MEDICAL PHYSICS LABORATORY

FOR 3RD YEAR MEDICAL PHYSICS STUDENTS

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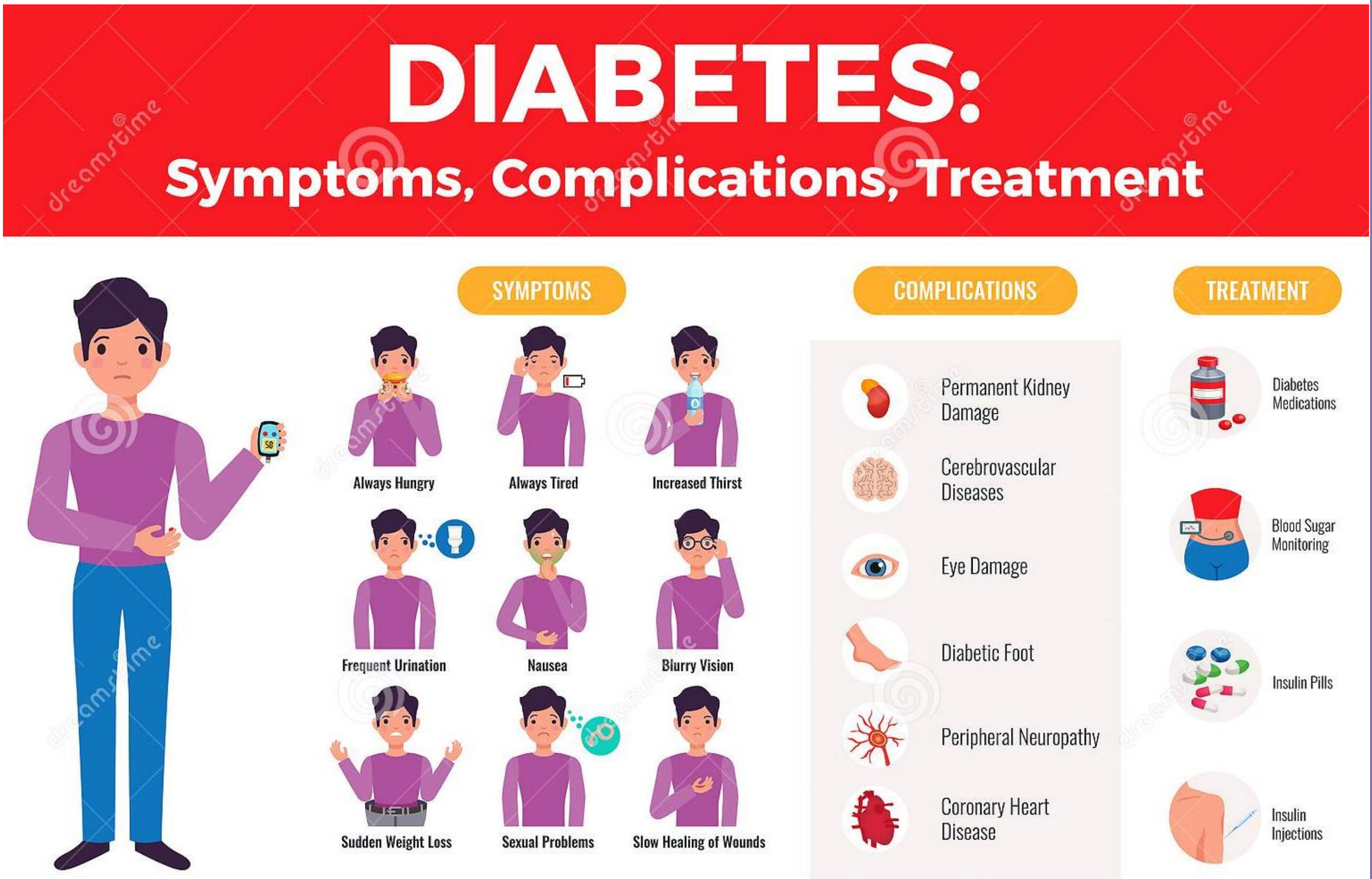
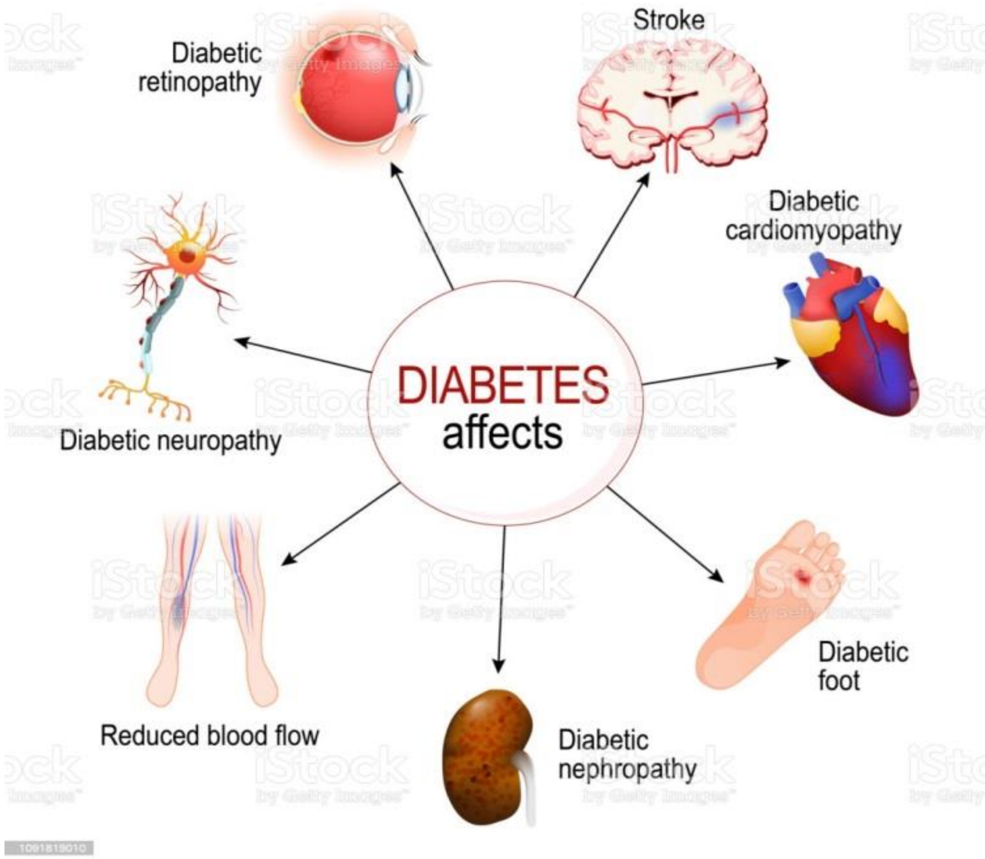
EXPERIMENT ONE

BLOOD GLUCOSE LEVELS TEST

Diabetes mellitus is a chronic metabolic disease. DM is classified as an increase in blood glucose levels that result from insulin resistance in peripheral tissues or disruption of insulin secretion by the pancreas. The diabetes can cause many complications. Serious long-term complications include cardiovascular disease, stroke, chronic kidney disease, foot ulcers, unhealthy lipid levels, damage to blood vessels (vascular and micro vascular), organ damage such as to the kidneys (diabetic nephropathy), nerve damage (diabetic neuropathy) and damage to the eyes. Diabetes is due to either the pancreas not creating enough insulin or the cells of the body not responding properly to the insulin produced. The normal range of blood glucose is 80-120mg/dL. The number of patients with DM has quadrupled (from 108 million in 1980 to 422 million in 2014) within 34 years only, while the worldwide incidence of diabetes among adults over 18 years of age has risen to 8.5% (2014) from 4.7% (1980). The WHO estimates that diabetes will be the 7th primary cause of fatality by 2030. The IDF Diabetes Atlas (2021) reports that 10.5% of the adult population (20-79 years) has diabetes, with almost half unaware that they are living with the condition. By 2045, IDF projections show that 1 in 8 adults, approximately 783 million, will be living with diabetes, an increase of 46%.


DIABETES:
Symptoms, Complications, Treatment
SYMPTOMS
Always Hungry
Always Tired
Increased Thirst
Frequent Urination
Nausea
Blurry Vision
Sudden Weight Loss
Sexual Problems
Slow Healing of Wounds
COMPLICATIONS
Permanent Kidney Damage
Cerebrovascular Diseases
Eye Damage
Diabetic Foot
Peripheral Neuropathy
Coronary Heart Disease
TREATMENT
Diabetes Medications
Blood Sugar Monitoring
Insulin Pills
Insulin Injections


DIABETES affects
Diabetic retinopathy
Stroke
Diabetic cardiomyopathy
Diabetic neuropathy
Reduced blood flow
Diabetic nephropathy
Diabetic foot

Types of Diabetic and Causes

There are three major types of diabetes:

1-Insulin dependent diabetes mellitus (IDDM, Type 1) or type 1 diabetes, Type 1 DM results from the pancreas's failure to produce enough insulin This is because the body's immune system attacks and destroys the insulin-producing cells in the pancreas. Treatment with insulin remains the most suitable therapy for T1DM patients. However, in many patients leading to long term vascular damage associated with kidney failure, heart disease, retinopathy and neuropathy

2-Non-insulin-dependent diabetes mellitus (NIDDM, Type 2) or type 2 diabetes, type 2 DM begins with insulin resistance, a condition in which cells fail to respond to insulin properly. As the disease progresses, a lack of insulin may also develop. It differs from type 1 diabetes because it is not caused by the body's immune system but solely from a combination of genetic predisposition and environmental factors. It's the most common form of diabetes.

3-Gestational diabetes is the third main form and occurs when pregnant women without a previous history of diabetes develop high blood sugar levels, which is a disorder that is diagnosed in the second or third trimester of approximately 7% of all pregnancies .

Type 1 Diabetes	Type 2 Diabetes
Often diagnosed in childhood	Usually diagnosed in over 30 year olds
Not associated with excess body weight	Often associated with excess body weight
Often associated with higher than normal ketone levels at diagnosis	Often associated with high blood pressure and/or cholesterol levels at diagnosis
Treated with insulin injections of insulin pump	Is usually treated initially without medication or with tablets

Table (1-1) shows the differences between type 1 and type2 diabetes

Common symptoms of diabetes

The general symptoms of diabetes include:

1-increased hunger

2-increased thirst

3-weight loss

4- frequent urination
5- blurry vision
6- extreme fatigue
7- Cuts and bruises don't heal properly or quickly.

Hyperglycemia is high blood sugar, while **hypoglycemia** is low blood sugar. Because both can cause major health problems for people with diabetes, it's important to keep blood sugar within a healthy range.

How does hypoglycemia occur with diabetes?

If you have diabetes, hypoglycemia can occur when you take too much insulin or another diabetes medication. Too much medication in your bloodstream causes your body's cells to absorb too much glucose.

How does hyperglycemia occur with diabetes?

The reason for hyperglycemia with diabetes depends on whether you have type 1 diabetes or type 2 diabetes.

If you have type 1 diabetes, your pancreas is unable to produce insulin. If you have type 2 diabetes, your pancreas doesn't produce enough insulin to stabilize your blood sugar. In both conditions, glucose can build up in your bloodstream, resulting in hyperglycemia.

Your diabetes medication keeps your blood sugar within a safe range. If you don't take your medication as instructed, you might experience blood sugar spikes. This can also occur due to poor eating habits, inactivity, or an infection.

