparison with the class.

Questions:
1. Why is it important to know both the systolic and diastolic blood pressure?
2. Why is hypertension dangerous?
3. What are the signs of hypotension?
4. Why do changes occur in blood pressure and pulse rate due to body position and exercise? Be sure to relate them to venous return, Bainbridge reflex, baroreceptor reflex, etc.
5. What happens to systolic and diastolic pressure during exercise? Explain why these changes occur.

AUSCULTATION

Auscultation, or the process of listening to the sounds of organs is an essential diagnostic tool. Because it is simple and noninvasive, it is a routine part of any physical examination.

I. Heart Sounds



Procedure:
1. Listen in a quiet area as some of these sounds are very faint.
2. Place the stethoscope on bare skin; the rubbing of clothing may simulate a murmur.
3. Listen at the four areas listed above, one for each valve.

Listen first for the heart sounds. They are called S1 and S2 and are traditionally described as "lub" and "dub" respectively. The first sound (S1) is caused by closure of the mitral and tricuspid valves and the two sounds tend to merge as one. The second sound (S2) is caused by closure of the aortic and pulmonary semilunar valves. Normally the sounds of the two valves closing during S2 are so close that they are heard as a single sound although they may split slightly on deep inspiration as pulmonary semilunar valve closure is delayed. Some people have significant splitting on lying down but it disappears on sitting up. This is a normal variation.

Next, listen for murmurs. Murmurs can be caused by valves that do not close properly. Note the timing of murmurs. Is it during S1 (systolic) or S2 (diastolic)? First listen to the “lub-dub” and then get the timing. Some murmurs may obscure the heard sounds. Systolic murmurs can be normal, especially in children. Diastolic murmurs are always pathological.

II. Lung Sounds

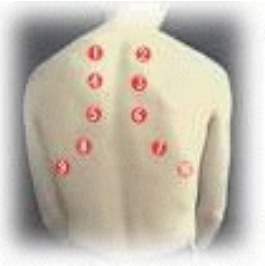
Listening to lung sounds is a very important diagnostic tool. There are many possible sounds one can hear:

Rales are small clicking, bubbling, or rattling sounds in the lung. These often sound like velcro. They are believed to occur when air opens closed air spaces. For example, rales can occur as a result of pneumonia.

Rhonchi are sounds that resemble snoring. They occur when air is blocked or airflow becomes rough through the large airways as in bronchitis.

Wheezes are high-pitched sounds produced by narrowed airways. They can be heard when a person breathes out (exhales). Wheezes are common in asthma.

Absent or decreased sound suggests lack of air flow to a particular area of the lung.



Procedure:

Lung sounds cannot be heard through the scapula, so listen through the intercostal spaces throughout the thorax on each side.

III. Borborygmus

Borborygmus is the sound made material flowing through by the GI tract. Normal sounds are due to peristaltic activity and consist of clicks and gurgles. High pitched sounds suggest a partial obstruction. Too few sounds, fewer than 3-4 sounds a minute, might indicate obstruction. No sounds for 3 - 4 minutes suggest paralysis of the GI tract.

Procedure:

Ausculate in all four quadrants of the abdomen.

RESPIRATORY PHYSIOLOGY

I. Spirometry

Lung disease is the fourth most common cause of death in the U.S. One of the most useful measures of lung function is spirometry. Spirometry assesses pulmonary function by measuring the volume of air that can move in and out of the lungs as well as the rate at which the air moves. Spirometry is important for diagnosing conditions such obstructive and restrictive pulmonary diseases. Obstructive lung disease is a decrease in expiratory flow rates, the anatomical basis of which is airway narrowing. Restrictive lung disease is clinically identified by decreased lung volumes. In order to determine lung function, we will be measuring two values:

FVC (Forced Vital Capacity): the maximum amount of air able to be exhaled on a single breath

FEV1 (Forced Expired Volume in 1 Second): the amount of air exhaled in the first second

Procedure:

1. Set up the spirometer and enter your data.
2. Inhale as deeply as possible and hold your breath until the machine beeps.
3. At the beep exhale as hard as possible. Keep exhalin g even after you run out of air until the machine registers (about 4-5 seconds).

