Operating Laboratory Equipment and Measurement Devices

THE TYPICAL HOME KITCHEN has bowls, spoons, whisks, knives, mixers, rollers, measuring cups, and many other tools designed for specific uses. Similarly, the biotechnology laboratory has tools and equipment intended for certain functions. Knowing how to identify and use these items is an essential skill.

Objective:

Identify common laboratory tools and equipment, and explain the function of each.

Key Terms:

analytical balances
beaker
beaker tongs
electronic balance
electrophoresis chamber
Erlenmeyer flask
forceps
graduated cylinder
inoculating loop
magnetic stirrer
meniscus
microcentrifuge
microcentrifuge tube rack
micropipette
microscope
mortar and pestle
Petri dish
pipette
pipette bulb (pipette pump)
spectrophotometer
taring
test tube tongs
thermocycler
transfer pipette
vortex mixer
water bath
weigh boat

Laboratory Equipment and Measurement Devices

Laboratory technicians are expected to operate many different tools and pieces of equipment daily. Proper use of these items is necessary for successful outcomes.

BASIC LABORATORY TOOLS

A variety of hand tools are used in the biotechnology laboratory. Each is designed for specific functions.

A **graduated cylinder** is a tool used for measuring precise volumes of liquid, with sensitivity from 0.1 mL to 1.0 mL, depending upon the divisions of the cylinder. Graduated cylinders are more reliable than beakers or flasks for measuring volumes of liquid. A liquid in a graduated cylinder forms a meniscus. A **meniscus** is the upward curve of a liquid in a slender container caused by the attraction of the molecules to the surface of the glass. A meniscus is formed when measuring with a glass graduated cylinder, but it is not formed when measuring with a polypropylene or other plastic graduated cylinder. A meniscus should be read from the bottom marking.

FIGURE 1. Graduated cylinder.

FIGURE 2. Beaker.

A **beaker** is a tool used for heating, stirring, and mixing solutions in a laboratory setting. Beakers come in many sizes (from 10 to 4,000 mL). A beaker is usually fitted with a spout for easy pouring.

An **Erlenmeyer flask** is a tool used for mixing, stirring, or shaking. The narrow neck design helps prevent splashing or spilling chemicals during mixing or shaking.

The **mortar and pestle** is a tool typically made of ceramic or clay and used to crush or grind substances. The mortar is the bowl. The pestle is the club-shaped handle used for crushing or grinding substances.

A **Petri dish** is a small circular glass or plastic dish used to culture cells, grow bacteria, or start plant tissue cultures. Petri dishes have lids that fit loosely to allow for easy opening and closing.

A **weigh boat** is a tool used to weigh small amounts of chemicals or other substances that should not be placed directly on the balance pan. Weigh boats, or weigh dishes as they are sometimes called, come in many different shapes, materials, and sizes.

Beaker tongs are tools used to handle beakers when the beakers are too hot to touch. Hot glass looks the same as cool glass, so it is essential always to use caution when handling glass that has been heated.

Test tube tongs are tools used to handle test tubes that have been heated and are too hot to touch.

Forceps are tools used to hold or grasp just about anything in the laboratory setting that might be too small or difficult for fingers to grasp.

A **transfer pipette** is a tool used to transfer small amounts of liquids, usually smaller than 5 mL. Transfer pipettes are typically used only once in situations where contamination is a concern. Transfer pipettes are not good for accurate measurements.

FIGURE 3. Transfer pipettes.

A **pipette** is a tool used to dispense volumes of liquid, from 1 mL to 25 mL. Smaller volumes are measured with a micropipette. Larger volumes are measured with a graduated cylinder.

A **pipette bulb** (**pipette pump**) is a device that helps pull liquids into the cylinder of a pipette. Pipette bulbs and pumps come in a variety of shapes, sizes, and materials. Each pipette bulb or pump has specifications regarding the pipettes with which it can be used.

