Biocompare

The Buyer's Guide for Life Scientists

Safety in the Laboratory: Avoiding Injury, Infection, and Contamination

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Contents

Who's Responsible for Lab Safety?

The answer, it turns out, is both simpler and far more complicated than one would think.

by Josh P. Roberts

Pretty much no matter where in the hierarchy we are, and in what kind of lab we work, we've all heard the drills:

- Don't mouth pipette
- Keep loose hair and clothing away from flames
- Know the location of exits, eye wash stations, and emergency showers
- Lift with your legs, not with your back
- Don't look into a laser

But who's actually responsible for enforcing these lab safety rules? The answer, it turns out, is both simpler and far more complicated than one would think. Simpler because, in general, the enforcement of these rules follows a standard employment chain of command. Far more complicated because the person in charge depends on (a) what kind of safety rule we're talking about and (b) where you are and who you work for.

What is lab safety?

Laboratory safety encompasses all aspects of the lab. Some guidance comes in the form of simple and obvious platitudes of everyday life (e.g., make sure a match isn't still smoldering when you throw it away). Others are more specialized or esoteric tidbits of wisdom (e.g., leave the lid loose when autoclaving liquids). And most fall into the in-between (e.g., use the shortest electrical cord possible). It's a near-mathematical impossibility to list all of the rules, and so common sense and mentorship by necessity play a role in learning to be safe.

Most of "life's hazards" can be grouped into nine general categories, with some overlap and some outliers best described as miscellaneous: "Chemical, biological, physical, mechanical, radiation, noise, high and low pressure, stress, and electrical," explains Jim Kaufman, president and CEO of The Laboratory Safety Institute, a non-profit providing courses and consultation. "We need to pay attention to all of them in the labs, because most labs have all of the hazards of life."

Image: Lab safety training has to start at the beginning–when somebody is starting to work in a lab, be it as a student or employee. Image from Dreamstime.

"Lab safety training has to start at the beginning–on hire, or when somebody is starting to work in a lab, be it as a student or employee," points out Dan Scungio, a laboratory safety officer for Sentara Healthcare and consultant who leads seminars and blogs under the name "Dan the Lab Safety Man."

Who's in charge?

Safety is a line management responsibility, says Joe Klancher, program manager of Lab and Research Safety in the University of Minnesota's Department of Environmental Health and Safety. In a university, the principle investigators (PIs) are the supervisors of the lab. "They can delegate some responsibility to people that work for them, but ultimately the PI is responsible, and the department heads are responsible for the PIs, and the deans are responsible for the department heads."

It's common in an academic setting for the PI to designate a post-doctoral researcher, or even a senior graduate student, to be in charge of safety. But who that ultimate designee is, of course, is dependent on the type of institution. And for the most part, there is not one single, official title for, or even way to describe, the person "in charge" of safety. It can be a laboratory safety officer, but in many labs it can be the lab manager, or quality coordinator, or "the part-time such and such," Scungio explains. "Very often you see that safety responsibility is delegated to somebody who has many other roles."

That designee may even be a peer, rather than someone in the hierarchy of discipline—even if it's in their job description. Especially in such cases, Kaufman recommends that the designee act like an airport windsock, imparting information but not commands: "You can be knowledgeable about safety regulations and hazards in the lab. Do your best in the nicest, friendliest, most collegial way to help these bright people to make choices."

An institutional department like Klancher's has what he calls a consultation, rather than an enforcer, role. "We provide tools and guidance and materials; we provide some oversight; we will do lab audits and inspections," he says. "But the intent is more continuous improvement than strictly a compliance function … to help identify best practices, to ensure that leadership is engaged, and to provide process and expertise."

It doesn't matter what kind of group you're working with. The formula is the same in health care, research, industry, and education, he says, and it doesn't matter what the hazards are.

Rules, regs and creds

With a few exceptions—notably biohazard safety and animal care and use, which often fall under the purview of institutional committees, and chemical hygiene and radiation safety, which have special requirements of their own—lab safety isn't so much about rules and regulations.

"For general lab work there's not a huge amount of regulatory scrutiny, in a way," muses Klancher. "There's OSHA's lab standard, but it's pretty vague and there's a lot of room for interpretation." And even the OSHA standard doesn't cover every public sector worker in every state.