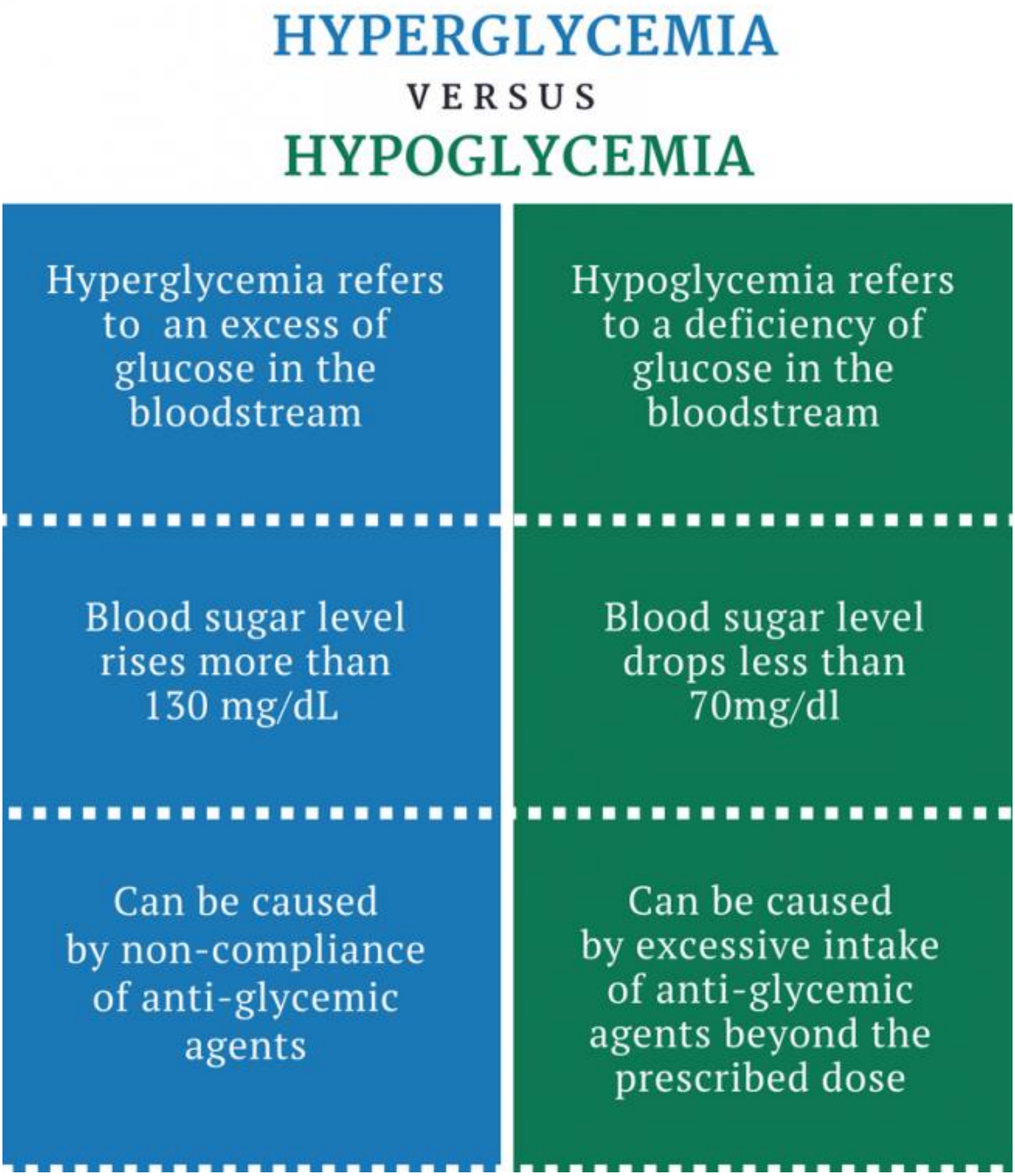


Table (1-2) Blood test levels for diagnosis of diabetes and prediabetes

	HbA1C range	**Fasting blood sugar (mg/dL)**
Diabetes	**≥ 6.5**	**≥ 126**
Pre-diabetes	**5.7 to 6.4**	**100 to 125**
Normal	**Approximately5**	**≤ 99**

EXPERIMENT TWO

The Blood pressure

The Blood pressure

Blood pressure (BP) is the pressure exerted by circulating blood upon the walls of blood vessels, and is one of the principal vital signs. During each heartbeat, BP varies between a maximum (systolic) and a minimum (diastolic) pressure.

The mean BP, due to pumping by the heart and resistance to flow in blood vessels, decreases as the circulating blood moves away from the heart through arteries. Blood pressure drops most rapidly along the small arteries and arterioles, and continues to decrease as the blood moves through the capillaries and back to the heart through veins.

Gravity, valves in veins, and pumping from contraction of skeletal muscles, are some other influences on BP at various places in the body.

The force exerted by the blood on the wall of a blood vessel is called the blood pressure.

Or

The pressure exerted by the flow of blood on the wall of a blood vessel is called blood pressure

Blood pressure is measured by an instrument called as Sphygmomanometer.

This pressure is greater in the arteries than the veins.

The pressure in the artery during ventricular contraction is called the systolic pressure.

The pressure in the artery during ventricular relaxation is called diastolic pressure.

The term *blood pressure* usually refers to the pressure measured at a person's upper arm. It is measured on the inside of an elbow at the brachial artery, which is the upper arm's major blood vessel that carries blood away from the heart. A person's BP is usually expressed in terms of the systolic pressure over diastolic pressure (mmHg), for example 140/90.

Various factors influence a person's average BP and variations. Factors such as age and gender influence average values. In children, the normal ranges are lower than for adults and depend on height. As adults age, systolic pressure tends to rise and diastolic tends to fall. In the elderly, BP tends to be above the normal adult range, largely because of reduced flexibility of the arteries. Also, an individual's BP varies with exercise, emotional reactions, sleep, digestion and time of day.

Differences between left and right arm BP measurements tend to be random and average to nearly zero if enough measurements are taken.

The risk of cardiovascular disease increases progressively above 115/75 mmHg. In the past, hypertension was only diagnosed if secondary signs of high arterial pressure were present, along with a prolonged high systolic pressure reading over several visits. Regarding hypotension, in practice blood pressure is considered too low only if noticeable symptoms are present.

The number of adults aged 30–79 years with hypertension has increased from 650 million to 1.28 billion in the last thirty years, according to the first comprehensive global analysis of trends in hypertension prevalence, detection, treatment and control, led by Imperial College London and WHO in 2020.

Blood Pressure Stages

Blood Pressure Category	Systolic mm Hg (upper #)		Diastolic mm Hg (lower #)
Normal	less than 120	and	less than 80
Elevated	120-129	and	less than 80
High Blood Pressure (Hypertension) Stage 1	130-139	or	80-89
High Blood Pressure (Hypertension) Stage 2	140 or higher	or	90 or higher
Hypertensive Crisis (Seek Emergency Care)	higher than 180	and/or	higher than 120

Source: American Heart Association

Complications of High Blood Pressure

1. Heart Attack

2. Stroke

3. Aneurysm

4. Heart Failure

5. Kidney Damage

6. Vision Loss

Symptoms of High Blood Pressure

Severe headacheصداع شديد

Fatigue or confusionالتعب أو الارتباك

Vision problemsمشاكل في الرؤية

Chest painألم في الصدر

Difficulty breathingصعوبة في التنفس

Irregular heartbeatعدم انتظام ضربات القلب

Blood in the urineدم في البول

Causes of High Blood Pressure

Smokingالتدخين
Being overweight or obeseزيادة الوزن أو السمنة
Lack of physical activityنقص في النشاط الجسدي
Too much salt in the dietالكثير من الملح في النظام الغذائي
Too much alcohol الكثير من استهلاك الكحول
Stress ضغط عصبي
Older ageكبار السن
Family history of high blood pressureتاريخ الأسرة من ارتفاع ضغط الدم
Chronic kidney diseaseفشل كلوي مزمن
Thyroid disorders **اضطرابات الغدة الدرقية**

Symptoms Low blood pressure

Dizziness or lightheadednessالدوخة أو الدوار

Fainting إغماء

Blurred visionعدم وضوح الرؤية

Nauseaغثيان

Lack of concentrationقلة التركيز

Causes of Low blood pressure

Pregnancyحمل

Decreases in blood volumeانخفاض في حجم الدم

Certain medicationsبعض الأدوية

Heart problemsمشاكل قلبية

Severe infection (septic shock) (الصدمة الإنتانية) العدوى الشديدة

Allergic reaction (anaphylaxis)رد الفعل التحسسي الحساسية المفرطة

Neurally mediated hypotensionانخفاض ضغط الدم بوساطة العصبي

Nutritional deficienciesنقص غذائي

A sphygmomanometer is a device for measuring blood pressure.
Purpose
The sphygmomanometer is designed to monitor blood pressure by measuring the force of the blood in the heart where the pressure is greatest. This occurs during the contraction of the ventricles, when blood is pumped from the heart to the rest of the body (systolic

pressure). The minimal force is also measured. This occurs during the period when the heart is relaxed between beats and pressure is lowest (diastolic pressure).

Description

A sphygmomanometer consists of a hand bulb pump, a unit that displays the blood pressure reading, and an inflatable cuff that is usually wrapped around a person's upper arm. Care should be taken to ensure that the cuff size is appropriate for the person whose blood pressure is being taken. This improves the accuracy of the reading. Children and adults with smaller or larger than average-sized arms require special-sized cuffs appropriate for their needs. A stethoscope is also used in conjunction with the sphygmomanometer to hear the blood pressure sounds. Some devices have the stethoscope already built in.

Operation

The flow, resistance, quality, and quantity of blood circulating through the heart and the condition of the arterial walls are all factors that influence blood pressure. If blood flow in the arteries is restricted, the reading will be higher.

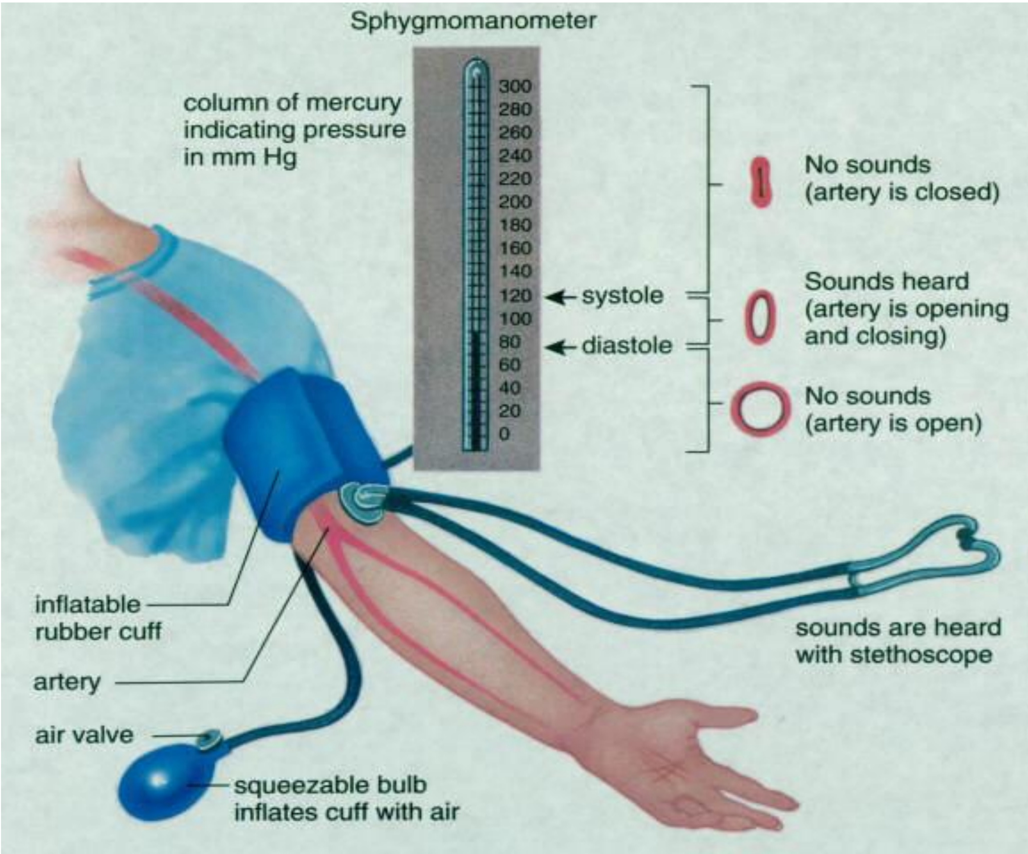
Blood pressure should be routinely checked every one to two years. It can be checked at any time, but is best measured when a person has been resting for at least five minutes, so that exertion prior to the test will not unduly influence the outcome of the reading.

