# General Lab Instruments

- principles of operation
- construction
- troubleshooting
- preventive maintenance
- performance monitoring


**18.7.13 Maintain a vortex mixer, roller, water bath and block heater**

**18.7.12 Maintain centrifuges and incubators**

**18.7.2 Maintain microscopes**

**Unit C18.7 Maintaining Laboratory Equipment**

**Module 279 19 C Medical Instrumentation II**

# Standard Lab 'Instruments'

## Beaker


- simple container for stirring, mixing and heating liquids
- generally cylindrical in shape, with a flat bottom and a lip for pouring
- available in a wide range of sizes, from one millilitre up to several litres.

## Erlenmeyer Flask


- flat, conical body, and a cylindrical neck
- allows contents to be swirled or stirred during an experiment - narrow neck keeps the contents from spilling out
- reduces evaporative losses compared to a beaker

## Volumetric Flask

- flat bottomed bulb with a long neck, usually fitted with a stopper
- the neck has a single ring graduation mark and a label
- used for making solutions to a known volume

## Graduated Cylinder

- used to accurately measure the volume of an object
- more accurate and precise for this purpose than flasks and beakers

## Test Tube

- common piece of glassware consisting of a finger-like length of glass or clear plastic tubing, open at the top, usually with a rounded U-shaped bottom
- available in a multitude of lengths and widths, typically from 10 to 20 mm wide and 50 to 200 mm long

## Beaker Tongs

tongs used to carry a beaker after it has been subjected to heat and/or cold temperatures

# Standard Lab 'Instruments'

## Medicine Dropper

- usually glass tubes tapered to a narrow point, and fitted with a rubber bulb at the top
- used to transfer small quantities of liquids

## Bunsen Burner

piece of laboratory equipment that produces a single open gas flame, which is used for heating, sterilization, and combustion

## C-Clamp

a device (shaped like a "C")used to hold or secure objects to a retort stand.

## Petri Dish

a shallow glass or plastic cylindrical lidded dish that biologists use to culture cells

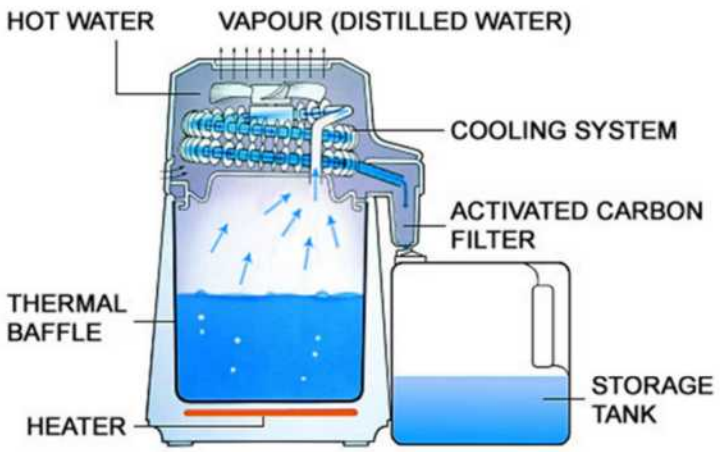
## Burette

- a vertical cylindrical piece of laboratory glassware with a volumetric graduation on its full length and a precision tap, or stopcock, on the bottom
- used to dispense known amounts of a liquid in experiments for which precision is necessary, (e.g. a titration experiment)

# Standard Lab 'Equipment'

Previously discussed standard lab equipment:

- (analytical) balances
- water distiller
- refrigerators




In these Lab lectures we will deal with:

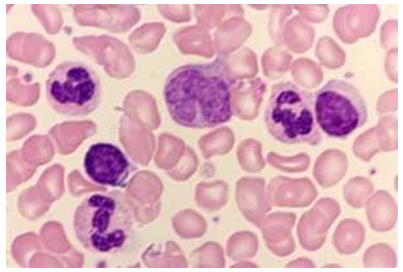
- microscopes
- centrifuges
- incubators
- mixers
- rollers
- water baths
- block heaters

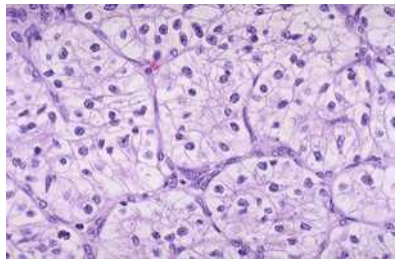
# Microscope: Use

The **optical** (or '**light**') **microscope** is a precision instrument with uses visible light and a system of lenses to magnify images of small tissue samples – up to **1000x** magnification - so that these can be studied in detail.