That goes for credentialing as well. Some jobs may ask for some training or experience in environmental health or lab safety. There are certifications offered by organizations such as the Association for Biosafety and Biosecurity, the Board of Certified Safety Professionals, and the American Society for Clinical Pathology that may be recommended in particular instances, says Scungio, but they are not legally required for the position.

When it comes down to it, lab safety is the responsibility of the employer and his or her designees. Rules may be laid down and policies implemented to protect employees. But it is the employees' responsibility to follow the rules and policies.

About the author

Josh P. Roberts has been a full-time biomedical science writer for more than a decade. Josh P. Roberts has an M.A. in the history and philosophy of science, and he also went through the Ph.D. program in molecular, cellular, developmental biology, and genetics at the University of Minnesota, with dissertation research in ocular immunology.

Biosafety Basics: Risk Assessment in the Laboratory

A risk assessment is an evidence-based approach to determine the biosafety measures required in the lab.

by Kimberly Dalton

Biological research may be rewarding, but it can also be dangerous—so it's important for researchers to take biosafety seriously. Every researcher needs to understand the risks they face and have a safety plan in place. But how do you go about evaluating risk and creating the plan in the first place?

Types of risks

First, it's valuable to understand the types of risks that may be present in a biological laboratory. Some examples of major biohazards are pathogens, recombinant organisms, and biological toxins:

Pathogens are microorganisms that can cause disease in humans, animals, or plants.

Recombinant organisms are microbes or animals that were genetically engineered for research and express recombinant or synthetic DNA.

Biological toxins are naturally generated compounds such as botox or ricin that can be harmful when injected, ingested, inhaled, etc.

Conducting the risk assessment

A biosafety risk assessment is an evidence-based analysis of the safety concerns in a given laboratory. It should be a collaboration between the principal investigator and his or her institution's biosafety officer, and it should take into account published guidelines, advice from experts, and governmental regulations.

Risk assessments always maintain a level of uncertainty. The only way to fully eliminate biohazard risks is to eliminate the research. But you can strive to make yourself as safe as possible without inhibiting your work. What you'll want to do is analyze the costs and benefits of safety in given situations and balance them to optimize safety and productivity. For example, you could wear a BSL-4 Ebola "moon suit" to work with HeLa cells and you would be very safe—but the time, money, and limited motion would be an unnecessary tradeoff for the limited benefits you would get.

Here are some guidelines to keep in mind when carrying out a risk assessment:

What is the agent? Certain agents are more dangerous than others. If you're studying anthrax, you'll need to put a steeper safety protocol in place than will a researcher studying the common cold.

What volume is being used? The more you use of a given pathogen, the more dangerous it becomes. A 10 L vat of an infectious agent is a lot riskier to have on hand than 25 mL cultures.

Where are you studying? Location really makes a difference. Working with a wheat pathogen in Kansas could have more serious consequences than working with the same pathogen in New York City.

What is the experience and health status of the researcher? An untrained researcher with diabetes will need to take a lot more precautions than an experienced researcher with a healthy immune system.

Dealing with hazards

One of the simplest ways to decrease laboratory hazards is to substitute lower-risk agents for their higher-risk counterparts whenever possible. If you're studying spore formation, can you use *B. subtilis* instead of *B. anthracis*?

Of course, substitution isn't always possible. If you have to work with higher-risk agents, there are other ways to control the hazards:

Administrative controls include communication and training. Signs should be posted in visible areas listing what the hazards are, how they can be dealt with, and who can be contacted with questions. Additionally, every person working in the lab should be properly trained to deal with each of the hazards that are present. It may also be necessary to lock up certain areas to prevent people from accidentally ending up in a hazardous location.

Engineering controls include lab setup and equipment that help control the transmission of hazardous agents by redirecting, blocking, or killing them. Examples are directional airflow, biosafety cabinets, fume hoods, and autoclaves.

Work practice controls include following good protocols as you work. Don't mouth pipette, always wash your hands, and autoclave biohazardous waste. Additionally, use the appropriate personal protective equipment (PPE) for the hazards you're working with. This may include lab coats, gloves, eye protection, respirators, etc.

Biosafety levels

There are four general safety levels at which laboratories operate, referred to as BSL-1 through BSL-4. The higher the number, the more precautions that are in place.

Most biology laboratories operate at BSL-2. Toxins, blood products, human-derived material, and mild pathogens tend to be handled at this level, and much of the time, so do even lower-risk agents. Even if your agent doesn't require more than BSL-1, working at BSL-2 will protect the samples from researchers by decreasing chances of contamination.

