UNIT XIII

Unit XIII Laboratory Safety and Biohazards

All laboratories have potential hazards, and the importance of understanding lab safety cannot be emphasized strongly enough. Scientists are expected to understand and be aware of the health and safety issues associated with their profession. Regardless of the standards for laboratory safety in their country of origin and regardless of their position, all researchers require a good understanding of safety features in English before they can begin working in an English-speaking laboratory. All research institutions in English-speaking countries require all new staff to go through a safety orientation or training course before they can begin work. Your employer or institution has a legal requirement to provide you with safety training before you begin work. Generally, a safety officer, a person who acts as the institutional or departmental administrator for safety-related matters, gives the course, and a written safety test must be completed by all new employees following training before work can commence in the laboratory. It is your legal duty to cooperate with your employer or institution's efforts to improve safety in the workplace. Not respecting safety regulations and procedures while working in a laboratory does not only put your own health and others' at risk, but it may also have an impact on the lab's license and may lead to disciplinary action against you. Everyone must be aware and responsible so we can all enjoy our research while staying safe!

In this chapter we aim to familiarize you with English vocabulary and symbols associated with laboratory safety and to give you some general safety guidelines. It is intended to help you address safety issues with confidence even under difficult and stressful circumstances such as emergency situations. This strong background knowledge on lab safety in English will make you more confident when you have to embark on the new experience of starting work in an English-speaking lab. Specific training requirements will not be discussed however, since they generally vary from country to country, between regions and localities within countries, and between institutions within localities.

In order to make you familiar with various aspects of biosafety in English, we have divided this unit into five sections: Personal protective equipment, Lab safety equipment, Chemical safety, Biological safety, and Radiation safety. Once you have finished reading this unit you can test your safety knowledge by taking the safety quiz located at the end of this chapter. An answer key is also provided.

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Personal Protective Equipment (PPE)

It is vital that lab workers wear the correct protective equipment for the experiment they intend to carry out in order to avoid injury. Personal protective equipment includes lab coats (also known as white coats), safety glasses and goggles, face shields, gloves, and masks. When used properly, PPE minimizes personal exposure to hazardous material. Failure to use personal protective equipment is generally seen as a violation of safety rules or procedures.

Lab coats are loose knee-length white coats with deep pockets. Throughout the world, lab coats have become mandatory in research and medical institutions. They must be worn correctly at all times within laboratory areas and always be removed immediately on leaving the laboratory area. A badly stained or torn coat is a hazard and should be replaced immediately. Lab coats are generally provided and cleaned regularly by the institution at no charge.

Protective eyewear, as the name implies, protects the eye area in order to prevent particles or dangerous materials from entering the eye. Protective eyewear must always be worn whenever there is a chance of eye injury. Anyone working in or passing through areas that pose eye hazards should wear eye protection. Eye injuries in the laboratory are very common and can result in serious eye damage or blindness. Most forms of eye protection are light in weight and made from highly impact-resistant material (such as polycarbonate). The main types of protective eyewear are safety glasses, safety goggles, and face shields.

Safety glasses look just like regular eyeglasses; however, the lenses are more durable and provide better protection against flying debris. Safety goggles are different from safety glasses in that they are tight-fitting and have side shields and also provide an extra level of protection beyond safety glasses; they provide full coverage to the eyes. When safety goggles are worn correctly, they will provide protection to the eye and skin immediately surrounding the eyes from dust and splashes of liquid coming from any direction (above, below, side, or face-on). A face shield is a hard, clear plastic sheet that that covers the eyes and face completely. It generally covers the forehead, extends below the chin, and wraps around the side of face. It is intended to cover the entire face from accidental splashes of harmful liquids and some even protect against excessive exposure to ultraviolet radiation (to avoid a sunburned face). Not all face shields protect against UV; be sure that the item is specified by the manufacturer as providing protection at the wave length(s) you intend to use. The type of eye protection needed depends on the circumstances. For example, when the entire face needs protection, a face shield is used. It is important that you wear eye protection any time you are exposed to a potentially hazardous situation. For maximum protection, select the appropriate protective eyewear designed for the specific experiment you carry out and make sure you wear the appropriate eye protection throughout the entire experiment.