The microscope is an important diagnostic aid in healthcare. It is used to examine body fluids, body tissues, and faeces throughout the clinical lab:

- In **hematology**, microscopic analysis of blood cells helps diagnose **blood disorders**, as well as **infections** and **allergies**.
- In **histology**, microscopic examinations can detect **abnormal changes in tissues** to differentiate benign, inflammatory, precancerous, or malignant conditions.
- In **biochemistry**, microscopic examination of **urinary sediment** is extremely valuable in laboratory evaluation of **kidney function**;





In order to increase visibility of details, **'staining'** or 'colouring' techniques (adding specific staining materials) are usually applied to the tissue samples before viewing.

# Microscope: models

A **binocular microscope** refers to any microscope with **two eyepieces**. High power microscopes typically have two eyepieces which view images through a **single high-power objective lens**. The image presented to each eye is exactly the same: a flat, 2-dimensional 'mono' image.


**Monocular microscopes** have a single eyepiece (ocular), showing a mono-image to one eye only.

# Stereo Microscope

A **stereo microscope** or dissecting microscope is designed for **low magnification**, typically using light **reflected from the surface** of an object rather than transmitted through it. The instrument uses two separate optical paths with **two objectives** and eyepieces to provide slightly different viewing angles to the left and right eyes. This arrangement produces a **three-dimensional (stereo) visualization** of the sample being examined.

The stereo microscope is often used to study the surfaces of solid specimens or to carry out close work such as dissection and **micro-surgery** (see 'Operating Microscope' in Medical Instrumentation I.

***operating microscope***


***stereo microscope***

# Microscope: models

A simple 'microscope' uses only one lens for magnification. It is found in simple magnification devices, such as the **magnifying glass**, and the loupe.


**Digital microscope**
with a display

An **electron microscope** uses a beam of accelerated electrons as a source of illumination. It can achieve magnifications of up to **10,000,000x**

# Microscope: Magnification

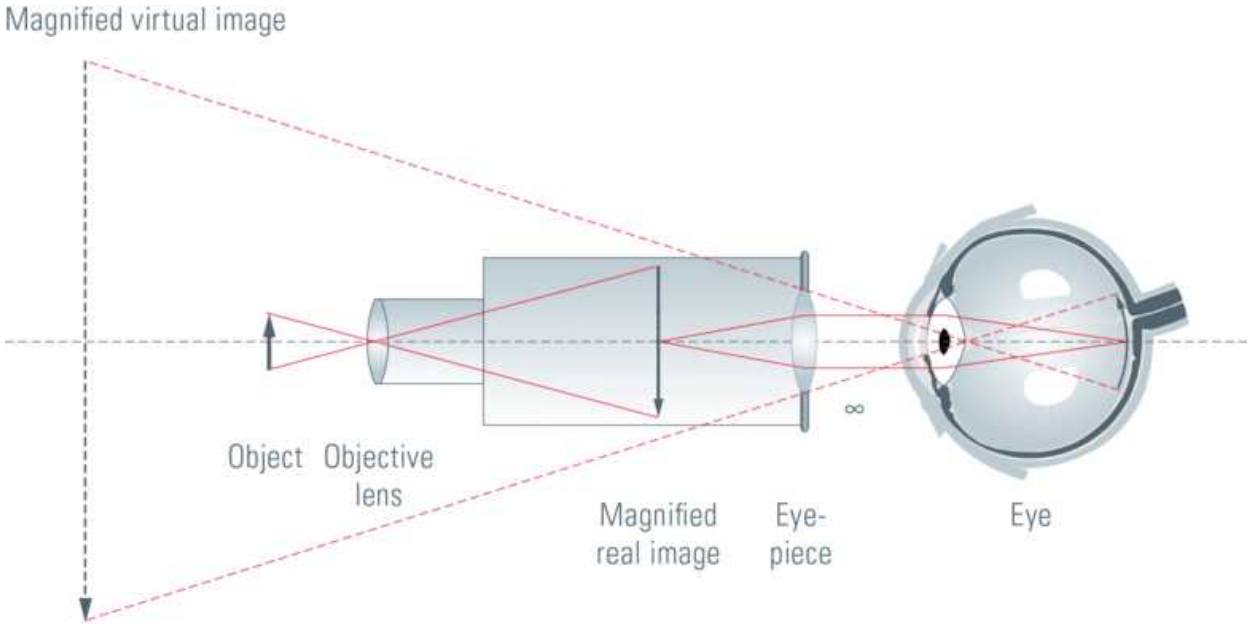
**Optical magnification** is the process to enlarge something in appearance. The degree of magnification is given by the **magnification factor**. Optical magnification is the ratio between the **apparent size** of an object ('its size in an image') and its **true size**, and thus it is a dimensionless number.