When the biohazard is a pathogen, the biosafety level required depends on considerations such as the infectious dose, pathogenicity and virulence, and resistance to therapy. For specific information about a pathogen's characteristics, check out its Health Canada Pathogen Data Safety Sheet (PSDS).

Pathogens are classified into four risk groups (RGs) according to their risk level. In general, the risk group number corresponds to the biosafety level:

Image: Signs should be posted in visible areas listing what the hazards are, how they can be dealt with, and who can be contacted with questions. Image from Dreamstime.

RG1 refers to agents that are not associated with disease in healthy adults. Examples include *E. coli, B. subtilis*, and *S. cerevisiae*.

RG2 refers to agents that are associated with human diseases of varying severity. They usually only cause minor illness in healthy adults, and prevention and treatments are often available. Examples include *Salmonella, Shigella, S. aureus*, HBV, and Zika.

RG3 refers to agents that can cause serious or fatal diseases in healthy adults, and there may or may not be treatments available. These are pathogens that are considered to give a high individual risk, though the community risk is low. Examples include *B. anthracis, Y. pestis*, HIV, and *M. tuberculosis*.

RG4 refers to agents that will cause serious or fatal disease in healthy adults, and treatment is not usually available. These pathogens give both a high individual risk and a high community risk. Examples include Ebola, Marburg, and Smallpox.

If you are interested in searching a database of pathogens and their associated risk groups, follow this link. Additionally, check out the *Biosafety in Microbiological and Biomedical Laboratories* (BMBL) to learn about biosafety guidelines in the US. The BMBL also defines the requirements for all four biosafety levels.

About the author

Kimberly Dalton joined Biocompare in 2018 and is responsible for product reviews, as well as news summaries, eNewsletter deployment, article writing, and social media. After receiving a B.S. in physiology with a minor in editing, Kimberly earned an M.S. in neuroscience.

What a Waste!

Ensuring that your lab waste is non-infectious and non-hazardous.

Josh P. Roberts

Just tossing something in the trash or recycling bin without hesitation may work at home. But in order to keep personnel and the public safe, and comply with regulations, care and thought need to go into disposing of biological, radiological, chemical, and other types of lab waste. From where it's initially placed, to how it's labeled, to who is responsible for its processing and transport, plastic packaging and office paper need to be treated differently from medical waste and flammable chemicals.

Biohazardous waste

Definitions of biohazardous waste are not hard to come by—they don't all line up exactly, but we all have a rough idea of what counts. For example, to the University of Tennessee (UT), Knoxville's Environmental Health and Safety (EH&S) biosafety program, it's basically any human or animal specimen or microbial culture material, including bacterial and cell culture materials and nucleic acids, or anything that may have been contaminated by it.

However, not all biohazardous waste is dealt with in the same way. In their handling and disposal guide, for example, UT distinguishes among solid (non-sharps) waste, liquid waste, sharps, and pathological waste, and throws in agricultural waste as a separate category. Many institutions and regulatory bodies break things down slightly differently, with varying criteria as to whether something is considered infectious waste or medical waste, for example, and what that means for downstream disposition.

Just to be on the safe side, UT recommends that "otherwise unregulated research lab biological wastes be managed as biohazardous waste."

Of course, biological waste is not the only biohazard that is generated. Organic chemicals like phenol and chloroform, mutagens such as ethidium bromide, neurotoxins like acrylamide, and other chemicals are common fixtures in a life sciences lab, as are radioisotopes (although they are less common than they once were). Their handling, storage, and disposal, however, are beyond the scope of this brief article.

Nature of the agent

Take a typical real-lab-life example. Say you're doing tissue culture work. You remove flasks from the incubator and move them into the biosafety cabinet (i.e., the hood) for some simple manipulations, like passaging the cells. In the process you aspirate liquid into a carboy and discard a flask.

The researcher needs to think about the nature of their agent. At the very least, the biological agent needs to be neutralized and rendered non-infectious. "If they did something like a recombinant nucleic acid manipulation, autoclaving is going to be appropriate," says Holly Gates-Mayer, a biosafety officer and manager of biosafety at the University of Colorado in Boulder.

But along with that, what else was done? "Did they add a drug? A chemical? Is there a heavy metal? Are nanomaterials involved with this now? Is there a radiological tracer?" she asks. Dealing with a mixed waste—with components that need to be treated in different waste streams—often requires strategies to tease apart its various aspects and to best render it non-infectious and non-hazardous.