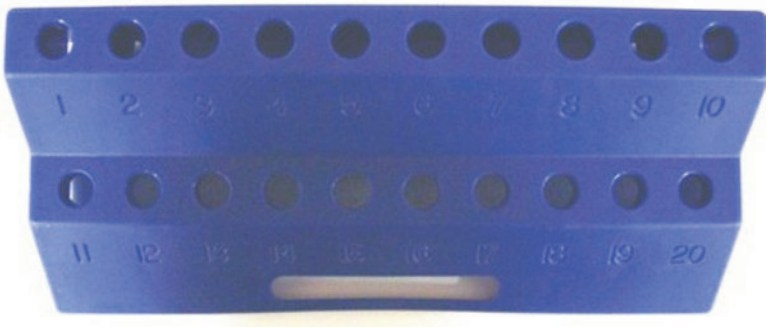

FIGURE 4. Microcentrifuge tube rack.

A **microcentrifuge tube rack** is a rack with smaller openings than a regular test tube rack to hold the smaller microcentrifuge tubes.

An **inoculating loop** is a tool made of plastic or nichrome wire used to spread cells around to inoculate Petri dishes or tubes of growing media.

FIGURE 5. Inoculating loop.

SOPHISTICATED EQUIPMENT

Besides using different tools to perform daily tasks in the laboratory, scientists use sophisticated equipment that often needs to be handled delicately.

An **electronic balance** is a device that measures the mass of objects to varying sensitivities depending upon the scale being used. An electronic balance is a precise instrument for measuring mass because the readings do not change with changes in elevation or gravitational force.

A **microscope** is a device used to view objects not normally viewable by the human eye. Microscopes have varying degrees of magnification, depending upon the ocular lens magnification and the objective lens magnification.

A **magnetic stirrer** is an automated stirring device equipped with magnets that rotate to spin a magnetic stir bar placed in a liquid. Magnetic stirrers allow scientists to stir mixtures at constant rates for long periods while they are completing other laboratory tasks.

A **water bath** is a laboratory device used to keep water at a constant temperature for the purpose of thawing substances, speeding reactions, and incubating cultures. Erlenmeyer flasks, test tubes, and other lab tools are placed in the water. An increase in the surface area of the container in contact with the water aids in transfer of heat and results in more uniform temperatures.

A **spectrophotometer** is a device used to detect concentrations of a solution based upon the amount of light transmitted, absorbed, or reflected by the substance. If the substance has a visible color, a visible light spectrum spectrophotometer is used. If the substance is colorless, an ultraviolet spectrophotometer, or UV spec, is used.

A **vortex mixer** is a device used to mix solutions or suspend cell cultures uniformly by agitating test tubes or vials that come in contact with the rubber fitting.

A **microcentrifuge** is a machine used in the laboratory to separate particles or molecules within a sample by their sizes through the use of a motor that creates a spinning motion to utilize inertia. Samples in a microcentrifuge are placed in microcentrifuge tubes. A microcentrifuge can make extracting a precipitant from a solution much easier because the precipitant is separated from the liquid.

An **electrophoresis chamber** is a specialized piece of equipment that uses electricity to separate DNA molecules by size. It is connected to a power source, with one end of the chamber attached to the positive terminal and the other end attached to the negative terminal. DNA samples are negatively charged and are loaded into the gel toward the negative terminal. The

ON THE JOB...

CAREER CONNECTION: Biological Science Technician

Biological science technicians hold essential positions in biotechnology laboratories. Their responsibilities include the set up, operation, and maintenance of laboratory instruments. They monitor experiments, make observations, calculate and record results, and often develop conclusions. Biological science technicians must keep detailed logs of all their work. They must often have expert knowledge of laboratory equipment so that they can adjust settings when necessary and recognize when equipment is malfunctioning.

According to the U.S. Department of Labor, most employers favor applicants who have at least two years of specialized postsecondary training or an associate's degree in applied science or science-related technology. Some biological science technician positions are reserved for specialists who have a bachelor's degree in biology. Roughly 30 percent of biological science technicians work in professional, scientific, or technical service firms. Others are employed in educational services, government, or pharmaceutical and medicine manufacturing.