To record blood pressure, the person should be seated with one arm bent slightly, and the arm bare or with the sleeve loosely rolled up. With an aneroid or automatic unit, the cuff is placed level with the heart and wrapped around the upper arm, one inch above the elbow. Following the manufacturer's guidelines, the cuff is inflated and then deflated while an attendant records the reading.

If the blood pressure is monitored manually, a cuff is placed level with the heart and wrapped firmly but not tightly around the arm one inch (2-3 cm)above the elbow over the brachial artery. Wrinkles in the cuff should be smoothed out. Positioning a stethoscope over the brachial artery in front of the elbow with one hand and listening through the earpieces, the health professional inflates the cuff well above normal levels (to about 200 mm Hg), or until no sound is heard. Alternatively, the cuff should be inflated 10 mm Hg above the last sound heard. The valve in the pump is slowly opened. Air is allowed to escape no faster than 5 mm Hg per second to deflate the pressure in the cuff to the point where a clicking sound is heard over the brachial artery. The reading of the gauge at this point is recorded as the systolic pressure. The sounds continue as the pressure in the cuff is released and the flow of blood through the artery is no longer blocked. At this point, the noises are no longer heard. The reading of the gauge at this point is noted as the diastolic pressure. "Lub-dub" is the sound produced by the normal heart as it beats. Every time this sound is detected, it means that the heart is contracting once. The sounds are created when the heart valves click to close. When one hears "lub," the atrioventricular valves are closing. The "dub" sound is produced by the pulmonic and aortic valves.

With children, the clicking sound does not disappear but changes to a soft muffled sound. Because sounds continue to be heard as the cuff deflates to zero, the reading of the gauge at the point where the sounds change is recorded as the diastolic pressure.

Blood pressure readings are recorded with the systolic pressure first, then the diastolic pressure (e.g. 120/70).



Heart beat

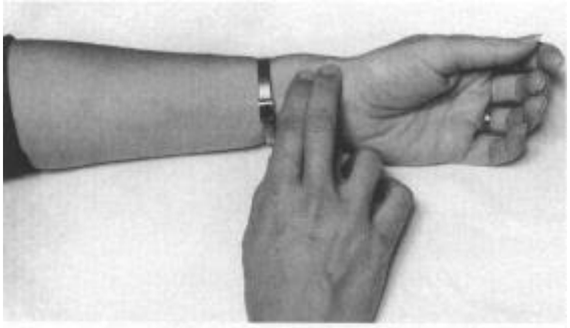


Figure 15.6. Measuring the pulse rate. Place the fingers over the radial artery at the wrist.

pulse rate?

Your pulse rate, also known as your heart rate, is the number of times your heart beats per minute. A normal resting heart rate should be **between 60 to 100 beats per minute**, but it can vary from minute to minute.

Your age and general health can also affect your pulse rate, so it's important to remember that a 'normal' pulse can vary from person to person.

Count the number of pulses for 60 seconds, and this will be the heart-rate in beats-per-minute.
Or just count the number of pulses for 30 seconds, and multiply that number by 2 for H.R. in bpm. At rest, a normal heart beats around 60-100 bpm

Body Temperature

Normal human body temperature, also known as *normothermia* or *euthermia*, is a concept that depends upon the place in the body at which the measurement is made, and the time of day and level of activity of the person. There is no single number that represents a normal or healthy temperature for all people under all circumstances using any place of measurement.

Different parts of the body have different temperatures. Rectal and vaginal measurements, or measurements taken directly inside the body cavity, are typically slightly higher than oral measurements, and oral measurements are somewhat higher than skin temperature. The commonly accepted average core body temperature (taken internally) is 37.0 °C (98.6 °F)

Methods of measurement

A medical/clinical thermometer showing the temperature of 38.7 °C

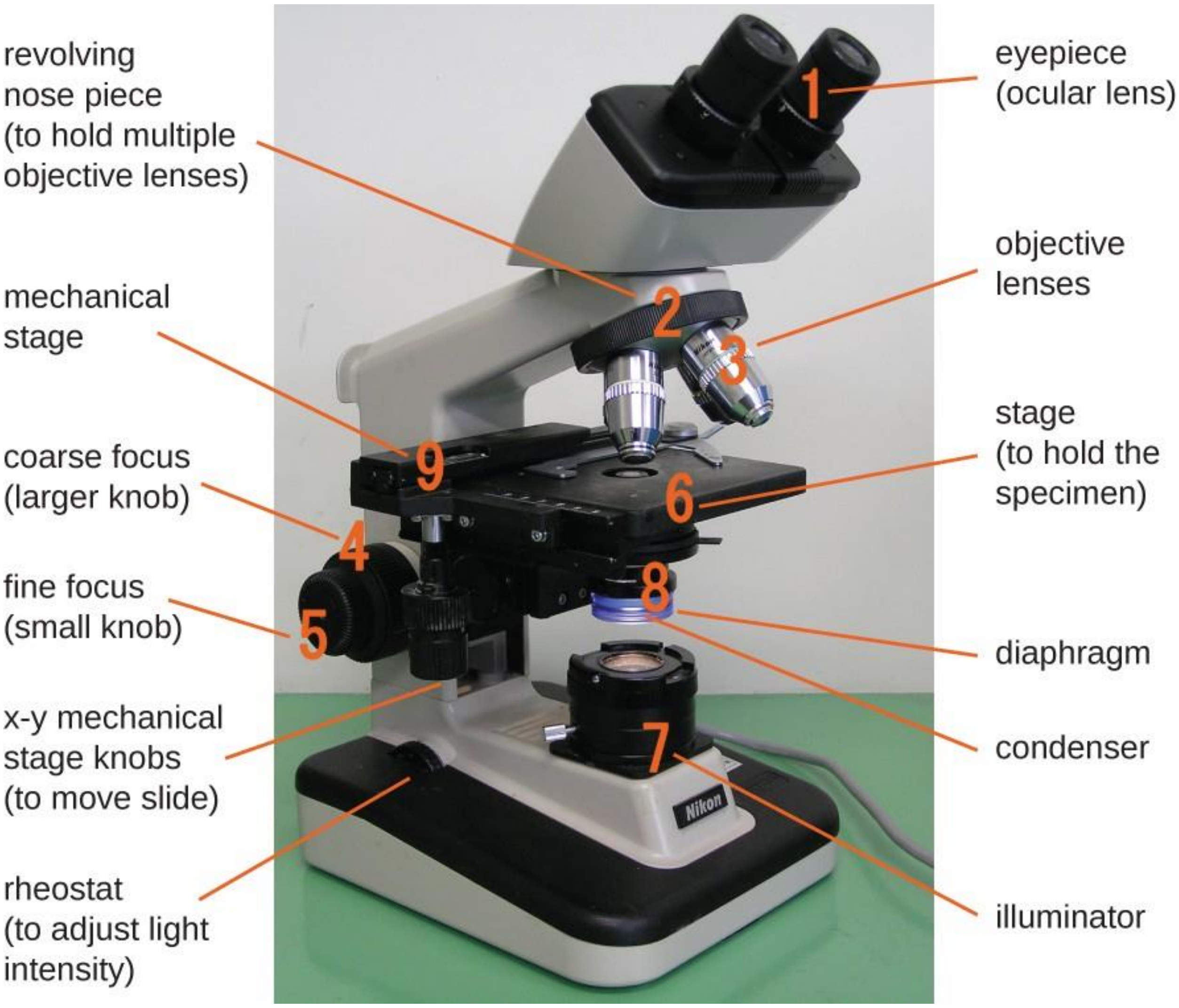
Taking a patient's temperature is an initial part of a full clinical examination. Sites used for measurement include:

- In the rectal
- In the mouth
- Under the arm
- In the ear
- In the vagina
- On the skin of the forehead

The temperature reading depends on which part of the body is being measured.

EXPERIMENT THREE

Optical microscopy



Microscope Definition- Microscopes are instruments that are used in science laboratories, to visualize very minute objects such as cells, microorganisms, giving a contrasting image, that is magnified. Microscopes are made up of lenses for magnification, each with its own magnification powers. Depending on the type of lens, it will magnify the specimen according to its focal strength.

Their ability to function is because they have been constructed with special components that enable them to achieve high magnification levels. they can view very small specimens and distinguish their structural differences, for example, the view of animal and plant cells, viewing of microscopic bacterial cells.

Microscopes are generally made up of structural parts for holding and supporting the microscope and its components and the optical parts which are used for magnification and viewing of the specimen images. This description defines the parts of a microscope and the functions they perform to enable the visualization of specimens.

Microscope Parts

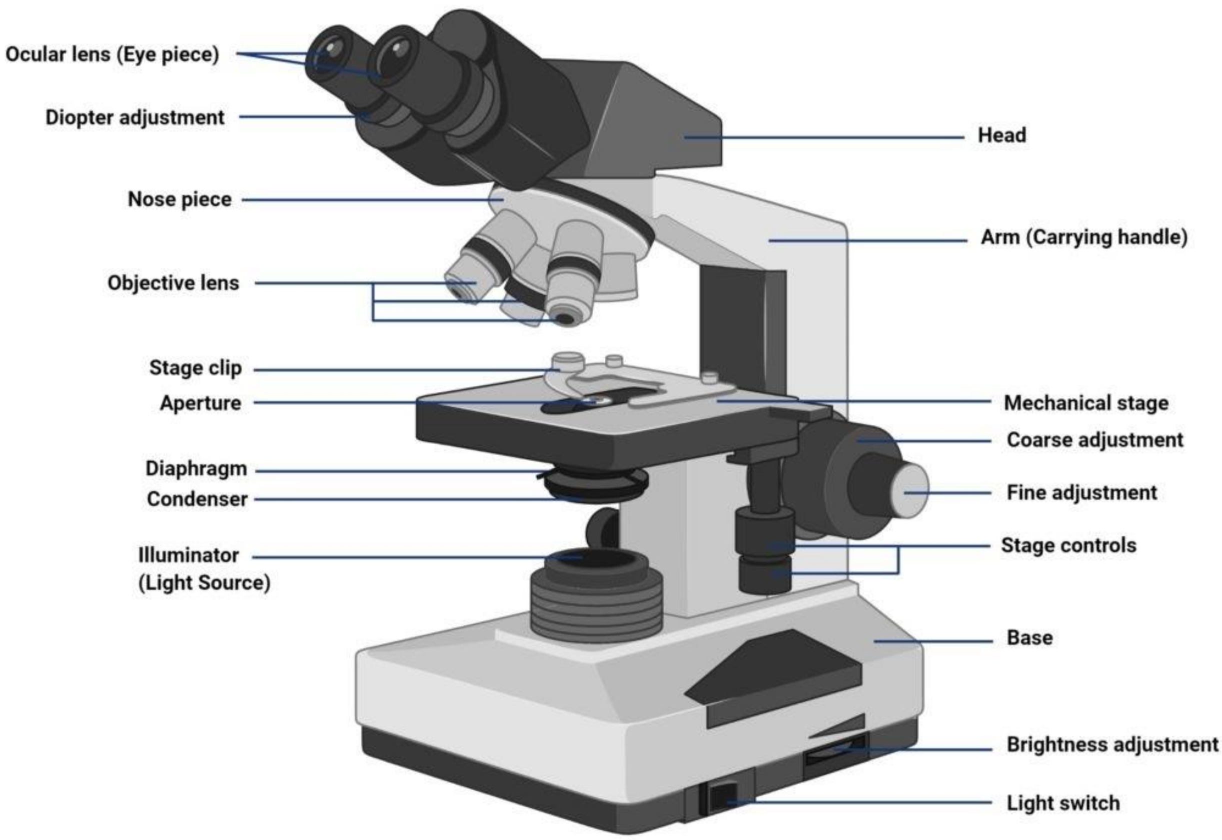


Figure: Parts of a microscope

What is a light microscope?