The spirometer will record your forced expiratory volume and your forced expiratory flow and compare it to an average healthy person of your size.

II. Siprometry after exercise

Exercise-induced asthma is a medical condition that occurs in 10 - 25% of the population. It happens when the airways narrow as a result of exercise. It often occurs after aerobic exercise (bicycling, running) in which people breath through their mouths. It is thought that because the air has not been warmed and humidified properly by the nasal passages it stimulates constriction of the bronchioles.

Procedure:

1. Using the portable spirometers, measure your FEV (forced expiratory volume)
2. Inhale as deeply as possible and hold your breath until the machine beeps.
3. At the beep exhale as hard as possible. Keep exhaling even after you run out of air until the machine registers (about 4-5 seconds). Record the results.
4. Run around the building until you start breathing through your mouth.
5. Repeat steps 1 - 3. If you start coughing when you try to blow through the spirometer, then that is a sign of asthma and you do not need to continue with this procedure.

Questions:

1. What are some specific examples of obstructive diseases and restrictive diseases?
2. What are some specific examples of diseases which are both obstructive and restrictive?
3. What are some genetic factors that might influence vital capacity and respiratory function?
4. If a peson is diagnosed as having exercise-induced asthma, should that person exercise? If so, how?

II. Carbon dioxide production

The amount of CO_2 produced by the body is a good measure of overall metabolism. In this exercise you will measure the amount of CO_2 you produce at rest and after exercise as a measure of the increased metabolic rate.

Procedure:

1. Combine in one beaker 150 ml of deionized water and 2 drops of phenolphthalein. Make sure the solution is thoroughly mixed. Using a dropper, add one drop of 0.1 M NaOH to the solution and mix thoroughly. If necessary keep adding the NaOH until the solution is a light pink.
2. Measure exactly half of the solution (75 ml) and pour 75 ml into each of two identical 125 ml Erlenmeyer flasks.
3. Measure your heart rate using a pulseoximeter.
4. Take a straw and, while sitting quietly, hold your breath for 5 seconds. Then exhale into one of the flasks for 5 seconds.

Warning: Be careful to exhale into the beaker and not inhale and swallow the solution. Phenolphthalein is a strong laxative.

5. Add one drop of 0.1 M NaOH at a time to the solution and swirl the solution. Repeat until the solution is the same color as the standard solution. Note how many drops this required.
6. Run around the building until you start to breathe through your mouth. Then repeat steps 3 - 5.
7. Calculate the ratio of physical exertion and CO_2 production by dividing the number of drops of NaOH required to titrate the solution by the heart rate.

Questions:

1. What was the percent increase in CO_2 production with exercise?
2. Assuming you are at 80% of your aerobic capacity when you were exercising, what is your percentage of aerobic capacity at rest?
3. If you exercised regularly, what physiological changes would occur to increase your aerobic capacity?
4. Was the ratio of CO_2 production and heart rate constant? Should it have been?

III. Blood oxygen

In a healthy person, about 95 -98% of arterial hemoglobin is oxygenated. If the amount of arterial oxyhemoglobin drops, it is an indication of a cardiovascular or respiratory problem. Sometimes these problems do not show up at rest, but only when the body is put under stress, for example when exercising.

Procedure:

1. Using the Pulse/Ox meter, measure your percentage of oxyhemoglobin at rest.
2. Run around the building until you begin breathing through your mouth.
3. Stop running and <u>immediately</u> put on the Pulse/Ox meter and measure the percentage of oxyhemoglobin.

Questions:

1. Why does blood oxygen level remain the same after exercise?
2. If it did not remain the same, explain what is wrong?

IV. Blood oxygen while holding your breath

In this exercise we will determine how quickly blood oxygen is used by measuring if there is a change in the amount of oxyhemoglobin as you hold your breath. We will also determine what factors can alter the length of time you can hold your breath.