The optical microscope magnifies an object in two steps. The **objective lens** produces a magnified, real image of the object and the **eye piece** projects this image into the observer's eye.

The **magnification (M)** is determined by the strength of eye piece and the objective lens, which is usually written on it.

For a microscope, M is calculated as

$$M_{microscope} = M_{objective} \times M_{eyepiece}$$



# Microscope: Construction


1. **ocular lens**, or **eyepiece**
   A cylinder containing two or more lenses to bring the image to focus for the eye. Eyepieces are interchangeable and have different degrees of magnification, typically **2x, 5x** and **10x**.
2. **objective turret**
   A cylinder containing one or more lenses to collect light from the sample.
3. **objective lenses**
   At the lower end of the turret objective lenses are screwed into a circular nose piece which may be rotated to select the required objective lens. Typical magnification values of objective lenses are from **4x to 100x**.
4. **coarse adjustment knob** and 5. **fine adjustment knob** to focus the image
6. **object holder** or **stage**
7. **mirror** or **light**
   sample illumination is controlled either via a mirror or via a controllable light source that is focused through an optical device called a
8. **condenser with diaphragms and filters** to process the light so that it becomes homogeneous.

# Oil Immersion Objectives

In light microscopy, oil immersion is a technique used to **increase the resolving power** of a microscope. This is achieved by immersing both the objective lens and the specimen in a **transparent oil** of high refractive index. A drop of oil is placed on top of the cover glass or specimen. After focusing the specimen under a low-power objective, the **oil-immersion lens** is moved into place. It contacts the oil and can touch the cover glass.


*oil-immersion lens*

***Immersion oils are transparent oils that have specific optical and viscosity characteristics.***

# Microscope: Maintenance

**User Maintenance: Cleaning** and **Storing**

When the microscope is not in use, it should be kept covered with a clean cloth or plastic cover to protect the lenses from settling **dust**. Overnight it should be placed inside its box, with the door tightly closed. When it is warm and humid, the microscope should be stored in dry conditions when not in use: in a 'warm cupboard', with two or more, constantly burning 25-watt bulbs. The temperature inside the cupboard should be a constant 30–35 °C, with low humidity or in a continuously air-conditioned room.

**Preventive Maintenance**, every six months

- Clean with air brush or blower; no use of alcohol
- Lubricate adjustments
- Check function: lighting, image quality, knobs, ..