Hand protection: careful attention must be given to protecting your hands when working with potentially dangerous chemical or biological materials. Safety gloves are coverings used to protect the hands, with a separate part for each finger

and thumb. Safety gloves are worn in biomedical research laboratories and animal rooms to protect the wearer from contact with damaging material. Gloves are provided by the laboratory for all its researchers. There are hundreds of different types of safety gloves. However, only a few different types of safety gloves are generally used in most biomedical research laboratories. Cryogenic gloves, heat resistant gloves, and chemical resistant gloves are the most common types found in biomedical laboratories. Cryogenic gloves are designed to provide protection to the hands from the dangers encountered when handling extremely cold items or substances, like liquid nitrogen. Liquid nitrogen can cause severe frostbites and cold burns. Gloves intended for liquid nitrogen use are generally not made to allow the hands to be put into the liquid. They only provide protection from accidental spills or contact with the liquid. These gloves are also designed to work with dry ice. Heat resistant protective gloves are designed to protect hands from intense heat and prevent heat burns. Biomedical research laboratories involved in RNA studies: glassware is often oven-baked at 200°C for at least 4 h to ensure it is free from enzymes that can degrade RNA (i.e., RNases). In order to remove glassware from these very hot ovens, one must use heat resistant gloves to protect hands from heat burns. Disposable chemical gloves are the most commonly used gloves in biomedical research laboratories and animal care facilities. These gloves may be made from latex, rubber, nitrile, polyvinyl alcohol (PVA), or polyvinyl chloride (PVC), etc. The type of chemical glove one will use should depend on the chemical being used. For example, nitrile gloves provide protection against oil based chemicals, whereas PVC gloves provide protection against aqueous chemicals. It is important to bear in mind that for chemical protection the wearer should determine the appropriate glove material to provide the desired protection. Some chemicals will rapidly penetrate some glove materials; therefore, incorrect selection or use of protective gloves can lead to chemical burns. One type of glove will not work in all situations.

Face masks, as the name implies, is a cover or partial cover for the face used for protection. It provides protective covering for the mouth and nose. Face masks generally found in biomedical research laboratories are called dust masks. These masks are the white disposable kind with two elastic bands, one that goes above the ears and the other below the ears. Dust masks block large airborne particles. They are often used when weighing out powders and during animal work. There are many different kinds of dust masks; therefore, know the limitation of the protection and wear the proper mask suitable for the job.

Laboratory Safety Equipment

The importance of understanding the types and use of safety equipment is essential to the practice of safe science. All employees are required to know how to use the available safety equipment before any emergencies occur. The majority of laboratories in English-speaking countries have access to the following basic safety equipment:

- ***Emergency eyewash stations*** provide on-the-spot elimination of accidental chemical or biological splashes to the eyes. They are designed to flush the eyes and face only.
- ***Safety showers*** provide on-the-spot removal of massive chemical or biological splashes on clothing or body. Safety showers are designed to have water sprayed over the entire body. Safety showers, however, are not designed to flush the user's eyes because the high rate or pressure of the water flow could cause damage.
- ***Fire blankets*** are, as the name implies, fire-resistant sheets of fabric that one uses to wrap around a person whose cloths are on fire.
- ***Fire extinguishers*** are essential portable fire-fighting tools used to control or put out small fires; however, they are not designed for large or spreading fires. There are different types of fire extinguishers, each of which are designed to put out different types of fires. The types and labeling of fire extinguishers vary among countries. For example, North America generally uses a picture labeling system to indicate which types of fires they are to be used on, whereas the UK uses a color coding system on their extinguishers. Using the wrong type of extinguisher can be dangerous; in some cases, it can cause a fire to spread. Therefore, it is extremely important to familiarize yourself in your institution with the types and labeling of fire extinguishers For example, water expelling type-A fire extinguishers should not be used on fires involving electrical equipment.

For your personal safety and the safety of others, you should know where the nearest fire extinguishers, fire alarm pull boxes, and fire exits are located. Fire alarm pull boxes are bright red boxes with handles generally located on walls near fire exits or in stairwells. In addition, you should know your institution's policy on fire safety. It is also important for the non-native English-speaking scientist to know that there are some common words associated with fire safety that are different in American and British English. For instance, a 'fire check' in Britain is a 'fire safety inspection' in America. The organization that is responsible for preventing and extinguishing unwanted fires is called a 'fire brigade' in Britain and a 'fire department' in America. A man or woman whose job is to stop unwanted fires is called a 'fireman' in Britain and a 'firefighter' in America. The building that houses the fire trucks or fire engines is called a 'fire station' in Britain and a 'firehouse' in America.