Procedure:

1. Measure your % oxyhemoglobin at rest.
2. Hold your breath for as long as possible.
3. Measure any changes in the amount of oxyhemoglobin at 10 second intervals.
4. Note how long you were able to hold your breath
5. Graph the results.
6. After about a one minute rest, repeat steps 1 - 5 above, but this time hyperventilate for about 30 seconds before you start holding your breath.
7. After about one minute rest, repeat steps 1 - 4 above, but this time slowly breathe out without breathing in.

Questions:

1.Are these results what you expected? Why? or Why not?
2.What stimulates breathing?
3. What regulates % oxyhemoglobin?
4. What effect does hyperventilation have on how long you can hold your breath?
5. What effect does breathing out have on how long before you have to inhale?

HEMATOLOGY

Blood tests are simple and provide a lot of information about a patient's health. When doing a routine blood test, physicians are looking at two sets of data. One is the biochemistry of the blood: cholesterol, ion concentrations, glucose, urea, etc. The other is the number and types of cells.

I. Erythrocytes

The normal number of erythrocytes (red blood cells) varies considerably:

Newborns: 4.8 - 7.2 million/microliter
Children: 3.8 – 5.5 million/microliter
Adults: (males): 4.6 - 6.1 million/microliter
Adults: (Females): 4.2 - 5.4 million/microliter
Pregnancy: slightly lower than normal adult values

Too few erythrocytes (anemia) results most commonly from lack of vitamin B_{12}, iron or hemorrhage. Too many erythrocytes (polycythemia) is often due to lung or heart disease. The diagnosis of anemia or polycythemia is dependent the number and size of erythrocytes. In this laboratory exercise we will not be counting erythrocytes directly, rather, we will be measuring hematocrit.

Hematocrit

Hematocrit is the percentage of total blood volume that is made up of erythrocytes, so that a hematocrit of 40 means that 40% of blood volume is made of erythrocytes. Therefore, hematocrit is used as a simple way to measure the number of erthrocytes in the blood. Normal hematocrit values are about 38-52 for men and 37-47 for women. In pregnant women, normal hematocrit can be as low as 28 by the end of pregnancy. In newborns, normal hematocrit is 42 - 65, but that quickly drops to 29 - 41 by about six months of age. It then slowly rises until puberty.

Procedure:

Make sure to follow all of the safety precautions for dealing with bodily fluids .

1. Swab the end of a finger with alcohol.
2. Pierce the side of the finger with the lancet
3. Fill the heparinized capillary tube at least half full. Air bubbles are not a problem.
4. Seal the tube by sticking the clean end of the tube in the clay pad.
5. Place the tube in a centrifuge with the clay end facing out and centrifuge for 5 minutes.
6. Determine the "packed cell volume", what percentage of blood is erythrocytes.

Questions:

1. Is the fact that the average hematocrit for women lower than that for men physiolgically significant?
2. If a person has a hematocrit of 38, will taking iron supplements increase the number of erythrocytes?
3. Why will emphysema result in polycythemia?
4. Why is normal hematocrit so much lower in pregnancy?
5. Why is normal hematocrit so high in newborns?
6. Why does normal hematocrit drop so much during infancy?

II. Leukocytes

The normal range for number of leukocytes (white blood cells) is about 5,000 - 10,000/microliter. Too few leukocytes, leukopenia, can result from certain types of cancers, infections and autoimmune diseases. Too many leukocytes, leukocytosis might result from certain types of cancers and infections. To distinguish different types of conditions, a differential white cell count is done which looks at the specific numbers of each type of leukocyte. Since each type of leukocyte has a particular function, it is important to know their relative abundance.

The specific number of each type of leukocyte in a healthy adult is approximately:

Neutrophils:	45% - 74%	Lymphocytes:	15% - 45%
Monocytes:	4% - 10%	Eosinophils:	1% - 6%
Basophils:	0 - 2%		

Differential White Cell Count

Make sure to follow all of the safety precautions for dealing with bodily fluids.