**Corrective Maintenance**

Usual problem is **image quality** (unclear images):

- check power, lighting (replace fuse, bulb)
- check cleanliness objective lens (clean)
- mechanical movement of adjustment knobs

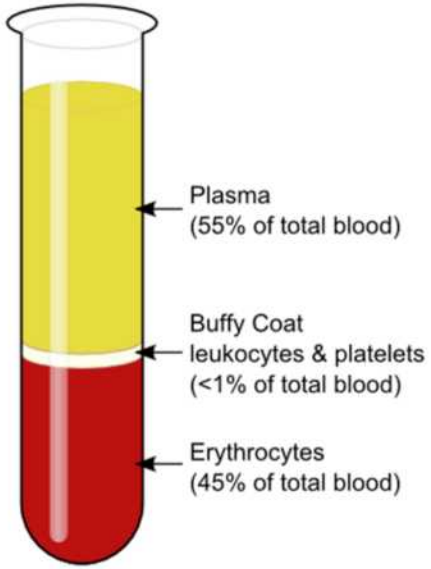
When there is a need to dismount the different components of a microscope, the main issue is to work very clean. Keep in mind that this is a precision instrument where everything should precisely fit together. Minimize application of force.

# Laboratory centrifuges: principle and use

A laboratory centrifuge is driven by a motor and spins around **liquid samples** in test tubes at high speed.
It is used to **separate substances** of greater and lesser density in the test tube fluids such as blood and urine.

***In a centrifuge, the tubes will point outward, so that the heavy parts are forced to the bottom of the tubes.***

Through rapid rotation, a **centrifugal force** (directed away from the center of rotation) is generated. This causes heavier particles in the test tubes to move furthest away from the center of rotation (to the bottom of the test tube).




***Centrifugation will separate blood in its heavier (erythrocytes) and lighter (plasma) elements.***

# Centrifuge Models

There are different types of laboratory centrifuges such as:

- **Micro-centrifuges** for small 'micro-'tubes (up to 2 ml)
- **Clinical centrifuges** for clinical applications like blood collection tubes, low-speed devices
- **Multipurpose benchtop centrifuges** for a broad range of tube sizes, high variability

Centrifuges may have a **refrigeration** function to prevent the temperature of sensitive samples to go up through the heat that is generated by the rapid spinning.

***Multipurpose benchtop centrifuge***

***Micro centrifuge***

***Clinical centrifuge***

***Large lab centrifuge***

# Centrifuges: Components

The centrifuge consists of a **motor,** a holder for the tubes which is called the **rotor** and some **control electronics**.

The rotor is connected directly to the motor shaft. There is no gear or other mechanics in between. A **timer** switches off the centrifuge automatically after some minutes.