"The important thing is that the researchers need to be very familiar with their agents, plus everything they've done to it," Gates-Mayer emphasizes. They're urged to consult with their EH&S, which will have the expertise in, for example, chemical use or radiation safety, to determine how to deal with what's left behind after the risk of infection is neutralized.

And what to do with the liquid waste sitting in the carboy? If it's not "mixed waste," it can generally be neutralized by adding bleach. But before dumping it down the drain, "confirm with EH&S about the ultimate disposal," she adds.

Ultimate disposal

That T-flask, pipette tips, and any other waste that came in contact with the potential biohazardous material are typically discarded into a foot-operated bin lined with an autoclave bag. (Bins have to be kept closed, and it's better not to have to open it by hand.) When the bag is about two-thirds full, the bag is collected for autoclaving. At Boulder, all the material needs to be accounted for on a three-part manifest: "It's kind of like a cradle to grave scenario, where they will fill out the relevant information about the nature of the materials that are inside the autoclave bag," with one part remaining attached to the bag, explains Gates-Mayer.

Once it's been rendered sterilized, EH&S will pick up the autoclaved waste for disposal. There is an indicator that makes it clear that it's been treated, and it's considered to be normal waste. But because "it's still in a bag that has a biohazard symbol on it," she says, Boulder goes through extra steps to reassure the public, even going so far as to place it in a specially designated area of the landfill.

Depending on the jurisdiction, this may not be an option. Many states require anything with the biohazard symbol to be treated as regulated medical waste, says Dan Scungio, a laboratory safety officer for Sentara Healthcare and a consultant who leads seminars and blogs under the name "Dan the Lab Safety Man."

Animal models offer yet other complexities, notes Gates-Mayer, and typically the carcasses will be frozen and later incinerated or biodigested. While this is done on-site at some larger institutions, Boulder doesn't have an incinerator or biodigester on campus, so frozen carcasses are picked up by a contracted vendor.

Most bench researchers don't need to know all the ins and outs of what happens to their waste once it's handed over to EH&S or a vendor for disposal. But they should have training on what constitutes hazardous material, how to handle it, and what to do with it until it's out of their hands.

About the author

Josh P. Roberts has been a full-time biomedical science writer for more than a decade. Josh P. Roberts has an M.A. in the history and philosophy of science, and he also went through the Ph.D. program in molecular, cellular, developmental biology, and genetics at the University of Minnesota, with dissertation research in ocular immunology.

Safety in the Lab, Avoiding Exposure

PPE, fume hoods, and biosafety cabinets.

Personal protective equipment (PPE) is the specialized clothing or equipment worn by an individual to protect them from exposure to health and safety hazards. In a laboratory environment this can range from safety glasses, gloves, and a lab coat, right through to a Biosafety Level 4 (BSL-4) positive pressure suit. Additional protection is offered by fume hoods and biosafety cabinets, two commonly used pieces of laboratory equipment that significantly decrease the potential for exposure to hazardous chemicals or biological agents.

Fume hoods are designed to remove chemical fumes and aerosols from the laboratory. They use a fan to draw in air through the front of the hood, which is then expelled from the laboratory (ducted fume hoods) or filtered and fed back into the room (recirculating fume hoods). A secondary function of fume hoods is to act as a physical barrier between chemical spills, runaway reactions, and fire.

Biosafety cabinets provide a clean working environment and allow safe handling of biological contaminants and other potentially hazardous materials. They exist in several different forms, depending on the type of containment that is required. Class I cabinets exhibit similar air movement to a fume hood, although the exhaust air must be High Efficiency Particulate Air (HEPA) filtered for environmental protection; class II cabinets vary according to the amount of air that is recirculated within the cabinet and are selected according to the nature and quantity of materials being used; class III cabinets are suitable for work with BSL-4 agents, providing a gas-tight enclosure with a completely sealed viewing window.

Whether carrying out a chemical reaction within a fume hood or working with microorganisms contained by a biosafety cabinet, safe work practices should always be followed. We've reached out to the scientific community to bring you three top tips for working with each of these platforms.

Image: Plan your work carefully so you can disinfect and place all the materials you need to conduct your experiment in the biosafety cabinet before you begin working. Image from Dreamstime.