1. Clean the end of a finger with an alcohol wipe.
2. Using a sterile lancet, pierce the side of the fingertip. Dispose of the lancet in the "sharps container."
3. Place a drop of blood near the end of a clean dry slide. (You will want to prepare about 3 slides to make sure one of them is stained correctly.)
4. Hold a cover slip at a 45^0 angle to the slide at the edge of the blood drop.
5. Quickly slide the cover slip along the slide so that the blood smears into a thin layer.
6. Allow the slides to air dry.
7. Stain one slide at a time.
8. Cover the top of the slide with stain for about 2 minutes
9. Add a few drops of Wright's buffer to the slide and gently mix by tilting the slide.
10. Let the slide sit for about 2 minutes.
11. Pour off the stain and gently rinse the slide with distilled water.
12. Wipe the bottom of the slide and rest the slide on its side on paper towels to allow it to air dry.
13. Examine the slide. If the staining is not good, repeat the above, but this time stain for longer or shorter times.
10. Count 100 leukocytes and determine their types. This will give you a percentage of the different leukocytes. Make sure you don't count the same leukocytes twice.

III. Blood typing

Procedure:

Make sure you follow all of the safety precautions for dealing with bodily fluids.

1. Clean the end of a finger with an alcohol wipe.
2. Using a sterile lancet, pierce the side of the fingertip. Dispose of the lancet in the "sharps container."
3. Place one drop of blood into the first well of the test plate or test card. Immediately add a drop of anti-A serum to that well and mix with a clean toothpick. Do not let the drop of blood sit on the plate for any length of time or it will begin to clot and give you a false positive result.
4. Repeat step 4 twice more, once with anti-B and again with anti-Rh.
5. Wipe your finger again with an alcohol wipe.
6. Dispose of everything that is contaminated with blood in the biohazard bag.
7. Check each plate for agglutination. You might need a magnifying glass in order to see small clumps.
8. Record your results.

Questions:
1. Why do the cells clump together in a positive result?
2. Why is it important for women to know their Rh type?

IV. Plasma glucose

In the U.S., there are about 1.25 million people with type I diabetes. It is estimated that there are about 28 million Americans with type II diabetes. Of this estimated 28 million, 8 million cases are undiagnosed. One of the simplest methods of detecting diabetes is measuring fasting plasma glucose levels. Fasting plasma glucose levels should be between 80 - 110 mg/dl when measured by a finger stick. (70 - 100 mg/dl when measured using venous blood). Values between 110 - 140 mg/dl suggest prediabetes, and over 140mg/dl is considered diabetes.

Procedure:

Make sure you follow all of the safety precautions for dealing with bodily fluids.

1. Swab the tip of your finger with alcohol and let it dry.
2. Turn on the glucose meter.
3. Insert the notched end of test strip into the meter with the contact strips facing up.
4. Lance your finger and touch the end of the test strip to the blood. Blood should fill the white window on the strip.
5. Within a few seconds, the glucose meter will show the results in mg/dl.
6. Discard the lancet and test strip properly.

Questions:
1. What are the potential consequences of diabetes mellitus?
2. Why are normal venous glucose levels lower than when measured from the finger?

URINALYSIS

Urine is a product of the body's metabolism and therefore its analysis can give vital information. Because a urine test is so simple and non-invasive, it is one of the most common diagnostic tests.

I. Color and clarity

Urine should be clear. Cloudy urine suggests a urinary tract infection. The color of urine is usually related to its concentration. More dilute urine is a very light yellow, while concentrated urine is darker yellow. Any other color may be due to blood, medications, and certain foods which can alter the color of urine.

Procedure:

Make sure you follow all of the safety precautions for dealing with bodily fluids.