DNA samples then migrate toward the positive terminal based upon size. The smallest DNA molecules will travel the farthest distance.

A **thermocycler** is a device used to perform a polymerase chain reaction (PCR) in which DNA segments are copied millions of times. The thermocycler controls the temperature of samples as the necessary series of reactions occurs to replicate the DNA fragment of interest. Each reaction requires a different temperature, and the thermocycler changes the temperature of the samples to facilitate the reactions necessary to make the DNA copies. The thermocycler is sometimes compared to a copying machine for DNA samples. Using PCR technology allows scientists to analyze very small fragments of DNA.

A **micropipette** is a small-range mechanical pipette calibrated to deliver measured volumes with high accuracy. A micropipette is used to measure volumes of 1 mL or less. Each micropipette has a set range and must be adjusted to specific volumes. A micropipette uses disposable tips that are generally used only once before being discarded.

OPERATION OF LABORATORY EQUIPMENT AND MEASUREMENT DEVICES

Laboratories are equipped with many specialized pieces of equipment. Each piece of equipment comes with detailed instructions on how to operate it properly.

Microcentrifuge

A microcentrifuge has a motor that spins at an extremely fast rate. The motor spins to rotate the samples, separating the molecules within the samples according to size. To prevent rotor damage, the tubes in the microcentrifuge must be properly balanced before it is operated. If only one sample needs to be placed in the microcentrifuge, a microcentrifuge tube with water can be placed opposite the sample to act as a counterbalance.

Electronic Balance

Electronic balances come in a variety of ranges and sensitivities. Extremely sensitive electronic balances are referred to as **analytical balances**. They are sensitive enough that minor wind currents caused by cooling and heating systems in a laboratory can result in reading fluctuations. It is important to ensure that any balance used to measure mass is level. Most balances are equipped with leveling adjustments.

Weigh boats or weigh dishes are frequently used to weigh materials that should not be placed directly on the balance tray. When using a weigh boat or dish, the scale must be tared to compensate for the mass of the boat or dish. **Taring** is finding the mass of an empty object that will be used to hold the substance to be weighed.

For operation of an electronic balance, it is necessary to turn it on, place the weigh boat on the scale, and push the "zero" button or the "tare" button. The reading on the display for the scale should return to and remain at zero. Once the display reads zero, the mass of the object can be determined.

Pipettes

Pipettes are used to measure small volumes of liquid very precisely and accurately. Typically, they are used to measure volumes from 1 to 25 mL.

A pipette requires a pipette pump or pipette bulb to draw liquid up into the cylinder. Sucking up liquid by mouth, or "mouth pipetting," is a major safety hazard and should never be attempted. A three-way pipette bulb has three letters on it. The letter "A" at the top of the bulb controls the air valve, which should be pressed while squeezing the round ball to release the air. The valve below the ball is labeled with an "S." This is the suction valve, which is pressed to draw liquid into the pipette. The "E" valve is to empty the contents of the pipette.

A pipette is sometimes designed "to deliver" the measured volume without forcing out the last drop that remains in the pipette. If a pipette is designed to deliver a small amount, some liquid may remain in the pipette tip.

A pipette should always be held vertically when operating to allow accurate readings of the meniscus. Pipetting from an angle can cause errors in measurement. A pipette should never be laid flat when it contains liquid because the liquid could enter the pipette pump and contaminate the pump for future use.

The pipette closest to the desired measurement will provide the most accurate measurement. For example, if the volume to be dispensed is 3.7 mL, a 5 ml pipette and a 10 ml pipette will work. For the best accuracy, however, the 5 mL pipette should be selected.

Micropipettes

Micropipettes are used to measure extremely small volumes of liquid very precisely and accurately. They are typically used to measure volumes smaller than 1 mL. Micropipette volumes are measured in microliters. One milliliter (mL) is equal to 1,000 microliters (μL).