Three top tips for working with fume hoods

- Make sure your fume hood has been calibrated and that it has a clear marker to indicate the highest sash height that can be used safely. The position of the sash is used to control the velocity of the air that passes through the fume hood, and if the sash is too high, fumes can enter the laboratory. When you're not using the fume hood, close the sash; this will provide containment in the event of a fire or an explosion. *Jane Scanlon, Associate Medicinal Chemist at Domainex*
- Any large equipment within the hood should be elevated to allow the air to flow underneath it and should never obstruct slots or baffles. If you mark a line on the bench surface within the hood, you can ensure that any apparatus is kept at least six inches back from the opening. *Kathryn Irons, Medicinal Chemist at RxCelerate Limited*
- Don't use the hood for storing laboratory chemicals or chemical waste. Items stored in the fume hood can interfere with airflow and introduce dangerous obstacles that provide potential health and safety risks. It's also possible that different chemicals may be incompatible with one another, creating unnecessary hazard. *Paul Meo, Medicinal Chemistry Program Manager at Discuva*

Three top tips for working with biosafety cabinets

- Make sure to choose a cabinet that's appropriate for the hazard level; I use a Class II BSC as I work with agents that may be associated with human disease. I decontaminate it regularly, and the laboratory it's in has limited access and biohazard warning signs at the door. I always wear a lab coat, gloves, and safety glasses while I work. *Lynwen James, Laboratory Technician at University of Essex*
- It's likely that you'll be spending a lot of time at the biosafety cabinet, for example if you're plating out cells and treating them with chemical compounds, so make sure that the cabinet is set up as ergonomically as possible. You need good knee/thigh clearance to maintain correct posture (consider the use of foot rests), a good height for moving items in and out of the cabinet, a wide access for forearm comfort (foam armrests can be really helpful), and a nice large work area to promote good aseptic technique. *Mark Stockdale, Group Leader, Applied R&D at Horizon Discovery*
- Plan your work carefully so you can disinfect and place all the materials you need to conduct your experiment in the cabinet before you begin working; this will prevent unnecessary movement of items in and out of the cabinet as you work, which could disrupt the airflow. Never place items over the air grilles, and always disinfect the work surface before and after use. *t*Fume hoods and biosafety cabinets are essential pieces of laboratory equipment, carefully designed to protect both personnel and products. By selecting a suitable platform and using it appropriately, exposure to potentially hazardous materials can be avoided.

10 Easy Steps for Cleaning a Spill in the Biosafety Cabinet

Prevent injury, infection, and contamination after a spill.

A safety cabinet or biological safety cabinet (BSC) is an enclosed, ventilated laboratory workspace for users to safely handle materials that might contain pathogens. There are several different models of BSCs, which are differentiated by the user's experimental focus and the degree of biocontainment required.

The primary purpose of a BSC is to protect the laboratory worker and the surrounding environment from pathogens such as bacteria and viruses in use within the cabinet. All exhaust air is filtered through HEPA-filters as it exits the biosafety cabinet, removing the harmful pathogens. Most classes of BSCs have a secondary purpose, which is to maintain the sterility of materials inside the cabinet.

It happens at some point to even the most seasoned laboratory user that a spill occurs within the BSC. Taking precautionary measures before and during your work with hazardous materials will help keep you and others safe. Remember, if a spill occurs, don't panic. Follow these simple steps to keep you and your laboratory safe.

1. Keep a spill kit

The lab should have a kit or components readily available to address spills. Items include an easy-to-read outline of the spill-response Standard Operating Procedures (SOPs)—which should be posted, read, and understood by everyone in the lab—and appropriate personal protective equipment (PPE), including eye protection, a clean lab coat or scrubs, and spare slip-on shoes in case clothing contamination occurs. You will also need absorbent materials, disinfectant (e.g., 10% bleach), tongs, or forceps to pick up broken containers and a biohazard-waste container.

2. Wear appropriate personal protective equipment

Before beginning your work in the BSC, be sure to dress appropriately, wearing the approved PPE designated for your laboratory. At a minimum, laboratory coats should be worn buttoned over street clothing, and protective eyewear should be on at all times. In addition, latex or nitrile gloves are necessary when handling culture, contaminated surfaces, or equipment. Be sure to follow the recommended procedures for the level of BSC you are working in.

3. Perform decontamination steps while the cabinet is operating

When a spill of biohazardous material occurs within a BSC, cleanup should begin immediately, while the cabinet continues to operate. Keeping the cabinet on will prevent the escape of airborne contaminants and ensure that whatever is in the cabinet stays in the cabinet, protecting those around you and the laboratory.