- ***First Aid Kits*** (also known as First Aid Box) contain emergency supplies for the treatment of unexpected minor injuries such as small cuts. Most first aid kits are labeled with a white cross on a green background; however, some kits are labelled with a red cross on a white background. First aid kits should be readily available to laboratory staff at all times. First aid kits can contain different items depending on the type of work performed in a laboratory. The names of the main contents found in a first aid kit are below:

- Adhesive strip (as known as 'bandage' or 'band aid' in North America and 'plasters' in the UK), is a material that you can place directly over a small cut in the skin in order to protect the wound and keep it clean. Various sizes are generally included in the kit.
- Various types and sizes of gauze dressing (or simply called gauze) — a cloth for covering a wound. It is usually made from cotton.
- Safety pins.
- Bottle of antiseptic solution.
- Eye pads.
- Disposable gloves.
- First aid book.
- Names of first aiders (these are people who have received basic training on how to give simple medical emergency treatment to injured persons) and how to contact them.

Chemical Safety

There are many hazards associated with working with chemicals. People who work with chemicals are required to know the hazards of the substances in their working area, and learn how to use them safely. Information on most substances is found on chemical safety data sheets, which are normally provided by the companies that you purchase your chemicals from. Laboratories should have a collection of safety data sheets for all chemicals found in their laboratory. Each chemical safety data sheet contains information, in a clear and concise manner, regarding a specific chemical such as physical data, recommended PPE, stability and reactivity, emergency and first aid procedures, health effects, toxicity, handling and storage, ecological information, and disposal considerations. Chemical safety sheets contain more data and information about the hazardous substance than the label found on the container holding the hazardous substance.

Chemical safety data sheet is also known as:

- Safety data sheet
- International chemical safety card (ICSC)
- Chemical safety card
- Product safety data sheet
- Material safety data sheet (MSDS)

What type of information will you find on a chemical label in English?

Labels are legal documents found on all hazardous substances. A label is the manufacturer's way of giving the user information about the product, telling you what the dangers are, and providing details about the supplier. Labeling requirements may differ from country to country; however, in most English-

speaking countries labeling of any container that holds a hazardous substance is regulated by a governing body. These labels include basic information such as product name, ingredients, supplier's name, storage measures, reference to a MSDS, hazard symbols, risk phrases, precautionary measures, and first aid measures. It is extremely important to read and understand the label for the safe use of the hazardous substance. If you require more detailed information about the chemical you are using, you should refer to the MSDS. Labels contain basic information due to lack of space and therefore should not replace the MSDS.

Hazard symbols are often found on chemical labels. These symbols provide the user with a guide for quick recognition of the hazards associated with a specific chemical. A chemical might be labeled with more than one hazard symbol. One must be able to recognize and understanding the meaning of hazard symbols for the safe use of hazardous substances. The table below contains the Workplace Hazardous Materials Information System (WHMIS) classification of chemicals and their hazard symbols. There are six classes, several of which have subdivisions. Each class has a specific symbol to indicate the nature of the hazardous material, and includes a brief explanation of the type of danger they refer to.

Many different additional hazard symbols exist; however, a comprehensive review of all the symbols is beyond the scope of this unit. Those of you who want more information on hazard symbols can look at the websites located at the end of this unit. We also strongly recommend you to check your workplace safety manual or ask your safety officer.

Class	Symbol	Hazard	Description of Hazard
A		Compressed Gas	Contents under pressure (e.g., nitrogen)
B		Flammable and Combustible Material	May catch on fire easily in the presence of a spark or open flame (e.g., propane)
C		Oxidizing Material	May increase the risk of a fire or explosion when in contact with other combustible material

Class	Symbol	Hazard	Description of Hazard
D		Toxic or Poisonous Material	Materials causing immediate and serious toxic effects
D		Poisonous and Infectious Material	Materials causing other toxic effects
D		Poisonous and Infectious Material	Biohazardous infectious material
E		Corrosive Material	May cause chemical burns(e.g., acids, bases, phenols)
F		Dangerously Reactive Material	Materials that are very unstable and may explode as a result of shock, friction, or increase in temperature (e.g., benzoyl peroxide)

Biological Safety

There are many hazards associated with working with biological materials. The purpose of this section is to familiarize you with English vocabulary and usage associated with biological safety. Biological safety training is mandatory for those working in laboratories with biological agents. Learning the vocabulary associated with this area will pave your way to more easily learning your institute's biological safety policy. The main topics covered in this section of the chapter are genetically modified organisms risk assessment, biocontainment levels, biological safety cabinets, and disposal of biological waste.