Micropipettes have predetermined ranges that they will measure. The most common micropipette sizes are P10, P20, P100, P200, and P1000. The number indicates the maximum value in microliters that a given micropipette will measure. The correct micropipette must be selected to ensure the highest degree of accuracy. For instance, a P10 micropipette will measure from 0.1 μL to 10 μL, and a P20 will measure from 2 μL to 20 μL. A micropipette will accurately measure any volume within its range.

Once the proper micropipette has been selected, the volume must be set using the adjustment knob on the top of the micropipette. It is important not to dial the adjustment knob beyond

FIGURE 6. Using a micropipette.

the range of the micropipette. Damage to the internal gear mechanism can cause serious damage to the micropipette, possibly ruining it. Therefore, setting and reading micropipettes should be practiced thoroughly to prevent unnecessary damage to the expensive micropipettes.

Each range and brand of micropipettes uses a different size tip. Once the micropipette to be used has been selected, the correct tip can be chosen and placed on the micropipette. To prevent contamination, a different tip is used for every measurement made.

The plunger on the micropipette has two stops. The first stop is to draw up liquid. The second stop is to expel the liquid. Following are the steps in using a micropipette.

1. Depress the plunger to both stops before dispensing any liquid so you become familiar with both stops.
2. Push the plunger to the first stop. Sometimes this may not be very far.
3. After pressing the plunger to the first stop, insert the micropipette tip into the liquid to be measured.
4. Draw the fluid into the tip by slowly releasing the plunger.
5. Leave the tip submerged in the liquid until the level of the liquid stops rising, and then remove the tip from the liquid.
6. Touch the tip to the inside wall of the container to which the liquid will be dispensed.
7. Slowly depress the plunger to the second stop.
8. Keep the plunger depressed to avoid sucking any liquid back into the tip, and remove the micropipette from the container.
9. Gently return the plunger to the up position without allowing it to spring back quickly.
10. Eject the tip by using the ejector button on the micropipette.

Always hold a micropipette vertically when operating. Otherwise, liquid could enter the internal compartment and cause contamination as well as damage.

Summary:

A variety of hand tools are used in the biotechnology laboratory. They include graduated cylinders, beakers, Erlenmeyer flasks, mortar and pestles, Petri dishes, weigh boats or weigh dishes, beaker tongs, test tube tongs, forceps, transfer pipettes, pipettes, pipette bulbs (pipette pumps), microcentrifuge tube racks, and inoculating loops.

More sophisticated tools include the electronic balance, microscope, magnetic stirrer, water bath, spectrophotometer, vortex mixer, microcentrifuge, electrophoresis chamber, thermocycler, and micropipette. Typically, pipettes are used to measure volumes from 1 to 25 mL, and micropipettes are used to measure volumes smaller than 1 mL.

Laboratories are equipped with many specialized pieces of equipment. Each piece of equipment comes with detailed instructions on how to operate it properly.

Checking Your Knowledge:

1. What are some hand tools used in the biotechnology laboratory?
2. What are some more sophisticated tools used in the biotechnology laboratory?
3. How do pipettes and micropipettes compare?
4. How is a microcentrifuge used?
5. How is a micropipette used?

Expanding Your Knowledge:

With your instructor, inventory the tools and equipment in your biotechnology classroom. In the process, correctly identify the different items, and define the function of each.

Web Links:

Biotechnology Laboratory Equipment
http://www.bio-link.org/vlab/Equipment.html

Manipulating Small Volumes
http://www.usc.edu/org/cosee-west/Jun07Resources/PipetteUsetraining.pdf

Microfuge and Centrifuge Operation
http://www.youtube.com/watch?v=lusAYY9DEyY&feature=channel

Balance Tutorials
http://www.ohaus.com/products/education/tutorials.asp?source=2

Pipetting Technique
http://www.youtube.com/watch?v=qorl6rKLmRs

Agricultural Career Profiles
http://www.mycaert.com/career-profiles