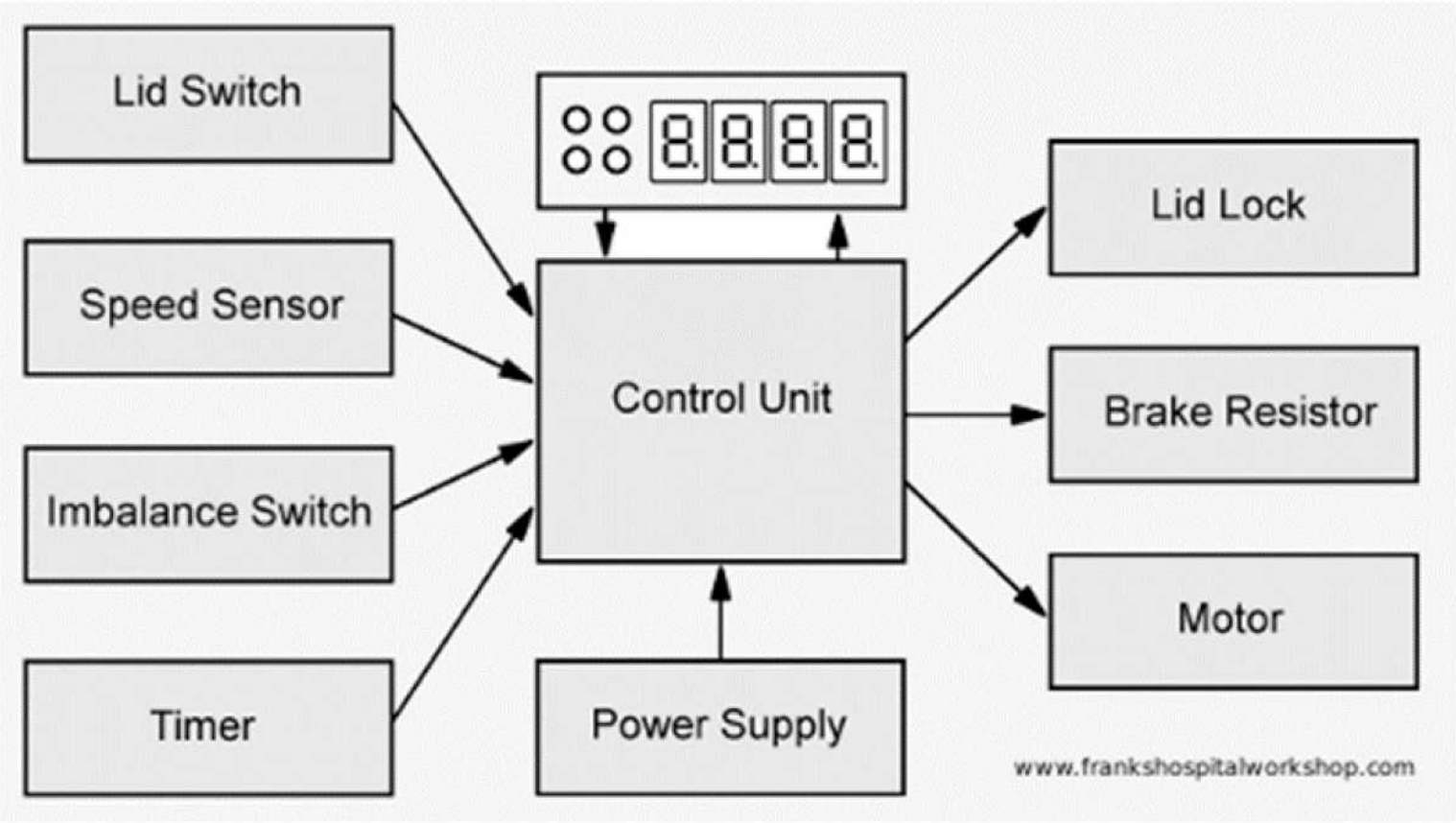
Centrifuges include a **speed control** and a **lid lock**, which prevents the lid from opening while the rotor is spinning.

***Swing out rotor***
for low speed applications

***Tubes come in various sizes***

***Fixed angle rotor***
for general purpose centrifuges: faster and less expensive

# Centrifuges: Control unit




The control unit checks on all (safety) sensors and switches the centrifuge off in case of danger.

# Centrifuges: Preventive Maintenance

Preventive maintenance to be done every 6 months, including the usual actions:

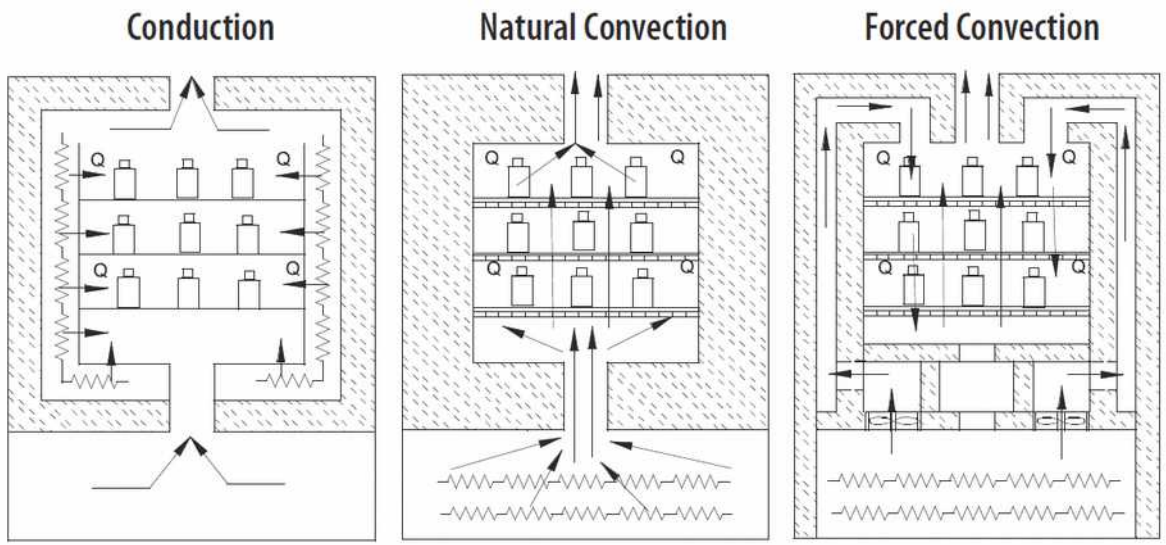
- **Cleaning** (if necessary, when the user are not doing this frequently, as they should be trained to do) inside outside. Note that **disinfection** – and working with gloves – may be necessary.
- **Outside & Inside visual check**: check on tight fixing of centre nut. Check for corrosion, printed circuit boards, ….
- **Lubrication**: grease to joints and bearings (no oil!)
- **Seals and Gaskets**: replace/repair if worn
- **Electric safety** inspection and tests
- **Functional tests**
  - check speed, timer (with tachometer)
  - verify lid security switch, alarms
  - temperature (in case of refrigeration)


