Proper laboratory technique is essential to the education of a successful technologist. Your success will depend upon your attitude and conduct. This laboratory is a safe place to conduct your work if you are careful. You must assume responsibility for the safety of yourself and your neighbors. The following are some safety and procedural rules to help guide you in protecting yourself and others from injury in the laboratory. Reckless behavior or non-compliance with the rules listed below will result in expulsion from the laboratory and will affect your grade in class.

**Emergency Quick Reference (from DPS)**

1. Remain calm
2. Call 911 and report the following:
   * Your name
   * Incident type
   * Incident location
   * Description of the incident
3. For injury/illness:
   * Keep victim still
   * Check breathing
   * Control bleeding
4. When police arrive, give them additional information and ask others to do the same

**General Lab Safety**

1. Do not perform any activity with the lab equipment that is not expressly authorized by your instructor. Never attempt to repair or adjust equipment unless such a procedure is part of your duties. Do not use the equipment in ways that the equipment was not designed for.
2. Learn the correct name and usage of the lab equipment before you start any lab work. Do not use equipment that you haven’t been trained on or are unfamiliar with. Do not use the equipment in ways that you were not trained for.
3. Read the information in the lab and be familiar with the assignment before you attempt your lab activity. If you are in doubt about any procedure, ask your instructor for help.
4. Acceptable safety goggles should be worn when working with dangerous equipment.
5. Sandals, flip-flops, and open toed shoes are not recommended footwear in the lab. Be careful about wearing loose or floppy clothing that could cause an accident. Long hair should be tied back so that it is kept out of the equipment. Jewelry should be avoided.
6. If the need arises, use the safety equipment provided for you. Know the location of the fire extinguisher. Know how to use the fire extinguisher and any other piece of pertinent safety equipment.
7. Be aware of the shut-down procedures for all pieces of equipment in the lab, including the emergency shut-off locations.
8. Report any accident or injury to your instructor at once.
9. Never eat, drink, smoke, or sleep in the lab.
10. At the close of each laboratory session see that your desktop and floor area are clean. All equipment must be returned to their respective locations and neatly arranged. A safe lab is a clean lab.
11. Be careful when working with components or surfaces that may be hot or become hot.
**Electrical Safety**

1. Remember that the human body is a conductor of electricity.
2. When using electricity keep the work area and your hands dry. Never work with electricity with wet hands, where spills have occurred, or with open wounds.
3. Never overload a circuit or component. Ask the instructor to check all electrical circuits before you turn on the power.
4. Do not work with any circuit until the input power is turned off and any power stored in the circuit is dissipated.
5. Avoid shorting out the terminals of a battery, power supply, or capacitor (unless explicitly told to do so). The wire can become dangerously hot or the equipment could become damaged.
6. Keep your hands, face, and other body parts away from live circuits. Turn off all power and ground all high voltage points before working on electrical equipment. Be sure power cannot be restored accidentally.
7. Never use water to put out an electrical fire. Water could lead to an increased electrocution risk or compound the problem in other ways.
8. Be sure each person is grounded before touching parts inside of a computer.
9. When practical, use only one hand when working with circuits and the other hand clear from the circuitry.
10. Remove any metallic jewelry that can accidentally short out a circuit.

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**Electricity: The Basics**

This section adapted from the Occupational Safety and Health Administration (or OSHA)

*What affects the flow of electricity?* Electricity flows more easily through some materials than others. Some substances such as metals generally offer very little resistance to the flow of electric current and are called "conductors." A common but perhaps overlooked conductor is the surface or subsurface of the earth. Glass, plastic, porcelain, clay, pottery, dry wood, and similar substances generally slow or stop the flow of electricity. They are called "insulators." Even air, normally an insulator, can become a conductor, as occurs during an arc or lightning stroke.

*How does water affect the flow of electricity?* Pure water is a poor conductor. But small amounts of impurities in water like salt, acid, solvents, or other materials can turn water itself and substances that generally act as insulators into conductors or better conductors. Dry wood, for example, generally slows or stops the flow of electricity. But when saturated with water, wood turns into a conductor. The same is true of human skin. Dry skin has a fairly high resistance to electric current. But when skin is moist or wet, it acts as a conductor. This means that anyone working with electricity in a damp or wet environment needs to exercise extra caution to prevent electrical hazards.