It is a device that shows the structure of living organisms that are not visible to the eye and the optical microscope can enlarge the studied objects from (50) to more than (1000) times.

optical microscopy is a technique working to closely view a sample through the magnification of a lens with visible light.

An optical microscope, also sometimes known as a light microscope, uses one or a series of lenses to magnify images of small samples with visible light. The lenses are placed between the sample and the viewer's eye to magnify the image so that it can be examined in greater detail.

Study of parts of a complex optical microscope:

A complex microscope is a sensitive tool that must be handled with care and consists of the following parts:

1. **Eyepiece** – also known as the ocular. this is the part used to look through the microscope. It's found at the top of the microscope. Its standard magnification is 10x with an optional eyepiece having magnifications from 5X – 30X.
2. **Eyepiece tube** – it's the eyepiece holder. It carries the eyepiece just above the objective lens. In some microscopes such as the binoculars, the eyepiece tube is flexible and can be rotated for maximum visualization, for variance in distance. For monocular microscopes, they are none flexible.
3. **Objective lenses** – These are the major lenses used for specimen visualization. They have a magnification power of 40x-100X. There are about 1- 4 objective lenses placed on one microscope, in that some are rare facing and others face forward. Each lens has its own magnification power.
4. **Nose piece** – also known as the revolving turret. It holds the objective lenses. It is movable hence it call revolve the objective lenses depending on the magnification power of the lens.
5. **The Adjustment knobs** – These are knobs that are used to focus the microscope. There are two types of adjustment knobs i.e fine adjustment knobs and coarse adjustment knobs.
6. **Stage** – This is the section on which the specimen is placed for viewing. They have stage clips that hold the specimen slides in place. The most common stage is a mechanical stage, which allows the control of the slides by moving the slides using the mechanical knobs on the stage instead of moving it manually.
7. **Aperture** – This is a hole on the microscope stage, through which the transmitted light from the source reaches the stage.
8. **Microscopic illuminator** – This is the microscopes light source, located at the base. It is used instead of a mirror. it captures light from an external source of a low voltage of about 100v.
9. **Condenser** – These are lenses that are used to collect and focus light from the illuminator into the specimen. They are found under the stage next to the diaphragm of the microscope. They play a major role in ensuring clear sharp images are produced with a high magnification of 400X and above. The higher the magnification of the condenser, the more the image clarity. More sophisticated microscopes come with an Abbe condenser that has a high magnification of about 1000X.
10. **Diaphragm** – it's also known as the iris. It's found under the stage of the microscope and its primary role is to control the amount of light that reaches the specimen. It's an adjustable apparatus, hence controlling the light intensity and the size of the beam of light that gets to the specimen. For high-quality microscopes, the diaphragm comes attached with an Abbe condenser, and combined they are able to control the light focus and light intensity that reaches the specimen.

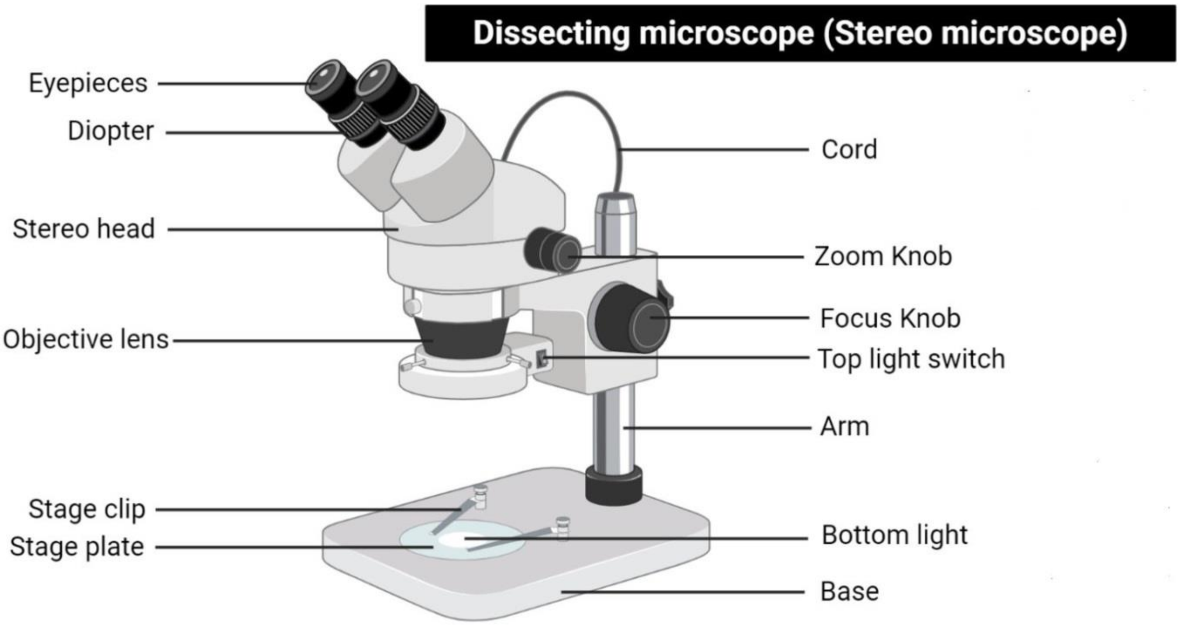
11. **Condenser focus knob** – this is a knob that moves the condenser up or down thus controlling the focus of light on the specimen.
12. **Abbe Condenser** – this is a condenser specially designed on high-quality microscopes, which makes the condenser to be movable and allows very high magnification of above 400X. High-quality microscopes normally have a high numerical aperture than objective lenses.

13. **Base: It is the bottom of the microscope**

Types of optical microscopes

There are many types of optical microscopes. They can vary from a very basic design to a high complexity that offers higher resolution and contrast. Some of the types of optical microscopes include the following:

- Simple microscope: a single lens to magnify the image of the sample, similar to a magnifying glass.
- Compound microscope: a series of lenses to magnify the sample image to a higher resolution, more commonly used in modern research.
- Digital microscope: may have simple or compound lenses, but uses a computer to visualize the image without the need for an eyepiece to view the sample.
- Stereo microscope: provides a stereoscopic image, which is useful for dissections.
- Comparison microscope: allows for the simultaneous view of two different samples, one in each eye.
- Inverted microscope: views the sample from underneath, which is useful to examine liquid cell cultures.



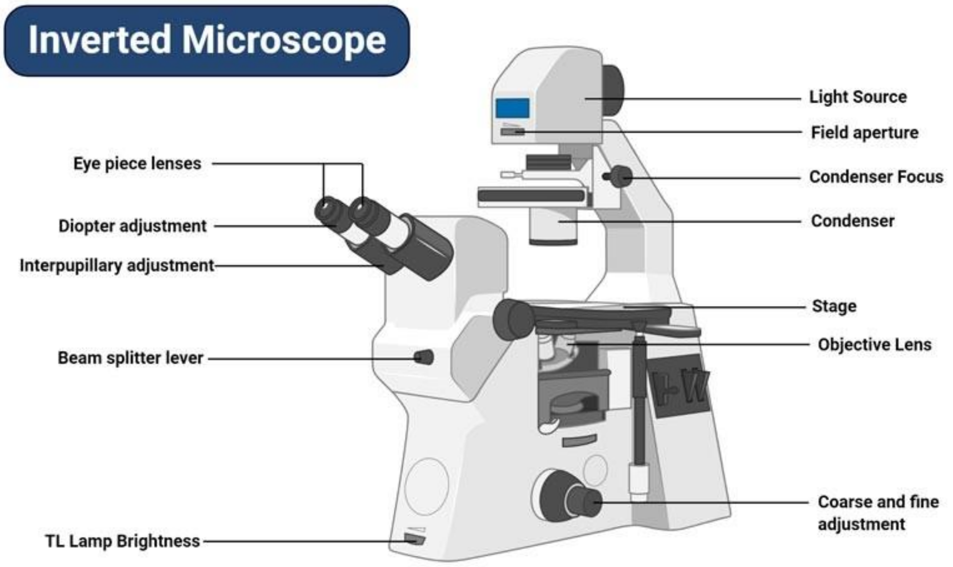


Figure: Inverted Microscope

Operation, applications and limitations

Optical microscopy is commonly used in many research areas including microbiology, microelectronics, nanophysics, biotechnology. It can also be useful to view biological samples for medical diagnoses, known as histopathology.

Microscopes in Botanical Field

Lab professionals and students who want to study the features of leaves, their cells, and many features of a plant, use this device. Botanists do multiple researches on various plants and fungi for research purposes which helps them find many new features.

Microscopes in Biological Field

We have seen this device in every biological laboratory. This device is used for observing microorganisms and their features. In this field, microscopes are used to study bacteria, cells and many more. This device helps biologists in their study of living organisms and their cell structures.

Microscope in Crime Detection

Use of microscopes in crime fields helps to simplify complex evidences and helps in studying them to solve cases. We use this device for forensics purposes and prove the convict is innocent or not. There is major application of these devices in this field and without it will not be possible to examine certain things which are not visible with naked eye.

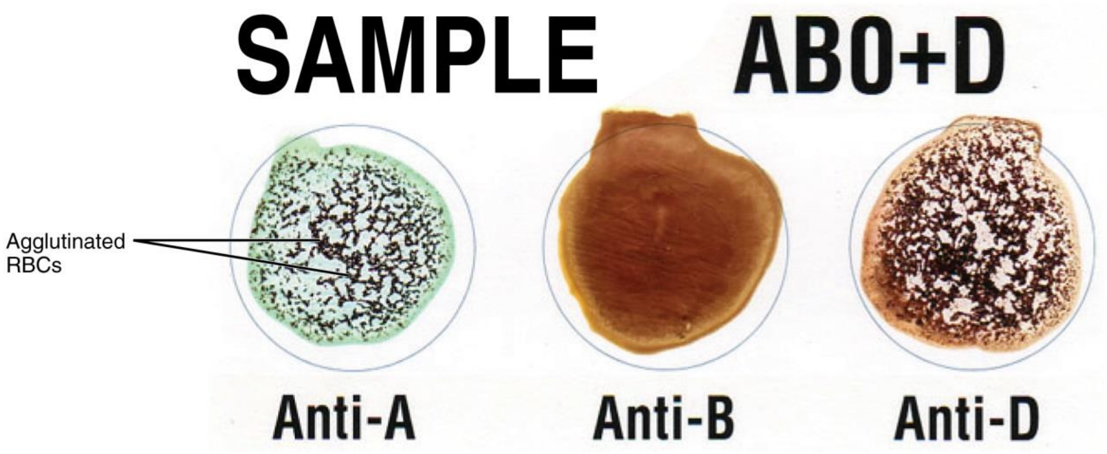
Microscopes in Education

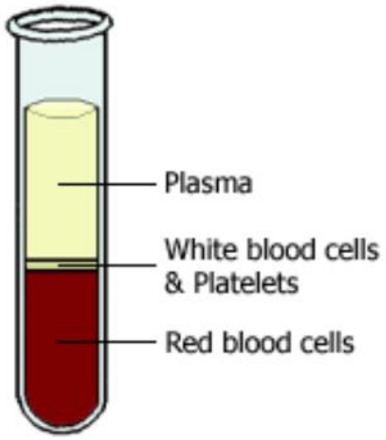
In various institutions, colleges, schools and universities, among various optical instruments, this lab tool will be found in every laboratory of major departments. Students use this device to learn new things and understand the world around them. Because of its excellent usage, it is one of the favorite device of students.