- ***Genetically Modified Organism (GMO) risk assessment*** looks at the risk of infection from a GMO to humans, animals, and the environment. A genetically modified organism is an organism whose genetic material has been altered by gene technology. All projects involving GMOs are required to undergo a risk

assessment before the project can begin. This generally involves submission of a GMO risk assessment form to the local GMO Safety Committee and approval of the risk assessment.

- ***Biocontainment levels*** are control measures used to lessen or completely prevent the escape of biological hazardous agents. There are four types of biocontainment levels. These four levels are designated as Biosafety Level (BSL) 1, 2, 3, and 4, Biosafety level 1 being the lowest BSL and level 4 the highest. A typical laboratory is a BSL 1 facility. BSL-1 is appropriate for working with micro-organisms that are not known to consistently cause disease in healthy adults (e.g., *E.coli*). BSL-2 is appropriate for working with micro-organisms that are known to cause mild disease to humans (e.g., Salmonella). BSL-3 is appropriate for micro-organisms that may be transmitted by the respiratory route which can cause serious and potentially lethal infection (e.g., SARS coronavirus). BSL-4 is appropriate for working with micro-organisms that pose a high risk of life-threatening disease and can be transmitted via the airborne route (e.g., Ebola virus). BSL-4 laboratories are difficult to design, build, and operate; therefore, most countries have only a few of these types of laboratories (e.g., Canada has two BSL-4 type laboratories; Australia and the UK both have three).
- ***Biological safety cabinets*** (or simply ***hoods***) are safety equipment used to contain biological agents and protect the operator and the environment. These cabinets come in three different classes: class 1, 2, and 3:
  - Class 1 cabinets protect the operator from the biological agent but not the agent from the environment.
  - Class 2 cabinets provide protection to both the operator and the biological agent.
  - Class 3 cabinets are totally enclosed to prevent the release of airborne particles. This type of cabinet is designed to be completely air-tight in order to completely contain the hazardous material.
- ***Biological Waste*** Any unwanted solid or liquid materials that are contaminated with biological agents are referred to as biological waste (note, neither garbage nor rubbish, as we refer to discarded material outside the lab). Safe disposal of biological waste is extremely important to the health and safety of our environment. Improper disposal of this type of waste may cause infection to spread outside the laboratory. Policies for correct disposal of this type of waste can vary, and once again it is important for you to familiarize yourself with the rules and procedures for the proper disposal of biological waste in your institution.

Radiation Safety

In order to work with radioactive materials, the laboratory that you plan to carry out your radioactive experiments in will need to have a radiation permit

(a license giving official permission) and you will need to attend a basic radiation safety training seminar.

Here are some terms you will encounter, the meaning of which may not be immediately obvious to the non-native English speaking scientist:

- ***Radioactive dosimeter badges*** (sometimes referred to as ***film badges***) are used to monitor radiation exposure over an extended period of time. These badges are worn when working with or in areas where radioactive materials are being used. It is usually in the shape of a small badge or pack which is clipped to a person's laboratory coat. It is used to determine whether the radiation level one is exposed to falls within established safety limits.
- ***Geiger counter*** (also known as a ***Survey meter***) is an instrument used to detect radiation in an area or object and measure its intensity. A tiny drop of contamination of a radioactive isotope can be easily detected with this instrument.
- ***Plexiglas shields*** are clear plastic materials used as protective barriers against radiation generated by beta-producing radioactive isotopes. These shields are placed between the user and the radioactive source. The most common beta-producing isotope used in biomedical research is 32 phosphorus (^{32}P). Plexiglas shields are not appropriate shields for gamma or X-ray producing sources.
- ***Decontamination versus Decommissioning*** – The use of these words in radiation protection may cause some confusion for non-English speaking individuals. Decontamination refers to the clean-up of loose or fixed surface radioactivity, whereas decommissioning is used when a radioactive work space or area is no longer used for radioactive work. See the examples below:
  - *All radioactive spills must be* decontaminated *using a special cleaning detergent*.
  - *The radioactive room was* decommissioned *and has now been transformed into a seminar room*.