1. Collect the urine sample in a clean cup. Measure the volume.
2. Observe the urine and record its color and clarity.

II. Specific Gravity

Specific gravity is the density of urine. Specific gravity is a measure of the number of dissolved particles and so is similar to osmolarity. This measurement reflects the ability of the kidney to concentrate or dilute the urine relative to plasma. Specific gravity between 1.002 and 1.035 is within the normal range. If the urine density is not greater than 1.022 after a 12 hour fast that means that the kidneys cannot concentrate the urine which is almost always due to very serious kidney disease. If the urine density is over 1.035 it may be a sign of diabetes mellitus.

Procedure:

1. Fill the urine cylinder about 2/3 full of urine
2. Float the urinometer and read specific gravity from the scale at the top. Make sure your decimal places are correct.

III. Multistix test

A. Protein: Protein is normally not found in urine or found in very small amounts. Protein in urine is an indication of damage to the glomerulus.
B. Glucose: Glucose is normally absorbed in the proximal convoluted tubules unless the plasma glucose concentration is greater than 200 mg/dl. The presence of glucose in fasting urine suggests diabetes mellitus.
C. Ketones: The presence of ketones in urine suggests a metabolic disorder, starvation or diabetes mellitus.
D. Blood: Trace amounts of blood may be present after vigorous exercise. Larger amounts of blood in the urine may be due to injury, infection or damage to the glomeruli.
E. Urobiligin, bilirubin: These are products of liver metabolism. Elevated levels suggest liver or gall bladder problems. Urobiligin is what gives urine its yellow color.

Procedure:

1. Dip the Multistix into the urine and immediately remove. As you remove the Multistix drag the edge along the lip of the container to wipe off excess urine from the edge.
2. Set the Multistix on a paper towel and read the results starting at 30 seconds.

IV. Microscopic Analysis of Urine

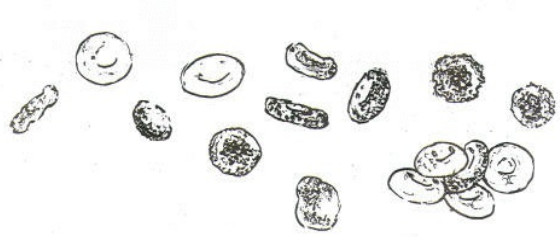
Procedure:

1. Place 10 ml of urine into a plastic centrifuge tube.
2. Centrifuge for approximately 5 minutes.
3. Decant the supernatant. Make sure you do not disturb the pellet at the bottom of the tube. (You should have about ½ ml of urine and pellet left in the tube.)
4. Add one drop of Sedi-Stain to the tube and gently mix.
5. Place one drop on a microscope slide and observe.

A. Cells

1. Erythrocytes

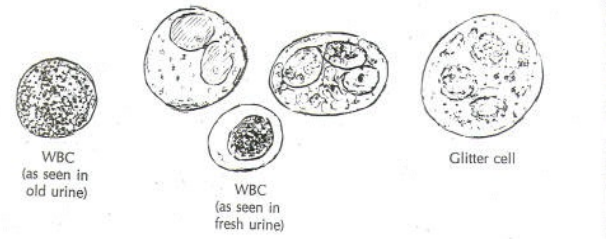
Erythrocytes (red blood cells) are rarely found in normal urine. Their presence may indicate damage to the urinary system due to trauma, kidney stones, infection, etc. Erythrocytes may appear normal, crenated or swollen depending on the tonicity of the urine.



Normal erythrocytes

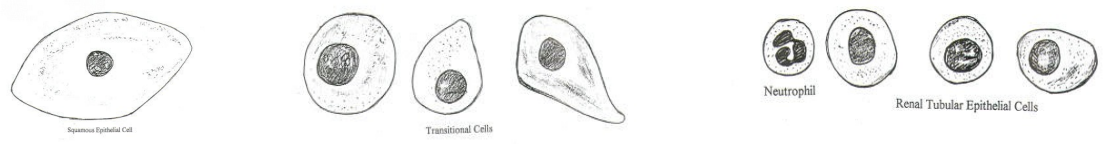
2. Leukocytes

Leukocytes (white blood cells) are rarely found in normal urine. Their presence usually indicates infection. Leukocytes may appear normal or swollen if the urine is hypotonic.