*What causes shocks?* Electricity travels in closed circuits, normally through a conductor. But sometimes a person's body -- an efficient conductor of electricity -- mistakenly becomes part of the electric circuit. This can cause an electrical shock. Shocks occur when a person's body completes the current path with:

- both wires of an electric circuit;
- one wire of an energized circuit and the ground;
- a metal part that accidentally becomes energized due, for example, to a break in its insulation; or
- another "conductor" that is carrying a current.

When a person receives a shock, electricity flows between parts of the body or through the body to a ground or the earth.
Effects of Current in the Human Body

<table>
<thead>
<tr>
<th>Current</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 mA</td>
<td>Generally not perceptible</td>
</tr>
<tr>
<td>1 mA</td>
<td>Faint tingle</td>
</tr>
<tr>
<td>5 mA</td>
<td>Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.</td>
</tr>
<tr>
<td>6–25 mA</td>
<td>Painful shock, loss of muscular control*</td>
</tr>
<tr>
<td>(women)</td>
<td></td>
</tr>
<tr>
<td>9–30 mA</td>
<td>The freezing current or &quot;let-go&quot; range.* Individual cannot let go, but can be thrown away from the circuit if extensor muscles are stimulated.</td>
</tr>
<tr>
<td>(men)</td>
<td></td>
</tr>
<tr>
<td>50–150 mA</td>
<td>Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.</td>
</tr>
<tr>
<td>1–4.3 A</td>
<td>Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.</td>
</tr>
<tr>
<td>10 A</td>
<td>Cardiac arrest, severe burns; death probable</td>
</tr>
</tbody>
</table>

* If the extensor muscles are excited by the shock, the person may be thrown away from the power source.


What kind of burns can a shock cause? Burns are the most common shock-related injury. An electrical accident can result in an electrical burn, arc burn, thermal contact burn, or a combination of burns. Electrical burns are among the most serious burns and require immediate medical attention. They occur when electric current flows through tissues or bone, generating heat that causes tissue damage.

Arc or flash burns result from high temperatures caused by an electric arc or explosion near the body. These burns should be treated promptly. Thermal contact burns are caused when the skin touches hot surfaces of overheated electric conductors, conduits, or other energized equipment. Thermal burns also can be caused when clothing catches on fire, as may occur when an electric arc is produced. In addition to shock and burn hazards, electricity poses other dangers. For example, arcs that result from short circuits can cause injury or start a fire. Extremely high-energy arcs can damage equipment, causing fragmented metal to fly in all directions. Even low-energy arcs can cause violent explosions in atmospheres that contain flammable gases, vapors, or combustible dusts.

Why do people sometimes "freeze" when they are shocked? When a person receives an electrical shock, sometimes the electrical stimulation causes the muscles to contract. This "freezing" effect makes the person unable to pull free of the circuit. It is extremely dangerous because it increases the length of exposure to electricity and because the current causes blisters, which reduce the body's resistance and increases the current. The longer the exposure, the greater the risk of serious injury. Longer exposures at even relatively low voltages can be just as dangerous as short exposures at higher voltages. Low voltage does not imply low hazard.

In addition to muscle contractions that cause "freezing," electrical shocks also can cause involuntary muscle reactions. These reactions
can result in a wide range of other injuries from collisions or falls, including bruises, bone fractures, and even death.

What should you do if someone "freezes" to a live electrical contact? If a person is "frozen" to a live electrical contact, shut off the current immediately. If this is not possible, use boards, poles, or sticks made of wood or any other non-conducting materials and safely push or pull the person away from the contact. It's important to act quickly, but remember to protect yourself as well from electrocution or shock.

How can you tell if a shock is serious? A severe shock can cause considerably more damage than meets the eye. A victim may suffer internal hemorrhages and destruction of tissues, nerves, and muscles that aren't readily visible. Renal damage also can occur. If you or a coworker receives a shock, seek emergency medical help immediately.