***A tachometer is an optical measurement equipment. It needs to 'see' the rotating object***

The majority of all centrifuge accidents results from user error: overfilling, unbalanced filling, ….

# Incubators ('brood stoves')

The incubator is a chamber of controlled **temperature**, **atmosphere** and **humidity** to maintain live organisms - such as bacteriological, viral, cellular cultures - in an environment suitable for their growth.
Some Incubators only control temperature (10 °C and go up to 75 °C) while others control the atmospheric composition (incl. CO2) as well. Some include refrigeration systems.




***Heat transfer systems used in incubators***


***incubator***

# Incubator Components

**Heating elements** (system of resistors), generally located in the lower part of the incubator.

**Cooling ventilator** for internal circulation of air

**Electronic control**

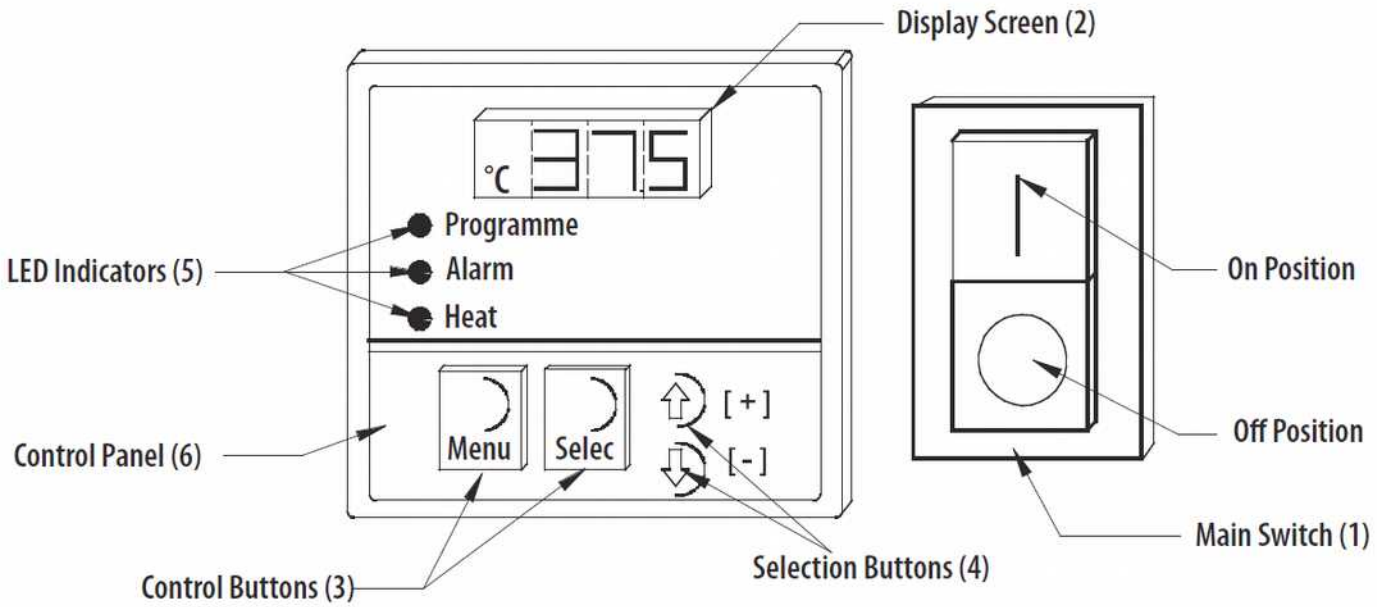
**Thermocouples**

**Glass door** (internal) with handle.

**Body of the incubator**

**Alarm temperatures** can be set to trigger an alarm when the temperature goes out of range (max and min).

**Free space** on the sides and back of the incubator is required to allow a passage for cables and ventilation (5-10 cm).




***Incubator Controls***

# Vortex Mixer

A **vortex** is a whirling mass of fluid or air, especially a whirlpool or whirlwind.

A **vortex mixer** is a simple device used commonly in laboratories **to mix small tubes of liquid**.

It consists of an electric motor with the drive shaft oriented vertically and attached to a **cupped rubber piece** mounted slightly off-center. As the motor runs the rubber piece oscillates rapidly in a circular motion. When a test tube or other appropriate container is pressed into the rubber cup the motion is transmitted to the liquid inside and a vortex is created.

Most vortex mixers have **variable speed settings** and can be set to run continuously, or to run only when downward pressure is applied to the rubber piece.

In cell culture and microbiology laboratories vortex mixers may be used **to suspend cells**. In a biochemical or analytical laboratory they may be used to **mix the reagents** of an assay.


***vortex mixer with speed control knob***

# Roller (mixer)

A **roller mixer** is a device to mix fluids in test tubes. It may have the capacity to **tilt** as well.  Speed, tilt and duration may be set by the user.

Used for e.g. blood samples. Gently rolling and tilting action prevents the sediment of the specimen and provides a homogenous specimen quality.