3. Epithelial cells

Epithelial cells are normally found in the urine in small numbers as they slough off. Large numbers of these cells may indicate damage to the urinary system.



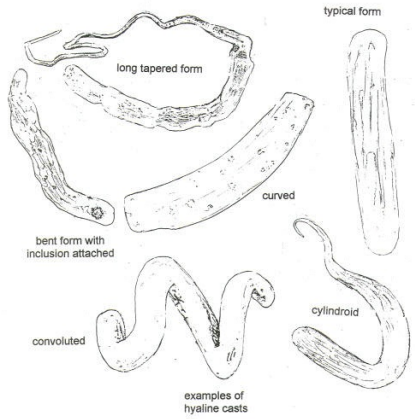
a. Squamous cells are large flat cells that may normally be found in urine. These are cells from the urethral orifice or skin.
b. Transitional epithelial cells are smaller than squamous cells and may normally be found in urine. These cells are from the lining of the ureters or bladder.
c. Renal tubule cells are the smallest of the epithelial cells. These are cells of the nephron.

B. Casts

Casts are clumps of protein or cells (or a combination) that are formed in the distal convoluted tubule or collecting duct and therefore take the shape of the tubule. Some casts are normally seen in urine. Low urine flow rate (dehydration) will increase the likelihood of cast formation.

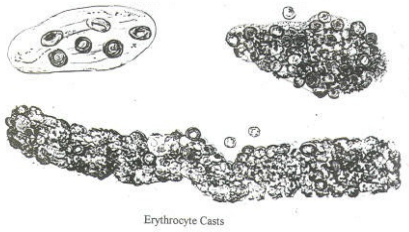
1. Hyaline casts

These are the most common casts and are normally found in urine. The are formed from mucoprotein secreted by the tubules.



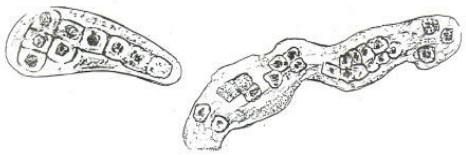
2. Red blood cell casts

These casts indicate trauma or infection in the kidney.



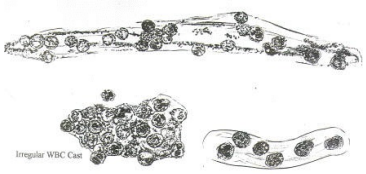
3. Epithelial cell casts

These casts consist of renal tubular epithelial cells. A few of these may be norm al, but many casts may indicate renal damage.



4. White cell casts.

These casts indicate infection of the kidney.



5. Granular casts

These are other cellular casts (like epithelial casts) which have degenerated. The presence of some granular casts is normal.

C. Crystals

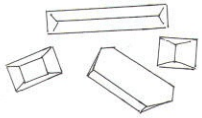
Crystals are commonly seen and normal. They often form simply due to the cooling of urine to room temperature and precipitation of various chemicals within the urine. The types of crystals which form depends on the pH of the urine. Large numbers of uric acid or calcium crystals suggest a predisposition to forming kidney stones.

Acid Urine pH	**Alkaline Urine pH**
Calcium Oxalate	Triple Phosphates
Uric Acid	Ammonium Biurate
	Calcium Carbonate
	Calcium Phosphate

Some crystals are only found in disease states, like those of the amino acid cysteine which may be due to liver disease.

calcium oxylate

uric acid



triple phosphate

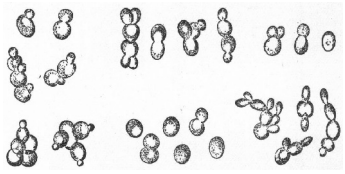
cystine

calcium phosphate

calcium carbonate

IV. Microorganisms

Urine is normally sterile. The presence of bacteria or yeast in urine is a sign of infection.