Safety Quiz

In most English-speaking research institutions, a written safety test must be completed before one can begin doing research. The sample quiz below is an example of what you will find in your new workplace. Safety quizzes generally consist of true and false, multiple-choice, and spot the hazard-type questions. Taking the quiz below will allow you to test your knowledge gained in this chapter. Answers are located at the end of the quiz (see answer key).

The following quiz is made up of two parts: the true and false part and the multiple choice part.

Part 1: Simply answer TRUE or FALSE to the following statements:

1) A laboratory coat is the standard minimum PPE in most laboratories. T/F
2) A white coat can be worn in common areas such as seminar rooms, staff rooms, and cafeteria. T/F
3) Latex gloves provide protection against all toxic chemicals and solvents. T/F
4) Class A water-based fire extinguishers should be used to control fires involving electrical equipment. T/F
5) Gloves should be selected on the basis of the material being handled. T/F
6) A person can be fired for asking questions about how to do their job safely or reporting unsafe working conditions? T/F
7) A radiation safety training course is often not mandatory for personnel who wish to work with radioactive materials. T/F
8) Geiger counters are used to monitor radiation exposure over an extended period of time. T/F
9) Plexiglas shields are protective barriers against all types of radiation. T/F
10) The following graphic symbol shown below indicates an oxidizing hazard. T/F

Part 2: Choose the correct answer for each question. One answer only.

1) What would immediately be used if your clothing caught fire or if a large chemical spill had occurred on your clothing?
   A. Fire extinguisher
   B. Safety shower
   C. Laboratory sinks
   D. Eye-wash fountain

2) What should be done if a chemical gets in the eye(s)?
   A. Use the safety shower
   B. Immediately put your safety goggles on
   C. Immediately begin rinsing the eye(s) in the eye wash station
   D. Nothing, unless the chemical causes discomfort

3) What does PPE mean?
   A. Personal Protective Equipment
   B. Proper Protective Procedures

C. Proper Personal Equipment
D. Proper Procedures for Equipment

4) Class A fire extinguishers are suitable for:
A. Fire involving electrical equipment
B. Fire involving flammable liquids, such as petrol, oil, and diesel
C. Fire involving ordinary combustibles, such as wood, paper, and fabric
D. Fire involving flammable metals, such as aluminium, magnesium, and sodium

5) If the following symbol is depicted on a label, the material found in the container is:

A. Corrosive
B. Dangerously reactive
C. Irritant
D. Poisonous

6) Which item should not be found in a typical first aid kit?
A. Plasters
B. Prescription drugs
C. Disposable gloves
D. Safety pins

7) What does the following symbol mean?

A. Flammable
B. Oxidizer
C. Explosive
D. Compressed Gas

8) Chemical safety data sheets should be consulted:
A. If a hazardous material is ingested
B. Before working with a chemical
C. For the requirement of specific PPE
D. All the above

9) What does GMO mean?
   A. Genetically Modified Organisms
   B. General Modification of Organisms
   C. Genetic Model Organisms
   D. None of the above

10) Which type of fire extinguisher should NOT be used on a fire involving electrical equipment such as computers?
   A. Foam
   B. Water
   C. Dry chemical/powder
   D. CO_2

Answer key:

Part 1 1) T, 2) F, 3) F, 4) F, 5) T, 6) F, 7) F, 8) F, 9) F, 10) T
Part 2 1) B, 2) C, 3) A, 4) C, 5) D, 6) B, 7) A, 8) D, 9) A, 10) B

For further information about safety please see the websites below.

http://bmbl.od.nih.gov/ BSL U.S. Department of Health and Human Services Centres for Disease Control and Prevention and National Institutes of Health

www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/index-eng.php Health Canada

www.osha.gov/ U.S. Department of Labor Occupational Safety & Health Administration

http://hsis.ascc.gov.au/Default.aspx Australia's Hazardous Substances Information System