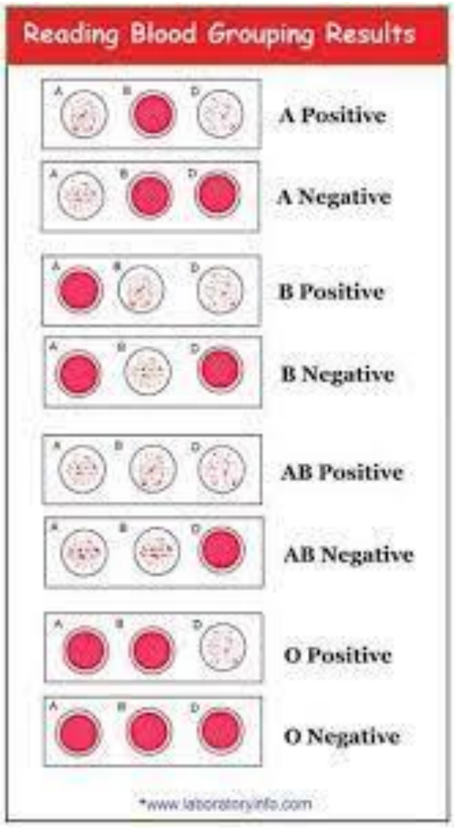
Microscopes in Medical field

Human's greatest contribution to healthcare would not have been possible without the use of microscopes. Scientists and lab professionals use this device to study various viruses and bacteria and find out cure for various diseases. Researchers use this device to study deadly microorganisms and how they affect human body

EXPERIMENT FOUR







BLOOD

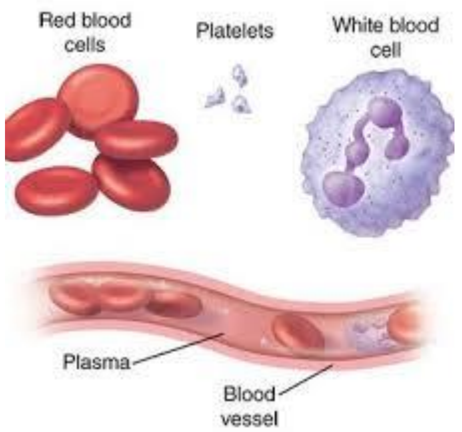


Figure 1 Blood Cells A single drop of blood contains millions of red blood cells, white blood cells and platelets

The average human adult has more than 5 liters of blood in his or her body. Blood carries oxygen and nutrients to living cells and takes away their waste products. It also delivers immune cells to fight infections and contains platelets that can form a plug in a damaged blood vessel to prevent blood loss.

Through the circulatory system, blood adapts to the body's needs. When you are exercising, your heart pumps harder and faster to provide more blood and hence oxygen to your muscles. During an infection, the blood delivers more immune cells to the site of infection. Blood is a fluid connective tissue critical to the transportation of nutrients, gases, and wastes throughout the body; to defend the body against infection and other threats; and to the homeostatic regulation of pH, temperature, and other internal conditions. Blood is composed of formed elements erythrocytes, leukocytes, and cell fragments called platelets and a fluid extracellular matrix called plasma. Because of the formed elements and the plasma proteins and other solutes, blood is sticky and more viscous than water. It is also slightly alkaline, and its temperature is slightly higher than normal body temperature.

1. Basic Hematology

A. Functions of Blood

1. **Transportation** of dissolved gases, nutrients, hormones, and metabolic wastes.
2. **Defense** against toxins and pathogens.
3. **Homeostasis:** Regulation of the pH, ion composition of interstitial fluids, water content, body temperature.

B. Characteristics of Blood

1. Blood is a **liquid connective** tissue which constitutes approximately 8% of human body mass.
2. Blood is 4-5 times more **sticky** than water.
3. Blood is somewhat sticky and has a salt concentration of about .85-.90%.
4. Blood temperature is slightly above normal body temperature (100.4^{o}F or 38^{o}C).
5. Blood pH ranges from 7.35 to 7.45 (slightly **alkaline**).
6. Blood volumes range from 4-6 liters:

a. Males have 5-6 liters
b. Females have 4-5 liters

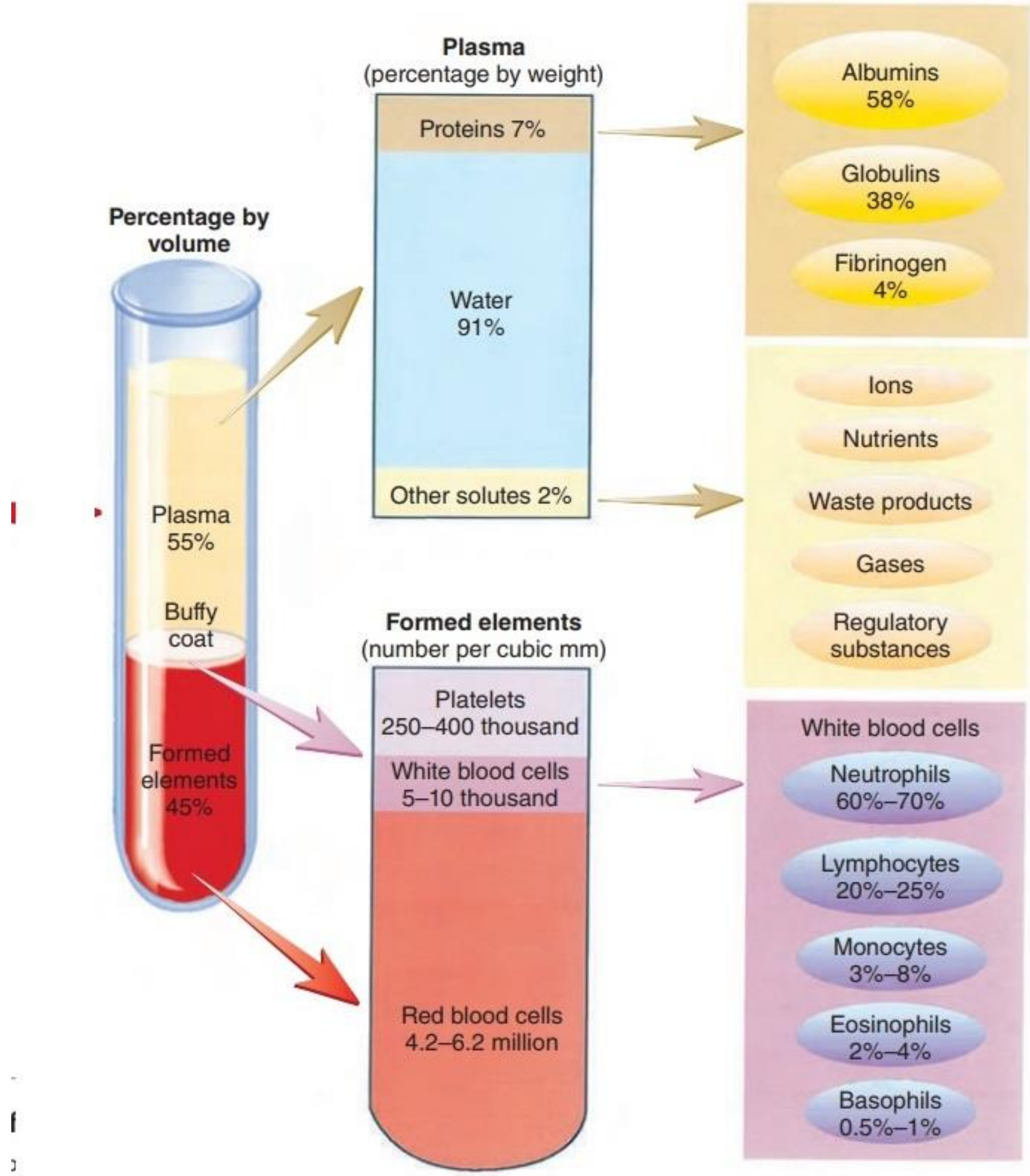
7. Whole blood is a **heterogeneous** mixture of non-living matrix called plasma (46 – 63%) and three formed elements (37 – 54%).

C. serum is the non-living component; it is composed of water and solutes (7% plasma proteins and 1% all other solutes.

Plasma is mainly water, but it also contains many important substances such as proteins (albumin, clotting factors, antibodies, enzymes, and hormones), sugars (glucose), and fat particles.

1. Water is the primary component of blood plasma (92%).

2. Plasma proteins are in solution rather than forming insoluble fibers like those in other connective tissues (such as the elastin and collagen fibers of areolar tissue, bone, or cartilage). If a test tube of blood is left to stand for half an hour, the blood separates into three layers as the denser components sink to the bottom of the tube and fluid remains at the top. The straw-colored fluid that forms the top layer is called plasma and forms about 60% of blood. The middle white layer is composed of white blood cells (WBCs) and platelets, and the bottom red layer is the red blood cells (RBCs). These bottom two layers of cells form about 40% of the blood. All of the cells found in the blood come from bone marrow. They begin their life as stem cells, and they mature into three main types of cells— RBCs, WBCs, and platelets. In turn, there are three types of WBC—lymphocytes, monocytes, and granulocytes—and three main types of granulocytes (neutrophils, eosinophils, and basophils).



D. Formed elements - blood cells and cells fragments suspended within the blood plasma.

1. **Erythrocytes** – also known as red blood cells; the most abundant blood cells and are specialized for the transport of oxygen.
2. **Leukocytes** – also known as white blood cells; participate in the body's defense mechanisms and are divided into five classes, each with a slightly different function.
3. **Thrombocytes** – also known as platelets; are not true cells but instead are only small, membrane-bound cellular fragments that contain enzymes and other substances important for the process of blood clotting.

The main difference between platelets and plasma is that platelets are a type of blood cells whereas plasma is the liquid that holds platelets. Platelets are small, colorless fragments, which are critical in blood clotting. Plasma suspends blood cells and other important substances.

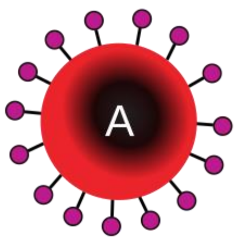
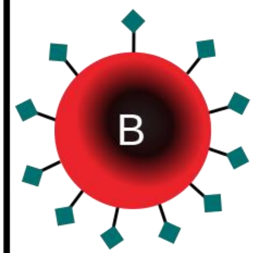
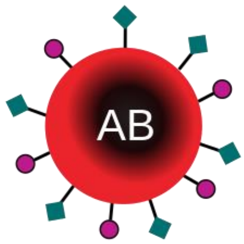
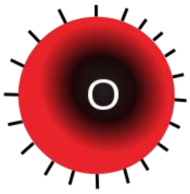
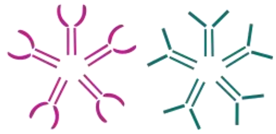
Blood Typing

Antigens are nonself molecules, usually large proteins, which cause an immune response. In transfusion reactions, antibodies attach to antigens on the surfaces of erythrocytes and cause agglutination and hemolysis. ABO blood group antigens are designated A and B. People with type A blood have A antigen on their erythrocytes, whereas those with type B blood have B antigens. Those with AB blood have both A and B antigens, and those with type O blood have neither A nor B antigens. The blood plasma contains preformed antibodies against the antigens not present on a person's erythrocytes.

A second group of blood antigens is the Rh group, the most important of which is Rh D. People with Rh^- blood do not have this antigen on their erythrocytes, whereas those who are Rh^+ do.

Antigens, Antibodies and Transfusion Reactions. Blood typing is based on antigens and antibodies

1. **Antigens/agglutinogens** found on the surface of red blood cells
2. **Antibodies/agglutinins** found in the plasma or serum.
3. Transfusion reactions occur due to incorrect blood types transfused into patient causing an immune reaction (large scale agglutination) possibly leading to hypoxia and kidney failure.

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in red blood cell	A antigen	B antigen	A and B antigens	None

A. ABO Blood Group:

1. **A blood type** - person has only the A antigen on the RBC surface (will have the anti-B antibodies in their plasma).
2. **B blood type** - person has only the B antigen on the RBC surface (will have the anti-A antibodies in their plasma).
3. **AB blood type** - person has both the A and B antigen on the RBC surface (will have neither the anti-A nor anti-B antibodies in their plasma).
4. **O blood type** - person has neither the A nor B antigen on the RBC surface (will have both the anti-A and anti-B antibodies in their plasma).