Plastic rollers are suitable for use with a variety of tubes.

***rotator mixer***

***roller mixer***

# Water bath

A water bath is a container filled with heated water.

It is used **to incubate samples in water at a constant temperature over a long period of time**.

The users can set the bath to a desired temperature, up to 99.9 °C.

It is used for:

- **warming** of reagents,
- **melting** of substrates or
- **incubation** of cell cultures
- to enable certain **chemical reactions** to occur at high temperature.

Water bath is a preferred heat source for heating **flammable chemicals** instead of an open flame to prevent ignition.

When temperatures above 100 °C are required, alternative methods such as oil bath, silicone bath or sand bath can be used

***water bath***

# Water bath: precautions

- Do not heat a bath fluid above its flash point.
- Water level should be regularly monitored, and filled with **distilled water** only. This is required to prevent salts from depositing on the heater.
- **Disinfectants** can be added to prevent growth of organisms.
- Raise the temperature to **90 °C** or higher **once a week for half an hour** for the purpose of **decontamination**.
- The cover is closed to prevent evaporation and to help reaching high temperatures.
- Set up on a steady surface away from flammable materials.

# Types of water bath

**Circulating water baths**
are ideal for applications when temperature uniformity and consistency are critical. Water is thoroughly circulated throughout the bath resulting in a more **uniform temperature**.

**Non-Circulating Water Baths**
This type of water bath relies primarily on convection instead of water being uniformly heated. Therefore, it is **less accurate** in terms of temperature control.

**Shaking Water Baths**
This type of water bath has extra control for shaking, which moves liquids around. This shaking feature can be turned on or off. In microbiological practices, constant shaking allows liquid-grown cell cultures grown to **constantly mix with the air.**

***shaking water bath***

***see video***

# Dry Block Heater

A (warming or dry) block heater is a device to **heat up laboratory test tubes** to a user defined temperature.

- different models with warming e.g. up to 100, 130 or 200 $^{0}$C
- with internal temperature sensor
- accuracy may be 0.1 – 1.0 $^{0}$C
- with timer
- with overheat protection
- mostly made from aluminum or steel block
- different models accommodate different numbers of test tubes

# END

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