4. Remove items from the spill area

Before attacking the spill, first remove the tubes, pipettes, and any other item that might have contained the spilled liquid and place them into the biohazard container in the cabinet. It is important to contain the contaminated materials inside the operating cabinet to avoid exposure to the laboratory. To prevent personal injury, always use tongs or forceps to pick up glass and sharps.

5. Cover the spill with absorbent material

Cover the spill inside the BSC with absorbent material, such as paper towels, and let the spill soak in. This helps prevent aerosolization of the contaminant. With the towel covering the spill, apply appropriate disinfectant for the type of spill onto the towel, working from the outer edge to the middle of the towel. Applying the disinfectant from the outside to the inside of the spill helps trap the material within the paper towel and decontaminant. It is important to note that the agent spilled must not be resistant to the disinfectant selected for cleanup. Having a laboratory procedure that addresses the biohazards you might encounter will ensure that you have the appropriate materials available for a spill. Bleach solutions have several advantages over others, including low cost, fast action, and broad spectrum of effectiveness, but they are corrosive on stainless-steel surfaces inside a BSC and should be rinsed. (See Step 9.)

Note: Use of chlorinated or halogen materials in the cabinet will damage the stainless steel.

6. Allow 20 minutes for disinfectant contact time

Depending on what material was spilled and what disinfectant you are using, you might need to vary the disinfectant reaction time. As a rule of thumb, 20 minutes should be adequate to neutralize the contaminant.

7. Wipe up the spill and excess liquids with towels

After the spill has been contained and the disinfectant has had adequate time to react, use the towels to wipe up excess liquid. Place used towels into a biohazard bag located in the cabinet.

8. Treat the area with the decontaminant again

Apply disinfectant to the spill area again and give it appropriate time to work before wiping up with fresh towels. This helps ensure that all contaminated materials and surfaces are decontaminated. Also check the spill pan under the work surface and disinfect following the same procedure, if needed.

Image: The primary purpose of a BSC is to protect laboratorians and the surrounding environment from pathogens such as bacteria and viruses in use within the cabinet. Image from Dreamstime.

9. Rinse the spill area well

If bleach (or any other corrosive disinfecting agent) was used to clean the spill, use sterile water to rinse and then again to wipe the residual bleach (or disinfectant) from the working surface. Bleach is very corrosive to stainless steel and will cause damage, over time, if used to clean the cabinet.

10. After the cabinet has been cleaned, remove and properly dispose of gloves and other protective equipment that has come in contact with contaminated material

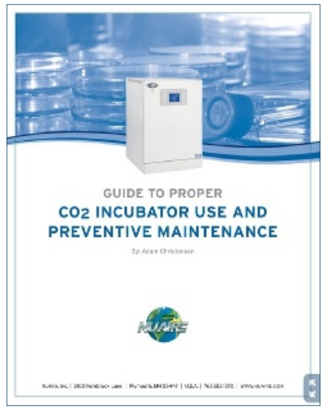
Thoroughly wash your hands with soap and water. Run the BSC for at least 10 minutes before resuming work. Report the spill incident to your supervisor.

Following these steps will help you keep yourself and those around you safe if a spill in the BSC occurs. It will also help to maintain your equipment for years of use.

So keep the workspace clean, and let the research flow!

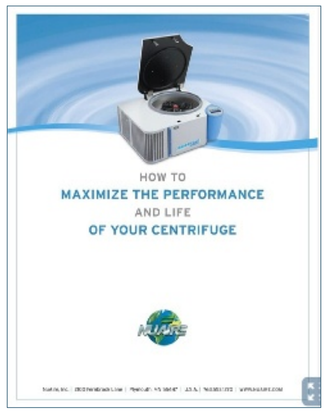
Resources

[Infographic] 10 Tips for Working Safely in the Laboratory with Your Biosafety Cabinet

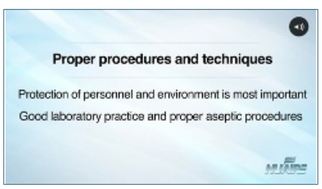


[White Paper] CO_2 Incubator: Proper Use and Preventive Maintenance

[White Paper] UltraLow Freezer: Proper Use and Preventive Maintenance



[White Paper] How to Maximize Centrifuge Performance



[Video] Using Proper Procedures and Techniques with the Biosafety Cabinet

[Video] Working in Your Biosafety Cabinet