1. **Universal donor** - blood type O; when injected will not agglutinate for lack of antigen.
2. **Universal recipient** - blood type AB; they possess no antibodies so no agglutination of cells will occur.

EXPERIMENT FIVE

BLOOD DRAW

A procedure in which a needle is used to take blood from a vein, usually for laboratory testing. A blood draw may also be done to remove extra red blood cells from the blood, to treat certain blood disorders. Also called phlebotomy and venipuncture

What is a CBC?

A complete blood count, or CBC, is an easy and very common test that screens for certain disorders that can affect your health. A CBC determines if there are any increases or decreases in your blood cell counts. Normal values vary depending on your age and your gender. Your lab report will tell you the normal value range for your age and gender. A CBC can help diagnose a broad range of conditions, from anemia and infection to cancer.

The Three Basic Types of Blood Cells

Measuring changes in your blood cell levels can help your doctor evaluate your overall health and detect disorders. The test measures the three basic types of blood cells.

Red blood cells

Red blood cells carry oxygen throughout your body and remove carbon dioxide. A CBC measures two components of your red blood cells:

hemoglobin: oxygen-carrying protein

hematocrit: percentage of red blood cells in your blood

Low levels of hemoglobin and hematocrit are often signs of anemia, a condition that occurs when blood is deficient in iron.

Increase in Level

High levels of RBCs might indicate chronic lung disease, liver disease, kidney disease, exposure to carbon monoxide, smoking, excess alcohol consumption etc.

Decrease in Level

Low levels of RBCs might occur due to anemia, certain medications, bleeding, deficiency of certain vitamins etc.

White blood cells

White blood cells help your body fight infection. A CBC measures the number and types of white blood cells in your body. Any abnormal increases or decreases in the number or types of white blood cells could be a sign of infection, inflammation, or cancer.

Increase in Level

It might result from infection, allergies, cancer etc.

Decrease in Level

A low level of WBCs indicates infection, autoimmune disease, deficiency of vitamins etc.

Platelets

Platelets help your blood clot and control bleeding. When a cut stops bleeding, it’s because platelets are doing their job. Any changes in platelet levels can put you at risk for excessive bleeding and can be a sign of a serious medical condition.

Increase in Level

Platelet count increases when a person recovers from surgery, anemia, cancer, deficiency of vitamin B12, inflammation, infection.

Decrease in level

Low count of platelets may be due to cancer, anemia, chemotherapy, autoimmune diseases, infections, chronic bleeding.

Purpose of the test

The purpose of a complete blood count is to give your health care provider details about the state of your health. It is an important medical tool because it uses one sample to analyze the complete spectrum of cells found in the blood as well as some of the characteristics of those cells.

Because it provides information about every type of cell in the blood, the CBC can provide information related to a wide variety of medical problems.

The main uses for the CBC are diagnosis, monitoring, and screening:

Diagnosis is determining the cause of a patient's symptoms. The CBC can identify many different abnormalities in the blood that can be linked to distinct medical problems. For this reason, the CBC is frequently used as a diagnostic test. In many cases, it can confirm or rule out certain conditions and may be used alongside other tests to arrive at a definitive diagnosis.
Monitoring is the process of following a patient's condition over time. A CBC can be used to monitor patients who have previously been diagnosed with blood disorders. It can help see how a person's condition has responded to treatment, and it may be used to watch for side effects of some medical treatments.
Screening is testing to find health problems before there are any symptoms. In some cases, a doctor may prescribe a CBC as a screening test during routine check-ups.

What does the test measure?

A CBC involves multiple measurements that include the number of blood cells and some of their physical features. A standard CBC includes several elements related to red blood cells, white blood cells, and platelets that are described in the following sections.

Red blood cell measurements

Red blood cells (RBCs) are also called erythrocytes. They carry oxygen from your lungs to the tissues and organs in your body. A CBC test includes several basic measurements of RBCs:

RBC count is the total number of red blood cells in your blood sample.
Hemoglobin measures the amount of this oxygen-carrying protein that is found inside RBCs.
Hematocrit measures the proportion of your total blood volume that consists of red blood cells.

A CBC also provides details about the physical features of red blood cells. These are known as RBC indices. There are several kinds of RBC indices:

Mean corpuscular volume (MCV) is a measurement of the average size of red blood cells.
Mean corpuscular hemoglobin (MCH) is the average amount of hemoglobin inside each red blood cell.
Mean corpuscular hemoglobin concentration (MCHC) is a calculated measurement of how concentrated hemoglobin is within red blood cells.
Red cell distribution width (RDW) is a measurement of the variation in the size of your red blood cells.

White blood cell measurements

White blood cells (WBCs) are also called leukocytes. They are an important part of the body's immune system. A standard CBC measures the WBC count, which is the total number of white blood cells in a sample of blood. A common variation of the CBC is the complete blood count with differential. The white blood cell differential is a breakdown of the amount of each of five different types of WBCs:

Neutrophils: Neutrophils make up the greatest percentage of WBCs and are produced by the bone marrow to fight a diverse array of inflammatory and infectious diseases.
Lymphocytes: Lymphocytes such as B-cells and T-cells are found primarily in the lymph system and fight bacteria and other pathogens in the blood.
Monocytes: Monocytes work in conjunction with neutrophils to combat infections and other illnesses while removing damaged or dead cells.
Eosinophils: Eosinophils are WBCs that are activated in response to allergies and some types of infections.
Basophils: Basophils are involved in early identification of infections as well as wound repair and allergic reactions.

Initial blood testing may include a CBC with differential, or this test may be done after an initial standard CBC was abnormal. Because each white blood cell type has a different function, the CBC with differential can be used to identify abnormal levels of specific WBCs, which may offer clues about an underlying health concern.

Platelet measurements

Platelets, also called thrombocytes, are cell fragments that circulate in blood and play an essential role in blood clotting. When there is an injury and bleeding begins, platelets help stop bleeding by sticking to the injury site and clumping together to form a temporary plug.

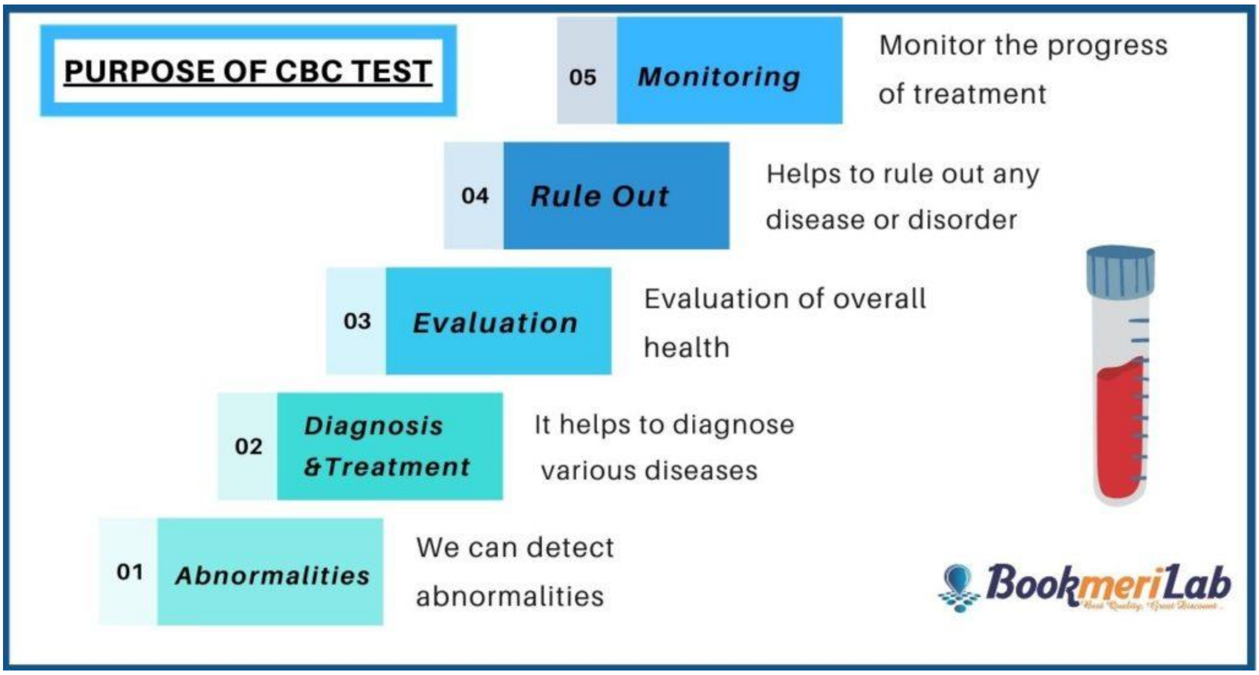
A standard component of the CBC is the platelet count, which is the number of platelets in your blood sample.

In some cases, your doctor may have the laboratory also measure the mean platelet volume (MPV), which determines the average size of platelets

Hemoglobin (Hb or Hgb). This is the protein in your blood that holds oxygen.

Hematocrit (Hct). This test tells how much of your blood is made up of red blood cells. A low score may be a sign that you don't have enough iron, the mineral that helps your body make red blood cells. A high score could mean you're dehydrated or have another condition.
Mean corpuscular volume (MCV). This is the average size of your red blood cells. If they're bigger than usual, your MCV will be higher. That could happen if you have low vitamin B12 or folate levels. If your red blood cells are smaller, you could have a type of anemia.
Platelets. These help your blood clot.

Mean corpuscular hemoglobin (MCH). This test tells how much hemoglobin is in your typical red blood cell.
Mean corpuscular hemoglobin concentration (MCHC). This measures the concentration of hemoglobin in a certain amount of blood.
Red cell distribution width (RDW). This shows how your much your red blood cells vary in size.
Reticulocyte count. This test measures the number of new red blood cells in your body.
Mean platelet volume (MPV). This result gives the average size of the platelets in your blood.
Platelet distribution width (PDW). This shows how much your platelets vary in size.
White blood cell differential. There are five types of white blood cells: basophils, eosinophils, lymphocytes, monocytes, and neutrophils. This test shows how many of each kind you have.



WBC Levels

Increase ↑	Decrease ↓
A high level of white blood cells might occur as a result of infection, medication, injury, pregnancy, allergic reactions, cancer, etc.	A low WBC count might indicate autoimmune diseases, infection, bone marrow disorder, diseases that compromise the immune system, deficiency of vitamins, lymphoma.

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RBC Levels

Increase ↑	Decrease ↓
Chronic lung disease, Liver disease, kidney disease, exposed to carbon monoxide, smoking, excess alcohol consumption etc.	Anemia, Certain medications, bleeding, deficiency of certain vitamins, etc.

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Platelet Levels

Increase ↑	Decrease ↓
Recovery from surgery, anemia, cancer, deficiency of vitamin B12, inflammation, infection.	Cancer, Anemia, Chemotherapy, Autoimmune diseases, infections, Chronic bleeding.