What is the danger of static electricity? Static electricity also can cause a shock, though in a different way and generally not as potentially severe as the type of shock described previously. Static electricity can build up on the surface of an object and, under the right conditions, can discharge to a person, causing a shock. The most familiar example of this is when a person reaches for a door knob or other metal object on a cold, relatively dry day and receives a shock. However, static electricity also can cause shocks or can just discharge to an object with much more serious consequences, as when friction causes a high level of static electricity to build up at a specific spot on an object. This can happen simply through handling plastic pipes and materials or during normal operation of rubberized drive or machine belts found in many worksites. In these cases, for example, static electricity can potentially discharge when sufficient amounts of flammable or combustible substances are located nearby and cause an explosion. Grounding or other measures may be necessary to prevent this static electricity buildup and the results.

Protection Against Electrical Hazards

What is the best way to protect yourself against electrical hazards? Most electrical accidents result from one of the following three factors:

- unsafe equipment or installation,
- unsafe environment, or
- unsafe work practices.

Some ways to prevent these accidents are through the use of insulation, guarding, grounding, electrical protective devices, and safe work practices.

What protection does insulation provide? Insulators such as glass, mica, rubber, or plastic used to coat metals and other conductors help stop or reduce the flow of electrical current. This helps prevent shock, fires, and short circuits. To be effective, the insulation must be suitable for the voltage used and conditions such as temperature and other environmental factors like moisture, oil, gasoline, corrosive fumes, or other substances that could cause the insulator to fail. Before connecting electrical equipment to a power source, it's a good idea to check the insulation for any exposed wires for possible defects. Insulation covering flexible cords such as extension cords is particularly vulnerable to damage.

What is grounding and what protection does it offer? "Grounding" a tool or electrical system means intentionally creating a low-resistance path that connects to the earth. This prevents the buildup of voltages that could cause an electrical accident. Grounding is normally a secondary protective measure to protect against electric shock. It does not guarantee that you won't get a shock or be injured or killed by an electrical current. It will, however, substantially reduce the risk, especially when used in combination with other safety measures discussed in this booklet.
A service or system ground is designed primarily to protect machines, tools, and insulation against damage. One wire, called the "neutral" or "grounded" conductor, is grounded. In an ordinary low-voltage circuit, the white or gray wire is grounded at the generator or transformer and at the building's service entrance. An equipment ground helps protect the equipment operator. It furnishes a second path for the current to pass through from the tool or machine to the ground. This additional ground safeguards the operator if a malfunction causes the tool's metal frame to become energized. The resulting flow of current may activate the circuit protection devices.

What are circuit protection devices and how do they work? Circuit protection devices limit or stop the flow of current automatically in the event of a ground fault, overload, or short circuit in the wiring system. Well-known examples of these devices are fuses, circuit breakers, ground-fault circuit interrupters, and arc-fault circuit interrupters. Fuses and circuit breakers open or break the circuit automatically when too much current flows through them. When that happens, fuses melt and circuit breakers trip the circuit open. Fuses and circuit breakers are designed to protect conductors and equipment. They prevent wires and other components from overheating and open the circuit when there is a risk of a ground fault.

Ground-fault circuit interrupters, or GFCIs, are used in wet locations, construction sites, and other high-risk areas. These devices interrupt the flow of electricity within as little as 1/40 of a second to prevent electrocution. GFCIs compare the amount of current going into electric equipment with the amount of current returning from it along the circuit conductors. If the difference exceeds 5 mA, the device automatically shuts off the electric power.

What devices are meant to protect operators? A common misconception is that operators will be protected from accidental electrocution by standard circuit breakers and fuses. In fact, these devices provide little to no protection to the user. They are designed to protect the power system and equipment connected to it. Operators are protected by isolation (insulation of electric devices), equipment grounding, and Ground Fault Circuit Interrupters (or GFCIs). Therefore, it is imperative that operators ensure this protective equipment is present and in working order. Do not remove ground terminals from equipment and check all wiring for damage before using.