yeast

bacteria

NUTRITION

In this exercise, you will analyze your eating habits as well as your activity over a period of four consecutive days. During this time you will do the following:

1. Keep a detailed log of your activity over a period of 96 consecutive hours.

2. Keep a detailed log of your food and drink intake over the same period.

3. These logs should be included in your final report.

4. Using a website such as: **www.livestrong.com/myplate** or **www.my-calorie-counter.com** calculate and log the number of calories burned for each activity (sleep burns calories too). How many calories did you burn each day? Over the four days?

5. Using the same or similar web sites, nutritional information on packages, etc. detail your food intake for each meal and snack with respect to the following:
A. calories
B. grams fat
C. milligrams sodium
D. grams fiber
E. milliliters of water

6. Assess your stress levels for each four hour period of each day on a rating of 1 - 5, where 1 is absolute calm and 5 is totally stressed.

7. Using the results of your nutritional, activity and stress assessments, how would you rate your overall life style? What would you do to improve it? What are the limitations of this assessment?

MAJOR NEUROTRANSMITTERS

Neurotransmitter	Receptor	Type*	Location
Acetylcholine (ACh)	Cholinergic		
	Nicotinic	I (Na^+, K^+)	Skeletal muscle Autonomic ganglia CNS
	Muscarinic	G	Smooth and cardiac muscle Many glands
Catecholamines			
Norepinephrine	α Adrenergic	G (Ca^{2+} channels)	Arterioles (constriction)
	β Adrenergic	G (cAMP)	Heart stimulation
Dopamine	Dopamine	G	CNS: muscle coordination CNS: behavior
Monoamines			
Serotonin	Seratonergic	I (Na^+, K^+)	CNS: mood and emotion
Amino Acids			
Glutamate	Glutaminergic	I (Na^+, K^+)	CNS: memory
Glycine	Glycine	I (Cl^-)	CNS: skeletal muscle relaxation
GABA	GABA	I (Cl^-)	CNS: skeletal muscle relaxation
Polypeptides			
Opioids (endorphins, enkephalins)	Opiate	G	CNS: inhibit pain

*I - ion channel receptor
G - G protein coupled receptor

HORMONES THAT AFFECT METABOLISM

Hormone	Primary Function	Metabolic effects		
		Protein	**Carbohydrate**	**Lipids**
Thyroxine (T_4) - converts to T3	increase BMRand regulates development	↑proteolysis from muscle	↑glycogenolysis ↑gluconeogenesis	↑lipolysis
Growth hormone	growth (in children) regulates metabolism	↑protein synthesis	↑gluconeogenesis ↑glycogen synthesis ↓decreased glucose uptake	↑lipolysis
Insulin	↓plasma glucose	↑protein synthesis	↑glucose uptake ↑glycogen synthesis	↑fat deposition
Glucagon	↑plasma glucose		↑glycogenolysis ↑gluconeogenesis	↑lipolysis
Epinephrine	mimics/enhances sympathetic activity		↑glycogenolysis	↑lipolysis
Cortisol	control physical stress (starvation, infection, etc.)	↑proteolysis	↑gluconeogenesis	↑lipolysis ↑fat deposition in specific areas
Estrogen	female secondary sex characteristics / menstrual cycle			↑fat deposition in specific areas
Testosterone	male secondary sex characteristics	↑protein synthesis		↑lipolysis
Melatonin	regulates circadian rythms and other hormones			

Periodic Table of Elements

hydrogen 1 H 1.0079																	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305												aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 *	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
francium 87 Fr [223]	radium 88 Ra [226]	89-102 * *	lawrencium 103 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [266]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	ununnilium 110 Uun [271]	unununium 111 Uuu [272]	ununbium 112 Uub [277]		ununquadium 114 Uuq [289]				

* Lanthanide series	lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
* * Actinide series	actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendelevium 101 Md [258]	nobelium 102 No [259]