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Abbreviation	Test Name	Definition	Associated Disorders
WBC WBC Diff	White blood cells WBC differential Neutrophils Lymphocytes Monocytes Eosinophils Basophils	WBCs fight infection. The 5 different types of WBCs are listed to the left.	Infection, leukemia
RBC	Red blood cells	RBCs (with the help of hemoglobin) carry oxygen throughout the body	↓ Anemia, bleeding, malnutrition, kidney disease ↑ Polycythemia, heart and lung disease, dehydration
Hb or Hgb	Hemoglobin	Protein that carries oxygen	↓ Anemia, bleeding, malnutrition, cirrhosis, cancer ↑ Dehydration, polycythemia
Hct	Hematocrit	Amount of space in the blood that is occupied by RBCs	↓ Anemia, bleeding, malnutrition, cirrhosis, cancer
			↑ Dehydration, polycythemia, hemochromatosis
MCV	Mean corpuscle volume	Average size of the RBCs	Anemia, thalassemia, malnutrition
MCH	Mean corpuscle hemoglobin	Average amount of Hb in each RBC	Anemia, thalassemia, malnutrition
MCHC	Mean corpuscle hemoglobin concentration	Average amount of Hb in the RBCs compared to the average size of the RBCs	Anemia, thalassemia, malnutrition
RDW	Red cell distribution width	Amount of variation in size of the RBCs	Anemia, thalassemia, malnutrition
Plt	Platelet count	Platelets are sticky cells that help to form blood clots	Bleeding and clotting disorders
MPV	Mean platelet volume	Average size of the platelets	Bleeding and clotting disorders

EXPERIMENT SIX

Centrifuge

Laboratory Centrifuges

A centrifuge is a laboratory device that is used for the separation of fluids, gas or liquid, based on density. Separation is achieved by spinning a vessel containing material at high speed; the centrifugal force pushes heavier materials to the outside of the vessel. This apparatus is found in most laboratories from academic to clinical to research and used to purify cells, viruses, proteins, and nucleic acids. There are multiple types of centrifuge, which can be classified by intended use or by rotor design. From the large floor variety to the micro-centrifuge.

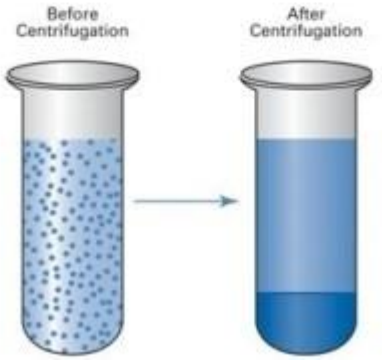
What is centrifugation?

Centrifugation is a technique used for the separation of particles from a solution according to their size, shape, density, viscosity of the medium and rotor speed.
The particles are suspended in a liquid medium and placed in a centrifuge tube. The tube is then placed in a rotor and spun at a define speed.
Separation through sedimentation could be done naturally with the earth gravity, nevertheless, it would take ages. Centrifugation is making that natural process much faster.
Rotation of the rotor about a central axis generates a centrifugal force upon the particles in the suspension.

Which factors have an influence on centrifugation :

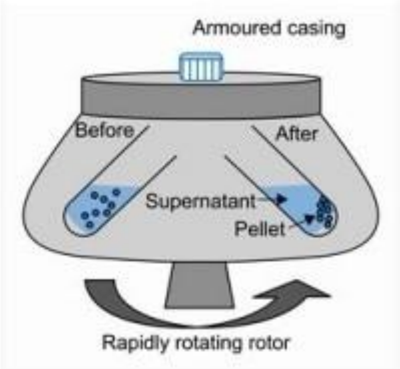
- **Density of both samples and solution**
- **Temperature/viscosity**
- **Distance of particles displacement**
- **Rotation speed**

A centrifuge is a device that separates particles from a solution through use of a rotor. In biology, the particles are usually cells, subcellular organelles, or large molecules, all of which are referred to here as particles.
There are two types of centrifuge procedures; one is preparative, the purpose of which is to isolate specific particles, and the other is analytical, which involves measuring physical properties of the sedimenting particles.
As a rotor spins in a centrifuge, a centrifugal force is applied to each particle in the sample; the particle will then sediment at the rate that is proportional to the centrifugal force applied to it. The viscosity of the sample solution and the physical properties of the particles also affect the sedimentation rate of each particle.
At a fixed centrifugal force and liquid viscosity, the sedimentation rate of a particle is proportional to its size (molecular weight) and to the difference between the particle density and the density of the solution.



In a solution, **particles whose density is higher than that of the solvent sink** (sediment), and particles that are lighter than it float to the top.

The greater the difference in density, the faster they move. If there is no difference in density the particles stay steady.



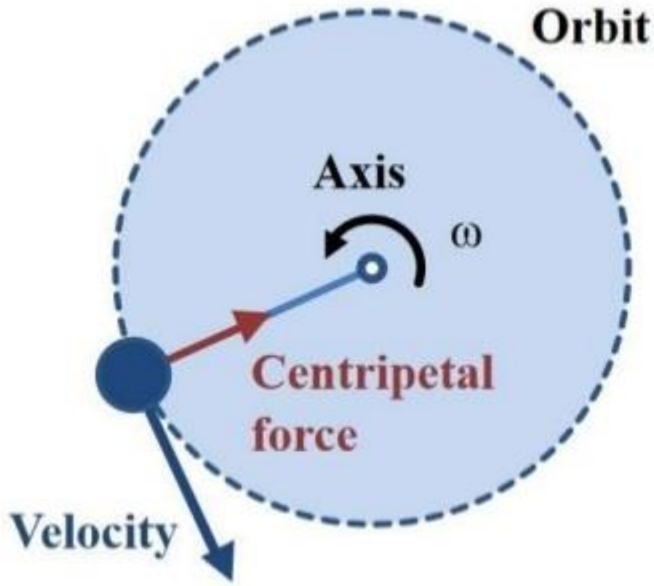
To take advantage of even tiny differences in **density to separate various particles in a solution**, gravity can be replaced with the much more powerful "**centrifugal force**" provided by a **centrifuge**.

Two forces counteract the centrifugal force acting on the suspended particles:

- **Buoyant force**: force with which the particles must displace the liquid media into which they sediment.
- **Frictional force**: force generated by the particles as they migrate through the solution.

Particles move away from the axis of rotation in a centrifugal field only when the centrifugal force exceeds the counteracting buoyant and frictional forces resulting in sedimentation of the particles at a constant rate.

Principle of Centrifugation



- In a solution, particles whose density is higher than that of the solvent sink (sediment), and particles that are lighter than it floats to the top.
- The greater the difference in density, the faster they move. If there is no difference in density (isopycnic conditions), the particles stay steady.
- To take advantage of even tiny differences in density to separate various particles in a solution, gravity can be replaced with the much more powerful “centrifugal force” provided by a centrifuge.
- A centrifuge is a piece of equipment that puts an object in rotation around a fixed axis (spins it in a circle), applying a potentially strong force perpendicular to the axis of spin (outward).
- The centrifuge works using the sedimentation principle, where the centripetal acceleration causes denser substances and particles to move outward in the radial direction.
- At the same time, objects that are less dense are displaced and move to the center.
- In a laboratory centrifuge that uses sample tubes, the radial acceleration causes denser particles to settle to the bottom of the tube, while low- density substances rise to the top.

Type of centrifuge

Separations are a critical step in your workflow; thus it’s important to consider the **centrifuge requirements and technical specifications** for your applications, from selecting the appropriate speed and g-force to exploring the latest trends in centrifugation.

1. Benchtop centrifuge

- Benchtop centrifuge is a compact centrifuge that is commonly used in clinical and research laboratories.
- It is driven by an electric motor where the tubes are rotated about a fixed axis, resulting in force perpendicular to the tubes.
- Because these are very compact, they are useful in smaller laboratories with smaller spaces.
- Different variations of benchtop centrifuges are available in the market for various purposes.
- A benchtop centrifuge has a rotor with racks for the sample tubes and a lid that closes the working unit of the centrifuge.
-

2. Hematocrit centrifuge

- Hematocrit centrifuges are specialized centrifuges used for the determination of volume fraction of erythrocytes (RBCs) in a given blood sample.
- This centrifuge provides hematocrit values that can be used for testing in biochemistry, immunity, blood test, and other general clinical tests.
- Hematocrit centrifuges may be used to help diagnose blood loss, polycythemia (an elevation of the erythrocyte count to above-normal levels), anemia, bone marrow failure, leukemia, and multiple myeloma.
- The microhematocrit centrifuge quickly attains speeds of 11,000 rpm and RCFs of up to 15,000 g to spin tube samples.

- The components of a hematocrit centrifuge are similar to that of the benchtop centrifuge, but this centrifuge is specialized for the use of blood samples.

3. High-speed centrifuge

- High-speed centrifuge, as the name suggests, is the centrifuge that can be operated at somewhat larger speeds.
- The speed of the high-speed centrifuge can range from 15,000 to 30,000 rpm.
- The high-speed centrifuge is commonly used in more sophisticated laboratories with the biochemical application and requires a high speed of operations.
- High-speed centrifuges are provided with a system for controlling the speed and temperature of the process, which is necessary for the analysis of sensitive biological molecules.
- The high-speed centrifuges come with different adapters to accommodate the sample tubes of various sizes and volumes.
- All three types of rotors can be used for the centrifugation process in these centrifuges.

4. Low-speed centrifuge

- Low-speed centrifuges are the traditional centrifuges that are commonly used in laboratories for the routine separation of particles.
- These centrifuges operate at the maximum speed of 4000-5000 rpm.
- These are usually operated under room temperature as they are not provided with a system for controlling the speed or temperature of the operation.
- Swinging bucket and fixed angle type of rotors can be used in these centrifuges.

- These are easy and compact centrifuges that are ideal for the analysis of blood samples and other biological samples.
- The low-speed centrifuge works on the same principle as all other centrifuges, but the application is limited to the separation of simpler solutions.

5. Microcentrifuge

- Microcentrifuges are the centrifuges used for the separation of samples with smaller volumes ranging from 0.5 to 2 µl.
- Microcentrifuges are usually operated at a speed of about 12,000-13,000 rpm.
- This is used for the molecular separation of cell organelles like nuclei and DNA and phenol extraction.
- Microcentrifuges, also termed, microfuge, use sample tubes that are smaller in size when compared to the standard test tubes used in larger centrifuges.
- Some microcentrifuges come with adapters that facilitate the use of larger tubes along with the smaller ones.
- Microcentrifuges with temperature controls are available for the operation of temperature-sensitive samples.

6. Ultracentrifuges

- Ultracentrifuges are the centrifuges that operate at extremely high speeds that allow the separation of much smaller molecules like ribosomes, proteins, and viruses.
- It is the most sophisticated type of centrifuge that allows the separation of molecules that cannot be separated with other centrifuges.
- Refrigeration systems are present in such centrifuges that help to balance the heat produced due to the intense spinning.
- The speed of these centrifuges can reach as high as 150,000 rpm.
- It can be used for both preparative and analytical works.

- Ultracentrifuges can separate molecules in large batches and in a continuous flow system.
- In addition to separation, ultracentrifuges can also be used for the determination of properties of macromolecules like the size, shape, and density.

7. Vacuum centrifuge/ Concentrators

- Vacuum centrifuge utilizes the centrifugal force, vacuum and heat to speed up the laboratory evaporation of samples.
- These centrifuges are capable of processing a large number of samples (up to 148 samples at a time).
- This type of centrifuge is used in chemical and biological laboratories for the effective evaporation of solvents present in samples, thus concentrating the samples.
- These are commonly used in high throughput laboratories for samples that might have a large number of solvents.
- A rotary evaporator is used to remove the unnecessary solvents and eliminate solvent bumping.
- The centrifuge works by lowering the pressure of the chamber, which also decreases the boiling point of the samples.
- This causes the solvents to be evaporated, concentrating the particles to be separated.

EXPERIMENT SEVEN

ANATOMY AND PHYSIOLOGY OF THE EAR AND HERING TEST

Divisions Of The Ear

- **External Ear**
- **Middle Ear**
- **Inner Ear**
- **Central Auditory Nervous System**

Function

Primarily, the ear serves two functions—hearing and regulation of balance.

Hearing

The outer ear is shaped to direct sound waves from the external environment to the ear canal. These are then directed towards the tympanic membrane (eardrum), causing it to vibrate. This

vibration then causes the malleus, incus, and stapes to vibrate, which leads the perilymph within the cochlea to vibrate, stimulating a small portion called the organ of Corti.

As the fluid moves, tiny hairs on the surfaces of the organ of Corti are stimulated and this is translated into electrical signals that are delivered to the auditory nerve of the brain for processing.[5]

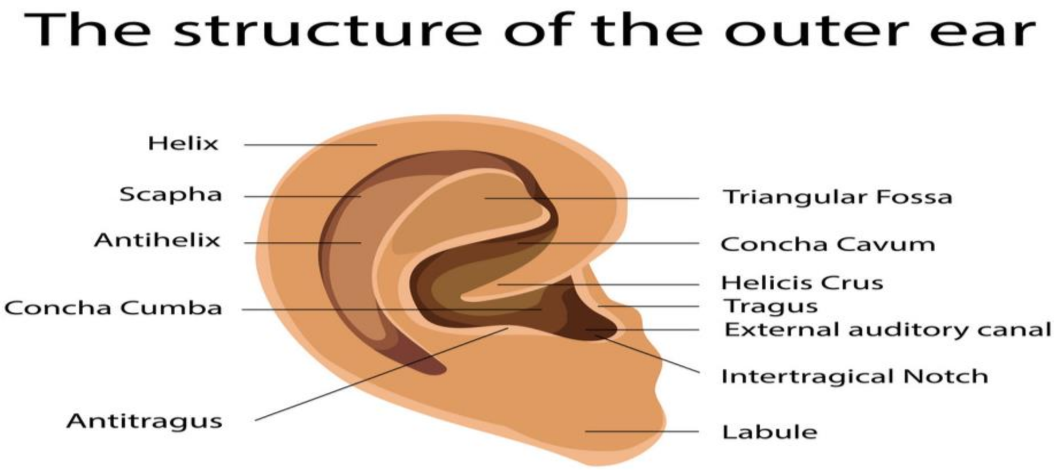
Balance

Sense of balance and position is regulated by structures in the inner ear, most notably the semicircular canals and the utricle and saccule in the vestibule.

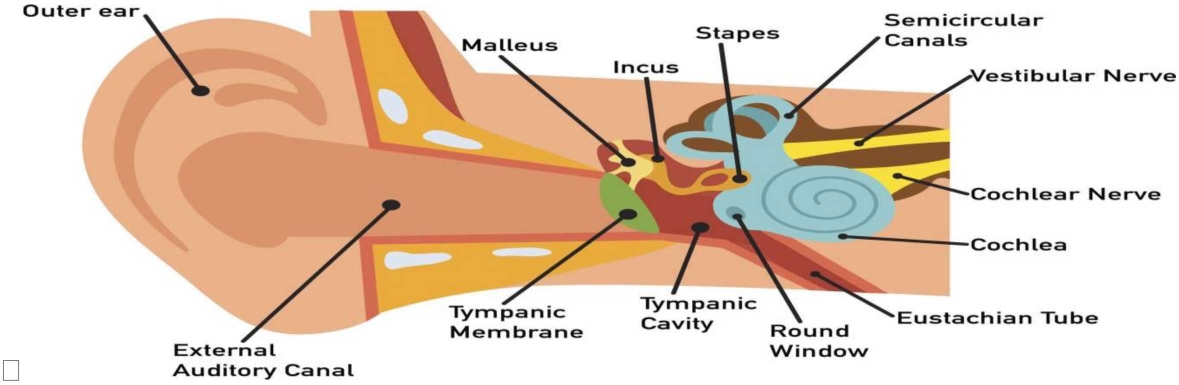
The three semicircular canals correspond to the three dimensions (x, y, and z), and connect to the utricle at an ampulla—a widening of the canal. Within the ampulla are special sensory cells called epithelia and hair cells underneath a substance called gelatinous copula. Each semicircular canal is filled with endolymph as well, and, as the head rotates, the endolymph is displaced, exciting the cells and generating a sense of balance.

Structures of the Outer Ear Pinna

- **Collect sound**
- **Localization**
- **Resonator**
- **Protection**



Structures of the Middle Ear



Anatomy

Tympanic Membrane

The tympanic membrane is also called the eardrum. It separates the middle ear from the external ear. It is semitransparent and under normal circumstances surrounded by air on both sides.

The Tympanic Cavity

Medial to the tympanic membrane is the tympanic cavity, which essentially makes up the middle ear. A healthy middle ear is filled with air.

It is a rectangular space with four walls, a ceiling, and a floor. The lateral wall consists of the tympanic membrane. The roof separates the middle ear from the middle cranial fossa. The floor separates the middle ear from the jugular vein.

The Ossicles

The ossicles are three tiny bones contained in the middle ear that are essential in conducting sound. They are called the malleus (the hammer), incus (the anvil), and stapes (the stirrup). They are connected by synovial joints and ligaments.

Sometimes the three bones are referred to as the ossicular chain. The chain carries vibrations from the tympanic membrane to the oval window. The stapes is the smallest bone in the human body.

The Auditory (Eustachian) Tube

The auditory tube runs from the anterior wall of the middle ear to the nasopharynx (back of the throat). The auditory tube ventilates the middle ear and also clears it of mucus and unwanted debris.

The inside of the tube is lined with cilia, small hairs that sweep mucus out of the tube where it drains into the back of the throat. The auditory tube of a child is much smaller in diameter than that of an adult and lies more horizontally. An adult auditory tube is approximately 31 mm to 38 mm in length.[3]

Function of Middle Ear

 Conduction

 Protection

 Transducer

 Amplifier

Structures of the Inner Ear

 Cochlea

 Vestibule

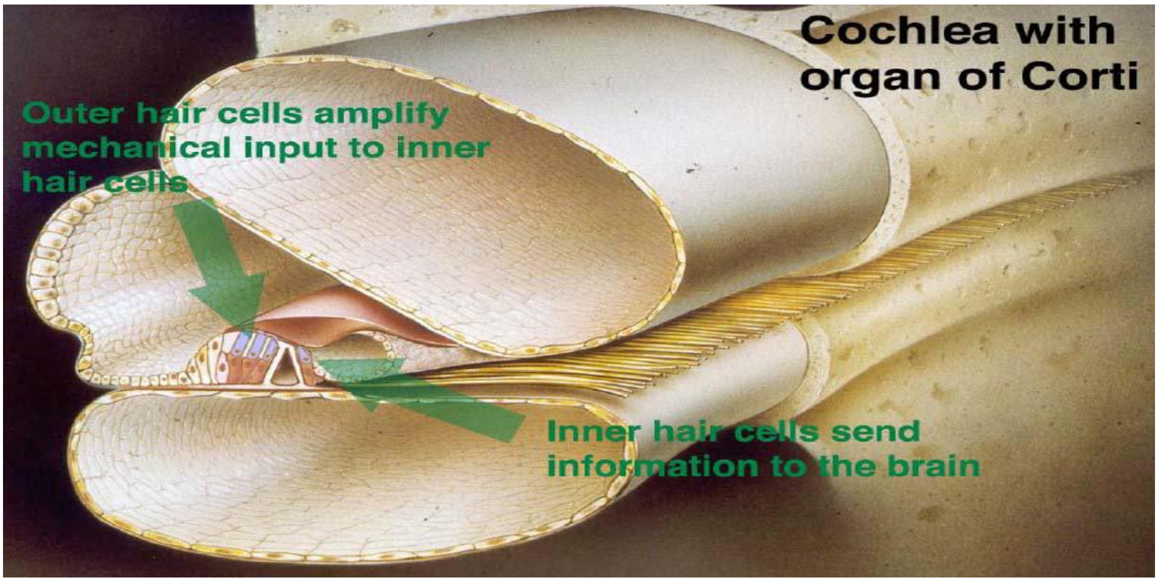
 Semicircular canals

Cochlea

 Snail-shaped organ with a series of fluid-filled tunnels

 converts mechanical energy into electrical energy

 It contain *Organ of Corti* (end organ of hearing)



Vestibular System

 Consists of vestibule and three semicircular canals

 Shares fluid with the cochlea

 Controls balance

 No part in hearing process *Vestibular System*

 Consists of vestibule and three semicircular canals

 Shares fluid with the cochlea

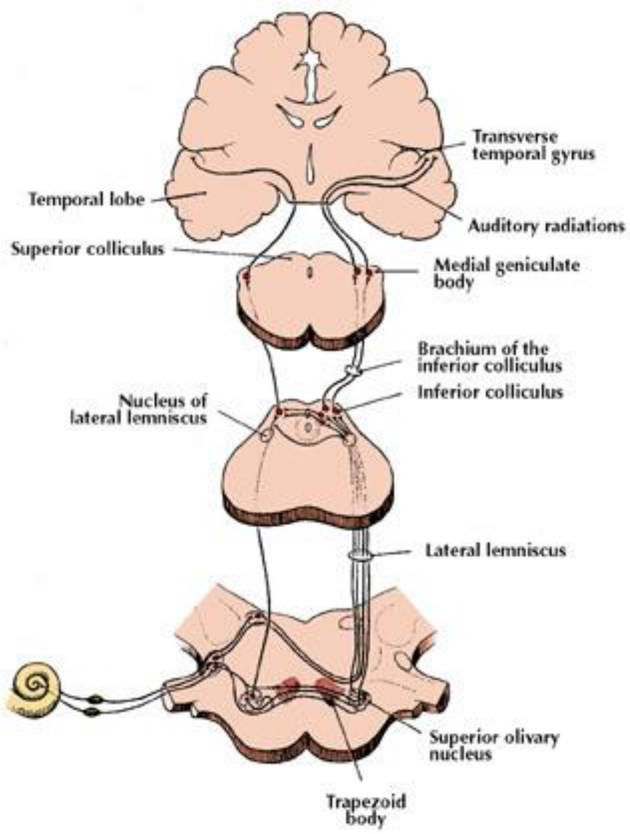
 Controls balance

 No part in hearing process Central Auditory Pathway

 Pathway between cochlea and auditory cortex

 Cochlear nerve

 Cochlear nucleus



A range of medical tests and examinations can be used to assess the ear and its functions. Common tests:

Pure Tone Testing

This type of test, also known as pure tone audiometry, uses air conduction to measure your ability to hear sounds at various pitches and volumes. You will be asked to wear headphones and sit in a specially designed booth. A series of sounds will be broadcast through the headphones. Every time you hear a tone you will be instructed to raise your hand or press a button. The results will then be charted on an audiogram.

Bone Conduction Testing

This is another type of pure-tone test that measures your inner ear's response to sound. A conductor will be placed behind your ear; it will send tiny vibrations through the bone directly to the inner ear. This is different than the traditional version, which uses air to send audible sounds. If the results of this test are different than the pure-tone audiometry, your Green Valley audiologist can use this information to determine your type of hearing loss.

Speech Testing

This type of testing is used to measure your speech reception threshold (SRT), or the faintest speech you can understand 50 percent of the time. It is administered in either a quiet or noisy environment and measures your ability to separate speech from background noise.

Tympanometry

This test measures the movement of your eardrum in response to air pressure. It can determine if there is a buildup of fluid, wax buildup, eardrum perforations or tumors.

Acoustic Reflex Testing

This test measures involuntary muscle contractions of the middle ear and is used to determine the location of your hearing problem (the ossicles, cochlea, auditory nerve, etc.) as well as the type of hearing loss.

Auditory Brainstem Response (ABR)

This type of testing is used to determine whether a specific type of hearing loss—sensorineural—exists. It is also frequently used to screen newborns for hearing problems. In an ABR test, electrodes are attached to your head, scalp or earlobes, and you are given headphones to wear. Your brainwave activity is measured in response to sounds of varying intensities.

Otoacoustic Emissions (OAEs)

OAEs are sounds generated by the vibrations of the hair cells in the cochlea of your inner ear. This type of testing uses a tiny probe fitted with a microphone and speaker to stimulate the cochlea and measure its response. Individuals with normal hearing will produce emissions; when hearing loss exceeds 25-30 decibels, no sound will be produced. This test helps determine whether there is a blockage in the ear canal, excess fluid in the middle ear or damage to the hair cells of the cochlea. OAE testing is often included in newborn hearing screening programs.

Any combinations of these tests may be ordered by your audiologist. Once they are complete, your Green Valley audiologist will be able to create an individualized treatment plan. Contact our office to schedule a hearing test today.